Digital Imaging and Communications in Medicine (DICOM)

Supplement 236: Waveform Presentation State

Prepared by: Working Group 32 Neurophysiology Waveforms

DICOM Standards Committee, Working Group 6

1300 N. 17th Street, Suite 900

Rosslyn, Virginia 22209 USA

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Document History

2022/06/06	Version 0		Initial version, fragmentary
2022/07/19	Version 1		First draft for wg-32
2022/09/20	Version 5		Draft for wg-06 / First Read
2022/10/14	Version 6		Changes after First Read
2022/11/11	Version 7		Added Cardio Use Case
2022/11/18	Version 8		After Discussion with WG-06
2023/01/18	Version 9		Prepared for WG-06 (2023-01-18)
2023/01/20	Version 10		Changes during and after WG-06 discussion Jan.2023
2023/03/17	Version 11		Prepared for WG-06 (2023-03-20)
2023/03/24	Version 12		Changes during WG-06 discussion (2023-03-20)
2023/03/24	Version 13		Prepared for WG-32 (2023-03-28)
2023/05/17	Version 14		Prepared for WG-32 (2023-05-17) • removed Annotation SR, moved to a separate document
2023/06/15	Version 15		Prepared for WG-32 (2023-06-15) • removed separate (Non-Patient-related) Montage object, only explicitly defined montages are required
2023/08/23	Version 16		Changes after meeting with WG-06 (June 2023) • removed Structured Display IOD and renamed the document • Structured Annotation Module • Montage Activation Module
2023/08/29	Version 17		Prepared for WG-06 (2023-08-30): • Presentation State Identification • Additional open issues • PS3.4 and PS3.6 changes
2023/08/29	Version 18		• Edits discussed in Meeting with WG-06 (2023-08-30) o Closed some open issues o Move Multiplex Group issues to a separate CP
2024/01/05	Version 19		• Document cleaned up • Re-written Open Issue #2
2024/01/12	Version 20		Changes during and after review with WG-06. • No authors for individual annotations in the PR – see closed issue #6 • No graphics in the Graphic Annotation Module, just text. Also changed the name of the module. • Removed ICC Profile Module and added an open issue for it (open issue #6). • Removed amendment of PS3.4 and placed an open issue for it (open issue #7)

			• Cleaned up the comments and preserved the discussions in additional closed issues.
2024/03/22	Version 22		Changes during and after Review with WG-06 • reworked Instance References (in the PR Relationship Module) • New IOD for Acquisition PR • changed Module Table overview • Changes in the Waveform Presentation State Relationship Module (also contain the reference to the Waveform Annotations SR) and in the Structured Waveform Annotations Module
2024/04/10	Version 23		Prepared for WG-32
2024/05/11	Version 24		Prepared for WG-06 2024-05
2024/05/29	Version 25		Prepared for WG-06 2024-05
2024/05/30	Version 26		Prepared for WG-06 2024-05
2024/05/30	Version 27		Public Comment

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Open Issues

1.	Q: Is it sufficient to just create a single Presentation State to store the display settings (montages) for a neurophysiology study during recording? Are there any other situation which also could trigger to store montage settings and so result in more than one Presentation State in one Study? A: Having more than one PR would not influence the content of the PR IOD. Its up to the display application how to present this fact to the user and how to select the PR to present.
2.	Q: When annotations are added to waveforms the user often sees the recording using a specific montage. Supplement 239 Waveform Annotations and this supplement define Annotations as always referring to the recording channels in the related waveform objects but it allows to store a recommended montage to show the annotation. Would it be useful if some annotations could choose to refer to the montage channel(s) instead of the recording channel(s)? For the Annotations stored in a separate SR object the definition of this relationship might be complicated.
3.	Q: Shall it be possible to refer to both – images and waveforms - from one PR, e.g. in Angiography or fMRI? Usually the objects are synchronized, but the existing PR objects only allow for referencing images and the new ones defined in this supplement only allows for referencing waveform objects.
4.	Q: Besides the storage of montages used in a neurophysiology recording, the proposed PR allows for both: containing simple text annotations and providing display information for annotations stored in a separate Waveform Annotation SR. Are there any scenarios which require annotations in the PR or shall all annotations go to SRs (there might be different ones depending on the situation when they are created)?
5.	Q: This supplement restricts the Presentation State to only refer to SR Documents in the same study. There might be use cases were the annotation SR resides in a different study. Should this be possible in the PR considering, that this results in issues in deciding about which metadata (Study A, Study B) to display?

6.	Q: Is it necessary to include the ICC Profile Module if all color values are defined as CIELab values in PCS?
7.	Q: This supplement allows assigning simple text annotations to dedicated waveforms – besides having complex annotations in referenced Waveform Annotation SRs. Presentation states for images support in addition presentation properties like graphical annotations. Are there any use cases which would require such additional properties in the Waveform Presentation State and, if yes, which one?
8.	Q: Within the presentation state object only the temporal coordinates of the annotation and color properties are defined. All other properties are left to the implementation of the viewing software. Would it be necessary to specify further display properties in the presentation state and, if yes, which one?
9.	Q: Part 4 of the DICOM standard provides a comprehensive chapter which describes the behavior of applications when they create and assign Presentation States to images (e.g. by a description of the pixel value rendering pipeline). The Waveform Presentation State is not intended to fully render the display of waveforms. Therefor no Service Class specific behavior is described in this supplement. Are there any specific requirements for displays to be normatively defined for applications assigning waveform presentation states to waveform objects and, if yes, which one?
10.	Q: Waveform Montages introduced in the supplement are fully defined within the Waveform Presentation State object, that uses them. Montages could also be defined and managed externally. Would it be necessary to also standardize such predefined montages and allow to refer to them in the Waveform Presentation state? If yes, this requires separate mechanisms to address and access such montage objects.
11.	Q: Is there any relevant information missing that should be added to Part 17?
12.	Q: Are there any properties in the PR that need to be digitally signed?

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Closed Issues

1.	Q: Should annotations also be included in the presentation state object or should annotations be saved separately - e.g. in a separate Structured Report document. If both is applicable: a clear distinction criterion is required: which annotations shall go to the display object, which go to the SR document. A: Annotations expressing clinical information (observations, measurements, …) should go to a separate object, a DICOM Structured Report object.
2.	Q: What sort of time information is required for display relevant information (when a filter was applied, when the montage was changed)? Relative to the recording (ms or samples)? A: relative to the recording
3.	Q: All IODs in PS3.3 A.33 Softcopy Presentation State Information Object Definitions relate to images, intention is the corrected display of pixel values. PS3.4 N describes how these objects apply to images. If the new Waveform Presentation State IOD is added to A.33, PS3.4 N needs to distinguish between different sorts of Softcopy Presentation State objects. Would it be better to add the new IODs in a separate chapter in PS3.3 (e.g. A.xx Waveform Presentation State Object Definitions)? A: Waveform Presentation State IOD has to go to a separate chapter in PS3.3. Description

	of Storage of these PRs has to go to a separate section in PS3.4.
4.	Q: Procedure Log is a SR intended to store time stamped events during a procedure (e.g. catheterization lab). Would the Procedure Log IOD fit the requirements as well as the Presentation State IOD? In imaging Presentation State objects are (usually) created after image creation, the neurophysiology the recording use case requires the PR to be created during the recording. A: Use a separate object to store the annotations, but an SR.
5.	Sup222 Microscopy Bulk Simple Annotations Storage introduced the definition of Annotations as separate IEs in MORW and E-R model. Shall the new IODs make use of this IE or choose another wording (not using Annotation) in order to keep the distinction? A: The existing definition is very general and does not contradict its use for waveforms. In the new IODs introducing the Annotations for waveforms, the definition could be narrowed.
6.	Q: Presentation State Identification contains date/time, when the PR was created, and coded content descriptor and content creator (optional). Is this sufficient to meet legal and billing requirements or should the authorship be stored for every annotation individually? A: Annotations which require authorship have to be stored in the Annotation SR, unless the authorship of the entire PR is sufficient. There is no authorship for individual annotations in the PR.
7.	Q: How should color and shading be encoded in the Presentation State and in the Structured Display Object? A: CIELab values
8.	Q: Is there a general requirement to have a temporal assignment of display settings (filters and montages): When where which settings in place? Or is this information just relevant in conjunctions with annotations: which settings were in place when the observations were made. A: The start time for a montage (offset in seconds to the start of the recording) can be stored.
9.	Q: A montage can combine any type of channels from different object types, not just EEG channels from Routine Scalp EEGs. A mechanism is required that provides the information about what type of object the channels belong to. A: The reference to the original waveform objects contains both, SOP Instance UID and SOP Class UID.
10.	Q: A concrete Presentation State object contains references to concrete SOP Instances - to concrete objects. It must be guaranteed that this reference works for recordings having been split to multiple files due to limitations on file size or recording gaps. A: Multiple Objects can be referenced; Multiplex Groups can span multiple objects.
11.	Q: Should the Presentation State contain timing information? In a sense: for which time range should this display settings be used. How should viewers then behave? Do they switch the display (the filters, montages) when scrolling through the recording? A: The Waveform Presentation State may contain timing information when (relatively to the

	recording) a montage was onset. It is up to the display implementers how to use this information.
12.	Does the MORW and the E-R model require an extension by introducing a new IE "Waveform Presentation"? A: Yes. Reason is, the current Presentation State IE is image oriented.
13.	Q: Some Modules in the Presentations state allow for (optionally) denoting who added the information (the annotation, the segment of interest). This supplement proposes to use the attribute Operator's Name and to restrict this to persons. Should also be devices/algorithms possible? A: There is no authorship for individual annotations in the PR – see closed issue #6. On the level of the PR itself, a personal authorship can be expressed via the Content Creator Macro in the Presentations State Identification Module or – if the PR is created by a device - via the General Equipment Module.
14.	Q: Shall Waveform Presentations States have a separate, new Modality Code? If no, the existing Presentation Series Module can be reused. In this case the description there has to be adapted (the Note talks about images). A: No. The new IOD would differ only with respect to this new Modality Code. The existing Module can be reused.
15.	Q: The Presentation State Relationship Module as currently defined can only be used for images (or CDA). It would require comprehensive changes if it should be used for waveforms as well (e.g. for images, it can refer to a list of frames. For waveforms, it has to refer to a list of channels). There were also discussions about cases, where a presentation state would reference both, image objects and waveform objects (e.g. in angiography or in echocardiography). This is reflected in another open issue. A: Under the assumption that Presentation States refer either to images or to waveforms the decision is to use a separate Module instead of changing the existing.
16.	Q: Shall Annotations in the PR use the existing Attribute "Observation DateTime" to reflect the point in time when the annotation was added? A: No. A new Attribute shall be defined. Observation DateTime is only used in SR context.
17.	Q: What are the conditions to record the display montages during waveform acquisition (recording use case)? What information should be stored and which time precision is required? A: There is always a montage defined. The first has to start at the beginning (beginning of the recording). The start times of the different montages shall be in timely order. Time precision "second" is sufficient.
18.	Q: This presentation state object introduces the possibility to assign display properties to waveform annotations coming from separate SR documents. Currently this is constraint to only allow Waveform Annotation SR as a source. Should we expand the scope that such annotations come from SR objects with various SOP Classes? A: No. Annotations from different types of waveforms such as ECG go to the same Waveform Annotation SR object. Annotation Groups are also found in other contexts like Microscopy and there is no intention to expand this presentation state to these objects.

19.	Q: Is it sufficient to just create a single Presentation State to store the display settings (montages) for a neurophysiology study during recording? Are there any other situations which also could trigger to store montage settings and so result in more than one Presentation State in one Study? A: Having more than one PR would not influence the content of the PR IOD. It is up to the display application how to present this fact to the user and how to select the PR to present.

72 ## 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
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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 highlights 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 waveform objects. These attributes only cover color and scaling of waveform channels.

91 In neurophysiology a **Montage** defines a list of channels for visualization of the data which is created by a
92 list of original channel sources and the method for their mathematical (linear) recombination. In principle
93 **Montages** could be either predefined and referenced by an object identifier or defined for a specific
94 recording.

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

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

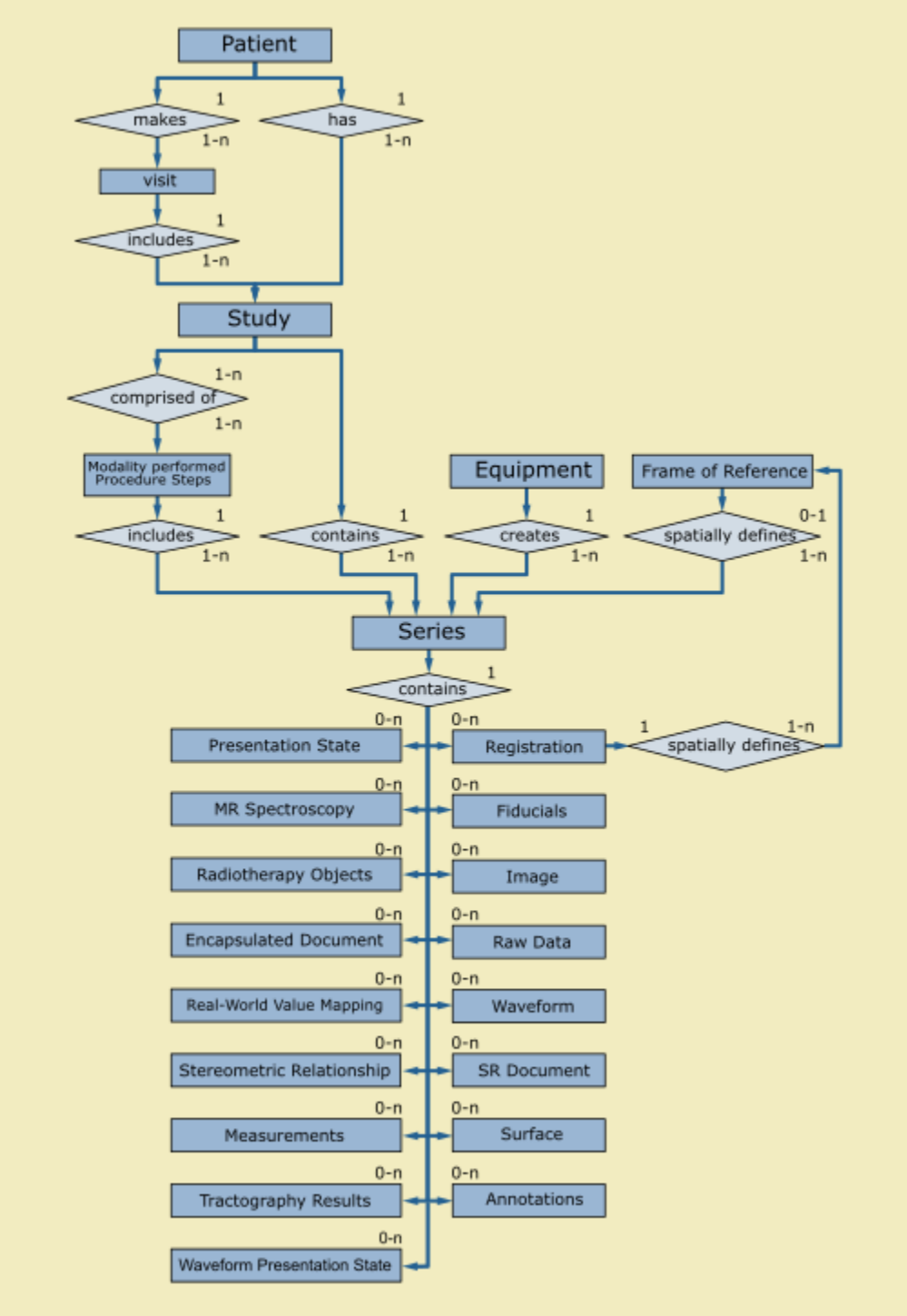
Changes to NEMA Standards Publications PS3.3
Digital Imaging and Communications in Medicine (DICOM)
Part 3: Information Object Definitions

Add a new Overview Table to PS3.3 A.1.4. Table A.1-x:

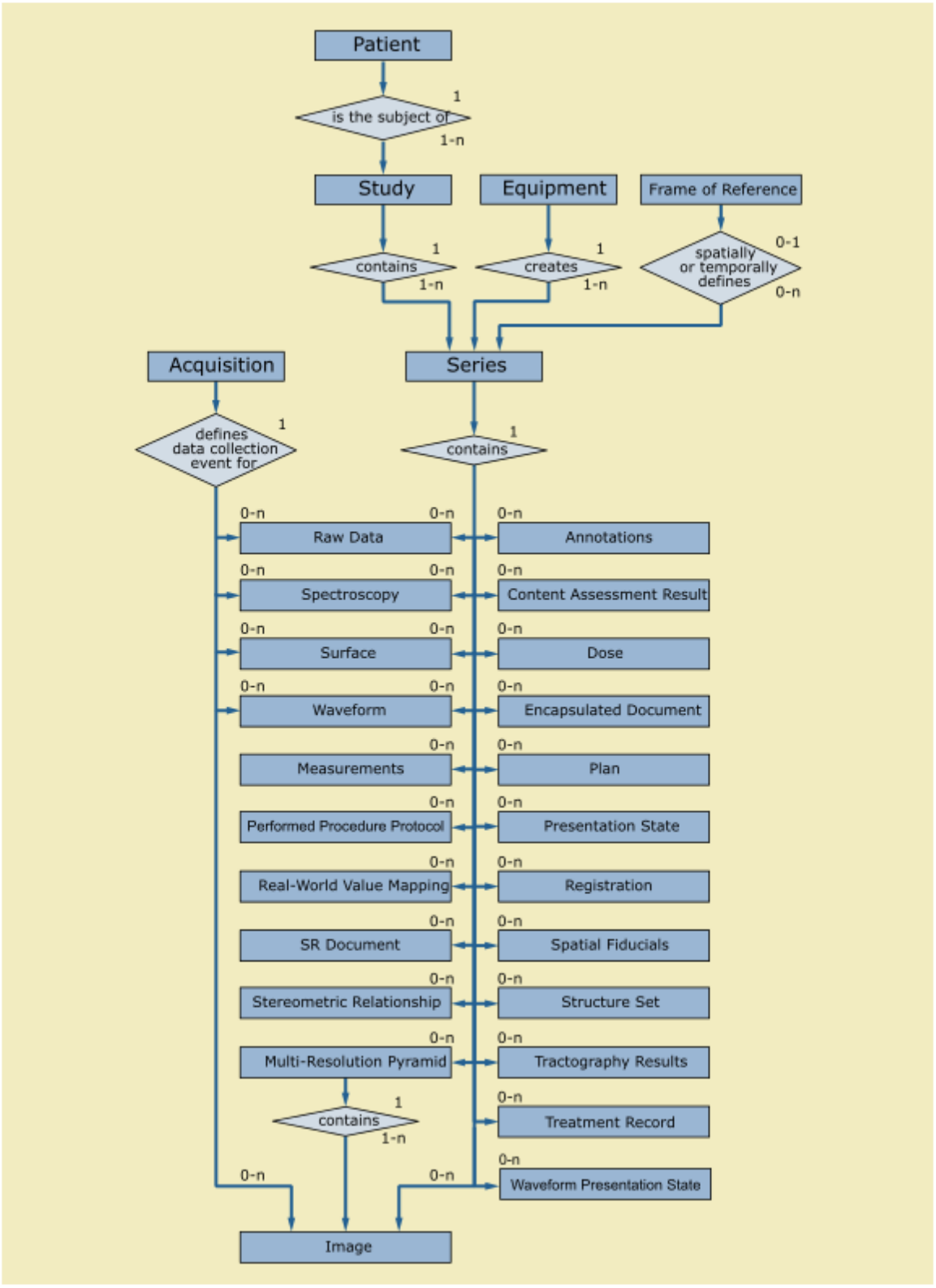
Table A.1-x. Composite Information Object Modules Overview – Waveform Presentation States

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
Presn. Series	M	M
Sync.	C	C
General Equip.	M	M
Enhanced General Equip.	M	M
Presn. State Ident.	M	M
Waveform Presn. State Relationship	M	M
Structured Waveform Annotations	U	U
Simple Waveform Annotations	U	U
Displayed Waveform Segments	U	U
Montage Activation	U	M
Waveform Presentation Montage	C	M
SOP Common	M	M

Amend PS3.3 7 DICOM Model of the Real World by adding Waveform Presentation State IE



Amend PS3.3 A.1.2 IOD Entity-Relationship Model by adding the Waveform Presentation State IE



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

117 **A.1.2.nnn Waveform Presentation State IE**

118 The Waveform Presentation State IE defines how referenced waveform objects will be presented.

The Waveform Presentation State IE comprises simple text annotations, segments of interest, and montages including filters, colors, gain, and vertical sizes of waveform traces if this information is to be applied to the referenced waveform(s).

Add the following new content to PS3.3 Section A.xx

A.xx Waveform Presentation State Information Object Definitions

A.xx.1 Waveform Presentation State IOD

A.xx.1.1 Waveform Presentation State IOD Description

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

Note: The Presentation State object allows to store simple textual annotations, as well as to provide display information for annotations stored in a separate Structured Report document. The policies related to the criteria for where specific annotations should be stored – in the Presentation State object or in the Structured Report document – are outside the scope of the standard.

A.xx.1.2 Waveform Presentation State IOD Entity-Relationship Model

This IOD uses the E-R Model in Section A.1-2, with only the Waveform Presentation State IE below the Series IE.

A.xx.1.3 Waveform Presentation State IOD Module Table

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

Table A.xx.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.xx.hh	M
	Structured Waveform Annotations	C.xx.aa	U

	Simple Waveform Annotations	C.xx.bb	U
	Displayed Waveform Segments	C.xx.cc	U
	Montage Activation	C.xx.dd	U
	Waveform Presentation Montage	C.xx.ee	C – Required if Montage Activation Module is present.
	SOP Common	C.12.1	M

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141 **A.xx.2 Waveform Acquisition Presentation State IOD**

142 **A.xx.2.1 Waveform Acquisition Presentation State IOD Description**

143 The Waveform Acquisition Presentation State Information Object Definition (IOD) provides information
144 about the display settings like filters and montages used during acquisition of the waveform. This allows
145 presentation of the “recording view” later during review of the waveform.

146 Note: The Presentation State object allows to store simple textual annotations, as well as to provide display
147 information for annotations stored in a separate Structured Report document. The policies related to the
148 criteria for where specific annotations should be stored – in the Presentation State object or in the
149 Structured Report document – are outside the scope of the standard.

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151 **A.xx.2.2 Waveform Acquisition Presentation State IOD Entity-Relationship Model**

152 This IOD uses the E-R Model in Section A.1-2, with only the Waveform Presentation State IE below the
153 Series IE.

154 **A.xx.2.3 Waveform Acquisition Presentation State IOD Module Table**

155 Table A.xx.2-1 specifies the Modules of the Waveform Acquisition Presentation State IOD.

156 **Table A.xx.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.xx.hh	M

	Structured Waveform Annotations	C.xx.aa	U
	Simple Waveform Annotations	C.xx.bb	U
	Displayed Waveform Segments	C.xx.cc	U
	Montage Activation	C.xx.dd	M
	Waveform Presentation Montage	C.xx.ee	M
	SOP Common	C.12.1	M

Adapt Section PS3.3 Section C.10.10.1 by adding an additional note to indicate, that this attribute is also used in context of waveform presentations states.

Note

This attribute is also used in context of Waveform Presentation States to express the relationship of a presentation property to selected waveform channels.

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

Note

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

Add the following new content to PS3.3 Section C.xx

C.xx Waveform Presentation State Modules

C.xx.hh Waveform Presentation State Relationship Module

Table C.xx.hh-1 specifies the Attributes of the Waveform Presentation State Relationship Module, which describes the waveforms to which a Waveform Presentation State applies.

Table C.xx.hh-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 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

Attribute Name	Tag	Type	Attribute Description
			that of the Waveform Presentation State.
>Referenced Instance Sequence	(0008,114A)	1C	The set of Structured Report Documents containing Waveform Annotations 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). The referenced Instances shall be of SOP Class 1.2.840.10008.5.1.4.1.1.88.77 Waveform Annotation SR Storage. One or more Items shall be included in this Sequence. Required if Structured Waveform Annotation Sequence (ggga,eee1) is present.
>> Include Table 10-11. "SOP Instance Reference Macro Attributes"			
>Referenced Waveform Sequence	(0008,113A)	1	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). One or more Items shall be included in this Sequence. 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. 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 (ggga,eee1), thus those Waveforms also need to be included here.
>>Include Table 10-11. "SOP Instance Reference Macro Attributes"			
>>Referenced Waveform Channels	(0040,A0B0)	1C	Identifies the waveform multiplex group and channel within the referenced Waveform SOP Instance. Pair of values (M,C). See C.10.10.1.1 Required it the Referenced Waveform SOP

Attribute Name	Tag	Type	Attribute Description
			Instance contains multiple channels and the reference does not apply to all Channels of all Multiplex Groups.

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181 **C.xx.aa Structured Waveform Annotations Module**

182 This Module defines how a display device applies Waveform Annotations that are stored in a separate
183 Structured Report document to a waveform.

184 **Table C.xx.-aa. Structured Waveform Annotations Module Attributes**
185

Attribute Name	Tag	Type	Attribute Description
Structured Waveform Annotation Sequence	(ggga,eee1)	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 a single 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	(ggga,eee2)	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 are displayed. One or more Items may be included in this sequence.
>>Annotation Group Number	(0040,A180)	1	Identifies the Annotation Group within the Referenced SR Document to which the display information applies.
>>Referenced Montage Index	(ggga,eeec)	3	The recommended viewing montage identified by the Montage Index (ggge,eeee) in the Waveform Montages Sequence (ggge,eeea).
>>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.

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187 **C.xx.bb. Simple Waveform Annotations Module**

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

190 A Simple Waveform Annotation shall be related to a Waveform.

191 **Table C.xx.-bb. Simple Waveform Annotations Module Attributes**
192

Attribute Name	Tag	Type	Attribute Description
Waveform Annotation Sequence	(gggb,eee1)	1	Selects and provides simple textual annotations for a group of waveforms or channels within these waveforms. One or more Items shall be included in this Sequence.
>Annotation DateTime	(gggb,eee2)	3	The date and time the annotation was added.
>Referenced Waveform Sequence	(0008,113A)	1C	The Waveform to which this annotation applies. All Waveforms referenced here shall be present in Referenced Waveform Sequence (0008,113A) inside the Referenced Series Sequence (0008,1115) in the top-level data set. 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 listed in Referenced Waveform Sequence (0008,113A) inside the Referenced Series Sequence (0008,1115) in the top-level data set.
>>Include Table 10-11 "SOP Instance Reference Macro Attributes"			
>>Referenced Waveform Channels	(0040,A0B0)	1	Identifies the waveform multiplex group and channels within the referenced SOP Instance. Pair of values (M,C). See C.10.10.1.1
>Include Table C.xx-a Temporal Range Macro Attributes			Enumerated Values for Temporal Range Type (0040,A130): **POINT** **MULTIPOINT**
>Referenced Montage Index	(ggga,eeec)	3	The recommended viewing montage identified by the Montage Index (ggge,eeee) in the Waveform Montages Sequence (ggge,eeea).

Attribute Name	Tag	Type	Attribute Description
>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 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.

193

194 **C.xx.cc Displayed Waveform Segments Module**

195 This Module defines Attributes required to define Waveform Segments and the properties how to display
196 them. A Waveform Segment is a temporal portion of a waveform ("Segment of Interest").

197 **Table C.xx-cc. Displayed Waveform Segments Module Attributes**
198

Attribute Name	Tag	Type	Attribute Description
Displayed Waveform Segment Sequence	(gggc,eee1)	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	(gggc,eee2)	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. All Waveforms referenced here shall be present in Referenced Waveform Sequence (0008,113A) inside the Referenced Series Sequence (0008,1115) in the top-level data set. 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 listed in Referenced Waveform Sequence (0008,113A) inside the Referenced Series Sequence (0008,1115) in the top-level data set.
>>Include Table 10-11. "SOP Instance Reference Macro Attributes"			

Attribute Name	Tag	Type	Attribute Description
>>Referenced Waveform Channels	(0040,A0B0)	1	Identifies the waveform multiplex group and channels within the referenced SOP Instances. Pair of values (M,C). See C.10.10.1.1
>Include Table C.xx-a 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. At least one of (003A,0231) Waveform Display Background CIELabValue and (003A,0244) Channel Recommended Display CIELab Value shall be present.
>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. At least one of (003A,0231) Waveform Display Background CIELabValue and (003A,0244) Channel Recommended Display CIELab Value shall be present.

C.xx.dd Montage Activation Module

This Module defines Attributes recording the timepoints of montage activation.

Table C.xx-dd. Montage Activation Module Attributes

Attribute Name	Tag	Type	Attribute Description
Montage Activation Sequence	(gggd,eeea)	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 (gggd,eeeb) value.

Attribute Name	Tag	Type	Attribute Description
>Referenced Montage Index	(ggga,eeec)	1	The Montage Index (ggge,eeee) of the montage in the Waveform Montages Sequence (ggge,eeea).
>Montage Activation Time Offset	(gggd,eeeb)	1	Time offset in seconds relative to the beginning of the recording. The offset of the first Item shall be 0.

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205 **C.xx.ee Waveform Presentation Montage Module**

206 This Module contains attributes describing presentation montages of waveform channels.

207 **Table C.xx-ee Waveform Presentation Montage Module Attributes**

Attribute Name	Tag	Type	Description
Waveform Montages Sequence	(ggge,eeea)	1	Description of Waveform Montages. One or more items shall be included in this sequence.
>Montage Name	(ggge,eeec)	3	The name of the montage.
>Montage Index	(ggge,eeee)	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 to refer to this montage.
>Montage Channels Sequence	(ggge,eeed)	1	Each item in this sequence represents a single channel calculated for presentation. One or more items shall be included in this sequence. Ordering of Items in this Sequence is significant for reference to specific channels.
>>Include Table C.xx.-b. Montage Channel Macro Attributes			
>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	(ggge,eeeb)	1	Number of the montage channel to be displayed in the Presentation group. This is the ordinal number of the item in the Montage Channels Sequence (ggge,eeed).
>>>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 CIELab 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 CIELab. 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.

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210 **C.xx.ff Montage Channel Macro**

211 This Macro consists of attributes describing a single channel of a waveform montage.

212 **Table C.xx-b. Montage Channel Macro Attributes**

Attribute Name	Tag	Type	Description
Montage Channel Number	(gggf,0202)	1	The number of the montage channel
Montage Channel Label	(gggf,0203)	3	Text label of the channel, which may be used for display purposes.
Montage Channel Source Sequence	(gggf,0208)	1C	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. Required if Source Waveform Sequence (003A,020A) is not present. Only a single Item shall be included in this Sequence.
>Include Table 8.8-1 "Code Sequence Macro Attributes"			*DCID 3001 "ECG Leads"* *DCID 3004 "Arterial Pulse Waveform"* *DCID 3005 "Respiration Waveform"* *DCID 3030 "EEG Leads"* *DCID 3031 "Lead Location Near or in Muscle"* *DCID 3032 "Lead Location Near Peripheral Nerve"* *DCID 3033 "EOG Lead"* *DCID 3034 "Body Position Waveform"*
Source Waveform Sequence	(003A,020A)	1C	A Sequence that provides reference to a DICOM Waveform from which this channel was derived. Required if Montage Channel Source Sequence (gggf,0208) is not present. 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 and channels within the referenced SOP Instances using a pair of values (M,C) as described in 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	(gggf,0209)	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	(gggf,020A)	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)	1C	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"*			*DCID 3001 "ECG Leads"* *DCID 3004 "Arterial Pulse Waveform"* *DCID 3005 "Respiration Waveform"* *DCID 3030 "EEG Leads"* *DCID 3031 "Lead Location Near or in Muscle"* *DCID 3032 "Lead Location Near Peripheral Nerve"* *DCID 3033 "EOG Lead"* *DCID 3034 "Body Position Waveform"*
>Source Waveform Sequence	(003A,020A)	1C	Reference to DICOM Waveform objects from which this channel was derived. One or more items are 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 and channel within the referenced SOP Instance using a pair of Values (M,C) as described in 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. 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 (003A,0210) (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.
>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.
>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.
>Include Table C.10.12-1 "Waveform Filter Characteristics Macro Attributes"			

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214 **C.xx.gg Temporal Range Macro**

215 *Ed. Note: This Macro could also replace this set of Attributes in the Waveform Annotation Module C.10.10*

216 This macro contains attributes that define one or more points in time or time ranges in waveforms or
217 dedicated channels of those waveforms. The waveforms and channels are selected in the enclosing data
218 set.

219 **Table C.xx-a. Temporal Range Macro Attributes**

Attribute Name	Tag	Type	Description

Temporal Range Type	(0040,A130)	1	See section C.xx.gg.g 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 C.xx.gg.h 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.

C.xx.gg.g Temporal Range Type

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

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

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

Enumerated Values:

POINT a single temporal point**; a single value shall be present**.

MULTIPOINT multiple temporal points**; multiple values shall be present**.

SEGMENT a range between two **different** temporal points**; two values shall be present.**

MULTISEGMENT multiple segments, each denoted by two temporal points**. An even number of values shall be present, each pair representing one segment.**

BEGIN range beginning at one temporal point, and extending beyond the end of the acquired data**; a single value shall be present.**

END a range beginning before the start of the acquired data, and extending to (and including) the identified temporal point**; a single value shall be present**.

C.xx.gg.h Referenced Sample Position

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

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

Changes to NEMA Standards Publications PS 3.4

Digital Imaging and Communications in Medicine (DICOM) Part 4: Service Class Specifications

Add new SOP Class to PS3.4 Annex B tables

B.5 Standard SOP classes

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

Table B.5-1. Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification (defined in PS3.3)	Specialization
…			
1.2.840.10008.1.XX1	**Waveform Presentation State Storage**	**Waveform Presentation State IOD**	
1.2.840.10008.1.XX2	**Waveform Acquisition Presentation State Storage**	**Waveform Acquisition Presentation State IOD**	

Changes to NEMA Standards Publications PS 3.6

Digital Imaging and Communications in Medicine (DICOM) Part 6: Data Dictionary

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

Table 6-1. Registry of DICOM Data Elements

Tag	Name	Keyword	VR	VM	
...					
(ggga,eee1)	Structured Waveform Annotation Sequence	StructuredWaveformAnnotationSequence	SQ	1	
(ggga,eee2)	Waveform Annotation	WaveformAnnotationDisplaySelection	SQ	1	

	Display Selection Sequence	Sequence			
(ggga,eeec)	Referenced Montage Index	ReferencedMontageIndex	US	1	
(gggb,eee1)	Waveform Annotation Sequence	WaveformAnnotationSequence	SQ	1	
(gggb,eee2)	Annotation DateTime	AnnotationDateTime	DT	1	
(gggc,eee1)	Displayed Waveform Segment Sequence	DisplayedWaveformSegmentSequence	SQ	1	
(gggc,eee2)	Segment Definition DateTime	SegmentDefinitionDateTime	DT	1	
(gggd,eeea)	Montage Activation Sequence	MontageActivationSequence	SQ	1	
(gggd,eeeb)	Montage Activation Time Offset	MontageActivationTimeOffset	DS	1	
(ggge,eeea)	Waveform Montages Sequence	WaveformMontagesSequence	SQ	1	
(ggge,eeeb)	Referenced Montage Channel Number	ReferencedMontageChannelNumber	IS	1	
(ggge,eeec)	Montage Name	MontageName	LT	1	
(ggge,eeee)	Montage Index	MontageIndex	US	1	
(ggge,eeed)	Montage Channels Sequence	MontageChannelsSequence	SQ	1	
(gggf,0202)	Montage Channel Number	MontageChannelNumber	IS	1	
(gggf,0203))	Montage Channel Label	MontageChannelLabel	SH	1	
(gggf,0208)	Montage Channel Source Sequence	MontageChannelSourceSequence	SQ	1	
(gggf,0209)	Contributing Channel Sources Sequence	ContributingChannelSourcesSequence	SQ	1	
(gggf,020A)	Calculatory Weight	CalculatoryWeight	FL	1	
(gggf,020B)	Contributing Channel Source Sequence	ContributingChannelSource Sequence	SQ	1	
..					

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

UID Value	UID Name	UID Keyword	UID Type	Part
…				
1.2.840.10008.1.XX1	**Waveform Presentation State Storage**	**WaveformPresentation StateStorage**	**SOP Class**	**PS3.4**

1.2.840.10008.1.XX2	**Waveform Acquisition Presentation State Storage**	**WaveformAcquisitionPresentationStateStorage**	**SOP Class**	**PS3.4**
…				

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Changes to NEMA Standards Publications PS3.15

Digital Imaging and Communications in Medicine (DICOM)
Part 15: Security and System Management Profiles

Add new Data Elements to PS3.15 Annex E

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

Attribute Name	Tag	Retd. (from)	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.
...														
Annotation DateTime	**(gggb,eee2)**	**N**	**Y**	**X/Z**						**K**	**C**			
Segment Definition DateTime	**(gggc,eee2)**	**N**	**Y**	**X/Z**						**K**	**C**			
...														

Changes to NEMA Standards Publications PS3.17

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

XXX Waveform Presentation (Informative)

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

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

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

In neurophysiology a **Montage** defines a list of channels for visualization of the data which is created from the originally recorded channel sources and it conveys the method for their mathematical (linear) recombination. In principle Montages could be either predefined and referenced by an object identifier or defined for each specific recording.

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

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

Use case: Recording
A technician performs an EEG recording. From time to time he changes the filter settings and also the montages, for example to check the quality of the raw channel data. If abnormalities occur or if external circumstances change that could be of importance for the evaluation of the recording, the technician adds an annotation at this point.
In addition to the annotations, the recording system also saves the current filter settings and the montage selected for the display in a waveform presentation state object.

Use case: post hoc Review
A physician acting as a post hoc reviewer looks through a completed EEG recording and marks potential epileptiform features. The annotations added by the technician during the recording are displayed for anyone reviewing the recording. The reviewing physician has the option of using the settings for display filters and montage stored in the presentation state object generated during recording.
If he adds annotations, these are stored as well.

Use case: Electronic Health Record
An epilepsy patient is treated in another organization and the neurologist wants to see the EEGs and findings of previous epilepsy monitoring recordings (accessible via the patient's health record). Montages and filter settings used during recording and review may be different between hospitals, and the neurologist may need to see directly what the outside EEG staff annotated, or she may wish to review the data with montage settings she prefers.

Use case: Automated Waveform Analysis

Algorithms may store observations and measurements as annotations and the settings used by the algorithm in the recorded data for future reference.

All these use cases require time locked annotations with identification of authorship and situation of annotation (‘during acquisition’ versus ‘post hoc’)