

DICOM Correction Proposal

STATUS	Assigned
Date of Last Update	2016/01/08
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Correction Number	CP-1013
Log Summary:	RT Ion Beams Scan Spot Ordering
Name of Standard	PS 3.3 2015
<p>The clarification about Scan Spot recording in RT Ion Beams Treatment Record from the DICOM WG-07 Ion Subgroup Meeting in Shanghai (see <a href="http://medical.nema.org/Dicom/minutes/WG-07/WG-07-ION/Ion_2014/WG-07-Ion-2014-06-15-Min.docx">http://medical.nema.org/Dicom/minutes/WG-07/WG-07-ION/Ion_2014/WG-07-Ion-2014-06-15-Min.docx</a>) states that:</p> <p>“There was also a discussion about the recording of modulated scanning treatments. The consensus of the group was that the DICOM standard should not prevent recording of the x, y values at the actual delivery positions with high precision. For future DICOM plans using dosimetric parameters (as opposed to equipment parameters), the record should allow recording as much detailed beamline parameters as necessary to simulate the delivered treatment.”</p> <p>Since the original ion supplement was produced, one or more manufacturers have stated that the delivery system may change the order and the number of delivered aiming spots with respect to that planned; as such the Recorded spots may not necessarily match the Plan spots.</p> <p>To ease the analysis of the record (by OIS and TPS) and the calculations for resuming a partial treatment by the Delivery System, we need to describe the link between the delivered spots in the RT Ion Beams Treatment Record and their corresponding prescription in the RT Ion Plan.</p> <p>Therefore, in addition to the existing tags Scan Spot Metersets Delivered (3008,0047) and Scan Spot Position Map (300A,0394), this change proposal adds an attribute in the RT Ion Beams Session Record to record for each spot its corresponding index in the prescription Plan.</p> <p>As the standard does not currently force the delivery system to follow the spot order as described in the plan, we also propose to add a tag that will indicate if the delivery system has the ability to re-order the spot or shall exactly follow the spot order exactly as presented in the RT Ion Plan.</p>	
Correction Wording:	

*In PS 3.3, Section C.8.8.26 RT Ion Beams Session Record Module, add the following attributes and make the changes indicated:*

**C.8.8.26 RT Ion Beams Session Record Module**

**Table C.8.8.26-1. RT Ion Beams Session Record Module Attributes**

Attribute Name	Tag	Type	Attribute Description
Treatment Session Ion Beam Sequence	(3008,0021)	1	Sequence of setup and/or treatment beams administered during treatment session.  One or more items shall be included in this sequence.

>Ion Control Point Delivery Sequence	(3008,0041)	1	<p>Sequence of beam control points for current ion treatment beam.</p> <p>One or more items shall be included in this sequence.</p> <p>The number of items shall be identical to the value of Number of Control Points (300A,0110).</p> <p>See Section C.8.8.21.1.</p>
...			
>>Number of Scan Spot Positions	(300A,0392)	1C	<p>Number of spot positions used to specify scanning pattern for current segment beginning at control point. Required if Scan Mode (300A,0308) is MODULATED.</p>
>> Scan Spot Position Map	(300A,0394)	1C	<p>The x and y coordinates of the scan spots are defined as projected onto the machine isocentric plane in the IEC GANTRY coordinate system (mm). Required if Scan Mode (300A,0308) is MODULATED. Contains 2N values where N is the Number of Scan Spot Positions (300A,0392).</p>
>>Scan Spot Metersets Delivered	(3008,0047)	1C	<p>A data set of Metersets delivered to the scan spot positions. The order of Metersets matches the positions in Scan Spot Position Map (300A,0394).</p> <p>The sum contained in all Metersets shall match the difference of the Delivered Meterset of the current control point to the following control point.</p> <p>Required if Scan Mode (300A,0308) is MODULATED.</p>
>>Scanning Spot Size	(300A,0398)	3	<p>The Scanning Spot Size as calculated using the Full Width Half Maximum (FWHM). Specified by a numeric pair - the size measured in air at isocenter in IEC GANTRY X direction followed by the size in the IEC GANTRY Y direction (mm).</p>

>>Number of Paintings	(300A,039A)	1C	<p>The intended number of times the scan pattern given by Scan Spot Position Map (300A,0394) and Scan Spot Meterset Weights (300A,0396) in the Referenced RT Plan was to be applied at the current control point.</p> <p><b>Note:</b>  <del>The actual number of paintings is not known or recorded. The Scan Spot Metersets Delivered (3008,0047) contains the sum of all complete and partial repaints.</del></p> <p>Required if Scan Mode (300A,0308) is MODULATED.</p>
>> <u>Scan Spot Reordered</u>	<u>(xxxx, xxx2)</u>	<u>3</u>	<p><u>Indicates that the spots were delivered in a different order than in the plan.</u></p> <p><u>Enumerated Values:</u>  <u>YES</u>  <u>The delivery machine changed the spot order</u></p> <p><u>NO</u>  <u>The delivery machine delivered the spots in the order as planned</u></p> <p><u>See Note 1.</u></p>

<u>&gt;&gt;Scan Spot Prescribed Indices</u>	<u>(xxxx,xxx1)</u>	<u>1C</u>	<p><u>The indices of the prescribed spots corresponding to each delivered spot. These indices are the ordinal positions of the spots in the Scan Spot Meterset Weights (300A,0396) in the Ion Control Point Sequence (300A,03A8) of the referenced RT Ion Plan. The numbering of indices of the prescribed spots shall start at zero (a value of zero refers the first ordinal position).</u></p> <p><u>Required, if Scan Scan Spot Reordered (xxxx, xxx2) equals YES.</u></p> <p><u>Contains N values where N is the Number of Scan Spot Positions (300A,0392).</u></p>
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Note 1: Recording an extra tuning spot is considered reordering, even if the spots were delivered in the prescribed order. If re-painted spots (i.e. Number of Paintings (300A,039A) > 1) are recorded separately, then this is also considered reordering.

*In PS 3.3, Section C.8.8.26 RT Ion Beams Session Record Module, add the following section:*

**C.8.8.26.X SCAN SPOT PRESCRIBED INDICES**

The Scan Spot Prescribed Indices (xxxx,xxx1) shall be use to map the delivered spot map to the prescribed one. The Scan Spot Prescribed Indices is of Type 2, meaning that if a delivery system is not able to map the delivered spot map to the prescribed one, the Scan Spot Prescribed Indices shall be present but can have a null value.

There are various cases how the scan spots are delivered in comparison with the prescribed spot order.

Following are various examples specifying how the scan spot prescribed index shall be used.

**Content of RT Ion Plan for following Use Cases**

It is assumed that the RT Ion Plan contains the following spot positions in the Scan Spot Position Map (300A,0394) and related Scan Spot Meterset Weights (300A,0396).

The following table is a representation of the prescription where “w” represents the Scan Spot Meterset Weight.

Scan Spot Position in the Scan Spot Position Map (300A,0394)	x0, y0	x1,y1	x2,y2	x3,y3	x4,y4
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Scan Spot Meterset Weight (300A,0396)	w0	w1	w2	w3	w4
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The prescription does not contain an explicit index for the scan spot order. The index is defined implicitly by the order of the spots within the prescribed map. The implicit index starts at 0.

The following examples specify some different cases of delivered scan spot order that can then be supported using the spot index in the RT Ion Beams Treatment Record.

### Treatment Recording Use Cases

The following tables contain 3 rows as follows:

First Row: The delivered Scan Spot Position in the Scan Spot Position Map (300A,0394). In this row the spot positions are annotated as they have been delivered. The index following the coordinate character refers to the index in the RT Ion Plan. If the index is appended, it shows that 2 or more delivered scan spots refer to the same Scan Spot Position in the RT Ion Plan.

Second Row: The Scan Spot Meterset Delivered (3008,0047). The Meterset Delivered is indicated by 'm'.

Third Row: The Scan Spot Prescribed Indices (xxxx,xxx1) referring to the position in the Scan Spot Meterset Weights (300A,0396) of the referenced RT Ion Plan are indicated as they are recorded in the RT Ion Beams Treatment Record.

#### Use Case 1 : No pause, no spot reordering, no spot splitting, no repainting

This use case is an example where the spots are treated in the exact order as prescribed in the RT Ion Plan.

Scan Spot Position in the Scan Spot Position Map (300A,0394)	x0, y0	x1,y1	x2,y2	x3,y3	x4,y4
Scan Spot Metersets Delivered (3008,0047)	m0	m1	m2	m3	m4
Scan Spot Prescribed Indices (xxxx,xxx1)	0	1	2	3	4

The Scan Spot Prescribed Indices (xxxx,xxx1) refer directly to the implicit indices of the prescription. Since there was no re-ordering, these values will start at 0 incrementing by 1, i.e. 0, 1, 2, 3, etc.

### Use Case 2 : Pause

This use case is an example of a spot broken up into two reported spots due to a pause in the middle of treatment.

Scan Spot Position in the Scan Spot Position Map (300A,0394)	x0, y0	x1,y1	x2a,y2a	x2b,y2b	x3,y3
Scan Spot Metersets Delivered (3008,0047)	m0	m1	m2a	m2b	m3
Scan Spot Prescribed Indices (xxxx,xxx1)	0	1	2	2	3

The pause occurred during the delivery of the 3<sup>rd</sup> spot (index 2). When the delivery resumed, the spot was not located at the same position prior to the pause. The notations x2a, y2a represent the position of the spot prior to the pause. x2b, y2b represent the position of the resumed spot. Both spots refer to the same prescribed spot. The meterset m2a represents the measured meterset prior to the pause and m2b represents the measured meterset after resumption.

### Use Case 3 : Tuning Spot

Some delivery systems use a tuning spot (aka pulse) to adjust the different beam parameters. This tuning spot can be delivered at the beginning of the beam or at any time during the beam. The tuning spot may not reach exactly the same position as a prescribed spot.

The suffix 't' indicates a tuning spot.

Scan Spot Position in the Scan Spot Position Map (300A,0394)	x3t, y3t	x0,y0	x1,y1	x2,y2	x3,y3	x4,y4
Scan Spot Metersets Delivered (3008,0047)	m3t	m0	m1	m2	m3	m4
Scan Spot Prescribed Indices (xxxx,xxx1)	3	0	1	2	3	4

A tuning spot was delivered at the beginning of a control point. The tuning spot will be present in the treatment record. As it is the first one being delivered for that control point, it will be the first one in the record.

The tuning spot in this example was targeting the 4<sup>th</sup> spot of the prescription. In the record the Scan Spot Prescribed Indices will refer to the 4<sup>th</sup> position (index 3). As the tuning spot may not match the prescribed position, it will have its own coordinates represented by the suffix 't'.

#### Use Case 4 : Repainting

Use case demonstrating how re-paints of the spot map within the same control point can be represented.

The suffix p<n> indicates a painting iteration.

Scan Spot Position in the Scan Spot Position Map (300A,0394)	x0p0,y0p0	x1p0,y1p0	x2p0,y2p0	x3p0,y3p0	x4p0,y4p0
Scan Spot Metersets Delivered (3008,0047)	m0p0	m1p0	m2p0	m3p0	m4p0
Scan Spot Prescribed Indices (xxxx,xxx1)	0	1	2	3	4
Scan Spot Position in the Scan Spot Position Map (300A,0394)	x0p1,y0p1	x1p1,y1p1	x2p1,y2p1	x3p1,y3p1	x4p1,y4p1
Scan Spot Metersets Delivered (3008,0047)	m0p1	m1p1	m2p1	m3p1	m4p1
Scan Spot Prescribed Indices (xxxx,xxx1)	0	1	2	3	4
Scan Spot Position in the Scan Spot Position Map (300A,0394)	x0p2,y0p2	x1p2,y1p2	x2p2,y2p2	x3p2,y3p2	x4p2,y4p2
Scan Spot Metersets Delivered (3008,0047)	m0p2	m1p2	m2p2	m3p2	m4p2
Scan Spot Prescribed Indices (xxxx,xxx1)	0	1	2	3	4

When repainting is requested (Number of Paintings (300A,039A) is greater than 1), the record shall contain each of the delivered paintings.

In the example, repainting was performed three times. Each repainted spot is described by the Scan Spot Position, the Delivered Metersets of the specific painting, and the Scan Spot Prescribed Indices.

### Use Case 5: Spot Reordering

In this use case, the number of spots remains the same, but they are simply treated in a different order than planned.

Scan Spot Position in the Scan Spot Position Map (300A,0394)	x3, y3	x1,y1	x4,y4	x2,y2	x0,y0
Scan Spot Metersets Delivered (3008,0047)	m3	m1	m4	m2	m0
Scan Spot Prescribed Indices (xxxx,xxx1)	3	1	4	2	0

When Scan Spot Re-Ordering is allowed, the spots are listed in the order of the delivery and reference the Scan Spot Prescribed Indices.

### Use Case 6 : Combination

This use case is a combination of all the above including tuning spots, repaints, and additional re-ordering.

The suffix 't' indicates a tuning spot.

The suffix p<n> indicates a painting iteration.

In this table, the color codes are as follows:

- Underline : tuning spot
- **Bold** : spot that has been re-ordered

Scan Spot Position in the Scan Spot Position Map (300A,0394)	<u>x3t, y3t</u>	<b>x1p0,y1p0</b>	<b>x4p0,y4p0</b>	<b>x0p0,y0p0</b>	x3p0,y3p0	<b>x2p0,y2p0</b>
Scan Spot Metersets Delivered (3008,0047)	<u>m3t</u>	<b>m1p0</b>	<b>m4p0</b>	<b>m0p0</b>	m3p0	<b>m2p0</b>

Scan Spot Prescribed Indices (xxxx,xxx1)	<u>3</u>	1	4	0	3	2
Scan Spot Position in the Scan Spot Position Map (300A,0394)	<u>x2t, y2t</u>	<b>x1p1,y1p1</b>	<b>x4p1,y4p1</b>	<b>x0p1,y0p1</b>	x3p1,y3p1	<b>x2p1,y2p1</b>
Scan Spot Metersets Delivered (3008,0047)	<u>m2t</u>	<b>m1p1</b>	<b>m4p1</b>	<b>m0p1</b>	m3p1	<b>m2p1</b>
Scan Spot Prescribed Indices (xxxx,xxx1)	<u>2</u>	1	4	0	3	2
Scan Spot Position in the Scan Spot Position Map (300A,0394)	<b>x1p2,y1p2</b>	<b>x4p2,y4p2</b>	<b>x0p2,y0p2</b>	<b>x2p2,y2p2</b>		
Scan Spot Metersets Delivered (3008,0047)	<b>m1p2</b>	<b>m4p2</b>	<b>m0p2</b>	<b>m2p2</b>		
Scan Spot Prescribed Indices (xxxx,xxx1)	1	4	0	2		

The repainting is represented by recording the spot multiple times and referencing to the same scan spot prescribed index.

The tuning pulse is recorded for the first two paintings and references the scan spot prescribed index of the spot being used for tuning.

The order of the spots is the spot order actually delivered.

The third painting did not deliver all the prescribed spots because some of the spot metersets were below the minimum deliverable meterset of the machine.

*In PS 3.3, Section C.8.8.25 RT Ion Beam Module, add the following attributes:*

C.8.8.25 RT Ion Beams

Table C.8.8.25-1. RT Ion Beams Module Attributes

Attribute Name	Tag	Type	Attribute Description
Ion Beam sequence	(300A,03A2)	1	Sequence of setup and/or treatment beams for current RT Ion Plan. One or more items shall be included in this sequence.
>Ion Control Point Sequence	(300A,03A8)	1	Sequence of machine configurations describing Ion treatment beam. The number of items shall be identical to the value of Number of ControlPoints (300A,0110). See Section C.8.8.25.7.
...			
>>Scan Spot Tune ID	(300A,0390)	1C	User-supplied or machine code identifier for machine configuration to produce beam spot. This may be the nominal spot size or some other machine specific value. Required if Scan Mode (300A,0308) is MODULATED.
<b>&gt;&gt;Scan Spot Reordering Allowed</b>	<b>(xxxx, xxx3)</b>	<b>3</b>	<b><u>Indicates whether the spot delivery order shall remain the same as planned order.</u></b>  <b><u>Enumerated Values:</u></b>  <b><u>ALLOWED</u></b> <b><u>The delivery device may deliver the spots in any order</u></b>  <b><u>NOT ALLOWED</u></b> <b><u>The delivery device shall not change the order of the spots within the map and must deliver them in the prescribed order.</u></b>

In PS 3.6, Section 6, add the following new attributes:

<b>(xxxx,xxx1)</b>	<b><u>Scan Spot Prescribed Indices</u></b>	<b><u>ScanSpotPrescribedIndices</u></b>	<b><u>IS</u></b>	<b><u>1-n</u></b>
<b>(xxxx,xxx2)</b>	<b><u>Scan Spot Reordered</u></b>	<b><u>ScanSpotReordered</u></b>	<b><u>CS</u></b>	<b><u>1</u></b>
<b>(xxxx,xxx3)</b>	<b><u>Scan Spot Reordering Allowed</u></b>	<b><u>ScanSpotReorderingAllowed</u></b>	<b><u>CS</u></b>	<b><u>1</u></b>

