Correction Number: CP-1274

Log Summary: Type 1 SQ Empty Items in Functional Groups

Name of Standard
PS 3.3 2011
PS 3.5 2011 + CP 1110

Rationale for Correction
CP-994 clarified that if a functional group sequence was not required for every frame, the sequence could be omitted from those per-frame functional group sequence items. It proposed that when the information was not required, the sequence itself should not be sent, rather than sending the sequence with a single empty item.

While a step forward, CP 994 did not quite resolve all the issues around inclusion of Functional Groups. This CP makes clear the difference between, and the conditions for, an absent Sequence, an empty Sequence, and a non-empty Sequence with empty Items.

Some Functional Groups are invoked as Mandatory in the IOD specification, consist of a Type 1 SQ attribute, but have content (Attributes in Items) that is Type 1C. [Example: in Enhanced CT Image IOD, Plane Position (Patient) Functional Group is Mandatory; that Functional Group consists of a Type 1 attribute Plane Position Sequence, and its Item has a single Type 1C attribute Image Position (Patient).]

In such a situation, the question arises as to the expected encoding for the frames where the Type 1C condition is not met. CP-994 stated that the Functional Group Sequence should then not be present – but this conflicts with the Mandatory invocation in the IOD.

Alternatively, the Functional Group could be present with an empty Item. The content of a Sequence Item is dictated by whatever the PS 3.3 IOD defines as being the content of the Item, and that this concept is distinct from whether or not the Sequence Attribute or the Sequence Item itself is required to be sent. I.e., an IOD that permits empty items for a required sequence is valid. This is distinct from the concept of Type 1 versus Type 2 sequences; for Type 1 sequences, Items must be present (even if the Items themselves are empty), whereas for Type 2 sequences, no Item is required (and indeed sending an empty Item when the IOD dataset for that Item requires content is not permitted). This is not explicit in PS 3.5, but should be made so.

A slightly different issue arises with the Type 1 Per-frame Functional Groups Sequence itself, within the Multi-frame Functional Groups Module, which requires one Item for each frame. In some cases, this attribute could possibly have no functional groups to encode, and so would require empty Items corresponding to the number of frames. [Example: Multi-frame Grayscale Byte SC Image has no mandatory functional groups, but the Mandatory Multi-frame Module has the Type 1 Per-frame Functional Groups Sequence.] This can be resolved by the same solution, i.e., recognizing that each such Item may be empty.

This CP clarifies the validity of a Type 1 SQ attribute with one or more empty Items. It also clarifies the requirement for empty Functional Groups in PS 3.3.

Correction Wording:
7.4.1 TYPE 1 REQUIRED DATA ELEMENTS
IODs and SOP Classes define Type 1 Data Elements that shall be included and are mandatory elements. The Value Field shall contain valid data as defined by the elements VR and VM as specified in PS 3.6. The Length of the Value Field shall not be zero. Absence of a valid Value in a Type 1 Data Element is a protocol violation.

Notes:  
1. For data elements with a string (CS, SH, LO) rather than binary, text or sequence Value Representation, and for which multiple Values are allowed, the presence of a single Value is sufficient to satisfy the Type 1 requirement, unless specified otherwise in the Attribute description, and other Values may be empty, unless otherwise specified by the IOD. The presence of one or more delimiter (BACKSLASH) characters alone, without any Values, is not sufficient to satisfy the Type 1 requirement, since even though the Value Length is greater than zero, there is no valid Value present.
2. A Type 1 Sequence Data Element will contain one or more Items, as defined by the IOD (irrespective of the VM of the Sequence, which is always one (Section 7.5)). Whether or not those Items may be empty (contain no Data Elements) depends on the IOD definition of the Data Set for each Item.

7.4.2 TYPE 1C CONDITIONAL DATA ELEMENTS
IODs and SOP Classes define Data Elements that shall be included under certain specified conditions. Type 1C elements have the same requirements as Type 1 elements under these conditions. It is a protocol violation if the specified conditions are met and the Data Element is not included.

When the specified conditions are not met, Type 1C elements shall not be included in the Data Set.

7.4.3 TYPE 2 REQUIRED DATA ELEMENTS
IODs and SOP Classes define Type 2 Data Elements that shall be included and are mandatory Data Elements. However, it is permissible that if a Value for a Type 2 element is unknown it can be encoded with zero Value Length and no Value. If the Value is known the Value Field shall contain that value as defined by the elements VR and VM as specified in PS 3.6. These Data Elements shall be included in the Data Set and their absence is a protocol violation.

Notes:  
1. The intent of Type 2 Data Elements is to allow a zero length to be conveyed when the operator or application does not know its value or has a specific reason for not specifying its value. It is the intent that the device should support these Data Elements.
2. A Type 2 Sequence Data Element will contain zero or more Items, as defined by the IOD (irrespective of the VM of the Sequence, which is always one (Section 7.5)). An empty Type 2 Sequence is one with no Items, as opposed to an Item that is present, but empty. Whether or not Items may be empty (contain no Data Elements) depends on the IOD definition of the Data Set for each Item, rather than the Type of the enclosing Sequence Data Element.

7.4.4 TYPE 2C CONDITIONAL DATA ELEMENTS
IODs and SOP Classes define Type 2C elements that have the same requirements as Type 2 elements under certain specified conditions. It is a protocol violation if the specified conditions are met and the Data Element is not included.

When the specified conditions are not met, Type 2C elements shall not be included in the Data Set.

Note: An example of a Type 2C Data Element is Inversion Time (0018,0082). For several SOP Class Definitions, this Data Element is required only if the Scanning Sequence (0018,0020) has the Value “IR.” It is not required otherwise. See PS 3.3.

7.4.5 TYPE 3 OPTIONAL DATA ELEMENTS
IODs and SOP Classes define Type 3 Data Elements that are optional Data Elements. Absence of a Type 3 element from a Data Set does not convey any significance and is not a protocol violation. Type 3 elements may also be encoded with zero length and no Value. The meaning of a zero length Type 3 Data Element shall be precisely the same as that element being absent from the Data Set.
Amend PS3.3 Section C.7.6.16

C.7.6.16  Multi-frame Functional Groups Module
Table C.7.6.16-1 specifies the attributes of the Multi-frame Functional Groups Module. This module is included in SOP instances even if there is only one frame in the instance.

Table C.7.6.16-1
MULTI-FRAME FUNCTIONAL GROUPS MODULE ATTRIBUTES

<table>
<thead>
<tr>
<th>Attribute Name</th>
<th>Tag</th>
<th>Type</th>
<th>Attribute Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shared Functional Groups Sequence</td>
<td>(5200,9229)</td>
<td>1</td>
<td>Sequence that contains the Functional Group Macros that are shared for all frames in this SOP Instance and Concatenation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Note:</strong> The contents of this sequence are the same in all SOP Instances that comprise a Concatenation.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>Zero or one Only a single</strong> Item shall be included in this sequence. See section C.7.6.16.1.1 for further explanation.</td>
</tr>
<tr>
<td>&gt;Include one or more Functional Group Macros that are shared by all frames. The selected Functional Group Macros shall not be present in the Per-frame Functional Groups Sequence (5200,9230).</td>
<td></td>
<td></td>
<td>For each IOD that includes this module, a table is defined in which the permitted Functional Group Macros and their usage is specified.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td><strong>The Item may be empty if the requirements for inclusion of the Functional Groups are not satisfied.</strong></td>
</tr>
</tbody>
</table>

| Per-frame Functional Groups Sequence  | (5200,9230)  | 1    | Sequence that contains the Functional Group Sequence Attributes corresponding to each frame of the Multi-frame Image. The first Item corresponds with the first frame, and so on. |
|                                       |              |      | One or more Items shall be included in this sequence. The number of Items shall be the same as the number of frames in the Multi-frame image. See Section C.7.6.16.1.2 for further explanation. |

| >Include one or more Functional Group Macros. | | | For each IOD that includes this module, a table is defined in which the permitted Functional Group Macros and their usage is specified. |
| An Item may be empty if the requirements for inclusion of the Functional Groups for the corresponding frame are not satisfied. | | | |
C.7.6.16.1  Multi-frame Functional Groups Module Attribute Description

C.7.6.16.1.1  Functional Group

A Functional Group is a set of Attributes that are logically related and may vary together. Functional Groups are defined by editorial convention in Macros. Those Functional Groups Macros that apply to all frames are included in the Shared Functional Groups Sequence (5200,9229). Functional Groups Macros whose attribute values may vary from frame to frame are included in the Per-frame Functional Groups Sequence (5200,9230).

A single Functional Group Macro shall not be included in both the Shared Functional Groups Sequence (5200,9229) and the Per-frame Functional Groups Sequence (5200,9230).

Notes: 1. In the case of a SOP Instance containing a single frame, some Functional Groups Macros may be contained in the Shared Functional Groups Sequence (5200,9229) and others in the one Item of the Per-frame Functional Groups Sequence (5200,9230).
2. Even if there are no Functional Groups Macros in the Per-frame Functional Groups Sequence 5200,9230) an empty Item is encoded for every frame, which an IOD is permitted to specify for a Type 1 Sequence, as described in PS 3.5.

It may happen that the Data Set for the Item of a Functional Group Sequence Attribute does not contain any value Attributes (e.g., a condition for a single Type 1C attribute in the sequence is not met); in this case, the Item is included but is empty.

Note: PS 3.5 describes that an empty Item is permitted for a Type 1 or Type 2 Sequence depending on what the IOD in PS 3.3 defines for the Data Set that is defined for that Sequence Item.

It may happen that a Functional Group Sequence Attribute is not required for a particular frame (e.g., an optional Functional Group). In this case the Functional Group Sequence Attribute is not included in the Shared Functional Groups Sequence (5200,9229) or the Per-frame Functional Groups Sequence (5200,9230) for a particular frame.

Note: The absence of the sequence attribute corresponding to a particular functional group macro indicates that the functional group is not used for a particular frame.