Digital Imaging and Communications in Medicine (DICOM)

Supplement 74: Utilization of Worklist in Radiotherapy Treatment Delivery

DICOM Standards Committee, Working Group 7 Radiation Therapy

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Scope and Field of Application

This Supplement defines IODs that are used in the radiotherapy context in conjunction with the Unified Procedure Step (UPS) SOP Class. It also supplies information on how these classes shall be used in Radiation Therapy.

Specifically the modifications introduced by this Supplement describe support for the following activity:

- A Treatment Delivery System (TDS) acting in the role of a UPS Pull SCU, retrieves a treatment delivery Unified Procedure Step (UPS) from a Treatment Management System (TMS) acting in the role of a Worklist Manager (UPS Pull SCP). The TDS retrieves the associated SOP Instances specifying the delivery, performs setup verification, delivers the treatment, creates any associated result SOP Instances, and updates the UPS. As a variant, an external Machine Parameter Verifier (MPV) may be responsible for verification of machine parameters, rather than the TDS.

This is achieved by the addition of the following:

- The RT Beams Delivery Instruction Storage Composite IOD, which contains the data necessary to instruct a TDS on what is to be delivered. A key element of the IOD is the RT Beams Delivery Instruction Module, which contains information on the RT Plan to be used, the beams within that plan that will actually be delivered, and any verification images associated with those beams.

- The RT Conventional Machine Verification Service Class, which specifies new services such that a TDS can instruct an MPV to externally verify a conventional treatment delivery, including potentially overriding one or more treatment parameters.

- The RT Ion Machine Verification Service Class, which performs the same function for Ion plans.

Description of how the treatment plan is communicated from the Treatment Planning System to the Treatment Management System is not included in this supplement – presumably this would be via an RT Plan Store to an Archive followed by a query/retrieve from the TMS, although it could be a store directly to the TMS.

Atypical use case flows such as „on-the-fly" treatment planning on the TDS are not described. These flows may well use features of Unified Procedure Step such as the ability to remotely schedule on the TMS, or if such a delivery is not explicitly scheduled then the TMS may need to handle unsolicited treatment record SOP Instances and reconstruct delivery session and potentially plan information.

This Supplement is being driven both by issues in current products, and the desire to address workflow, in particular treatment delivery workflow, at IHE-RO (Integrating the Healthcare Enterprise – Radiation Oncology).

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Part 2 Addendum

Add new SOP Classes to PS3.2 Table A.1-2 UID Values:

UID Value	UID Name	Category
1.2.840.10008.5.1.4.34.7	RT Beams Delivery Instruction Storage	Transfer
1.2.840.10008.5.1.4.34.8	RT Conventional Machine Verification	Workflow Management
1.2.840.10008.5.1.4.34.9	RT Ion Machine Verification	Workflow Management

Part 3 Addendum

Add the following section in PS3.3, Section 10:

10.X SELECTOR ATTRIBUTE MACRO

Table 10.X-1 specifies the Attributes that identify the context for a Data Element Tag that is used as a Selector Attribute (0072,0026) The attribute may be an attribute nested within one or more Sequences, and/or a Private Attribute.

Table.10.X-1
Selector Attribute Macro Attributes

Attribute Name	Tag	Type	Attribute Description
Selector Attribute	(0072,0026)	1	Data Element Tag of the attribute to be referenced.
Selector Value Number	(0072,0028)	1	Positive integer identifying which value of a multi-valued attribute identified by Selector Attribute (0072,0026) is to be referenced. The value 1 identifies the first value. The value zero identifies any value.
Selector Sequence Pointer	(0072,0052)	1C	Contains the Data Element Tags of the path to the Sequence that contains the Attribute that is identified by the Selector Attribute (0072,0026). This attribute shall have the same number of items as the level of nesting of the Selector Attribute (0072,0026). Required if the Selector Attribute (0072,0026) is nested in one or more Sequences. See 10.X.1.1.
Selector Sequence Pointer Private Creator	(0072,0054)	1C	Identification of the creator of a group of private data elements used to encode attributes in the Selector Sequence Pointer (0072,0052). This attribute shall have the same number of items as the level of nesting of the Selector Attribute (0072,0026). For values of the Selector Sequence Pointer (0072,0052) that are not the Data Element Tag of a Private Attribute, the corresponding value in Selector Sequence Pointer Private Creator (0072,0054) shall be empty. Required if Selector Sequence Pointer (0072,0052) is present and one or more of the values of Selector Sequence Pointer (0072,0052) is the Data Element Tag of a Private Attribute. See 10.X.1.2.
Selector Sequence Pointer Items	(0074,1057)	1C	Identification of the Item indices in the Selector Sequence Pointer (0072,0052).

Attribute Name	Tag	Type	Attribute Description
			This attribute shall have the same number of items as the level of nesting of the Selector Attribute (0072,0026). Required if Selector Sequence Pointer (0072,0052) is present. See 10.X.1.1.
Selector Attribute Private Creator	(0072,0056)	1C	Identification of the creator of a group of private data elements. Required if the Selector Attribute (0072,0026) value is the Data Element Tag of a Private Attribute. See 10.X.1.2.

10.X.1 Selector Attribute Macro Attribute Descriptions

10.X.1.1 Referencing Nested Elements

Examples of use are shown in the following table:

Example	Selector Attribute (0072,0026)	Selector Value Number (0072,0028)	Selector Sequence Pointer (0072,0052)	Selector Sequence Pointer Items (0074,1057)
Entire Patient's Name	0010,0010	0	absent	absent
Second value (e.g. PRIMARY or SECONDARY) in Image Type Attribute	0008,0008	2	absent	absent
Entire RT Beam Limiting Device Sequence attribute for the third Beam in an RT Plan	300A,00B6	0	300A,00B0	3
RT Beam Limiting Device Type attribute for the second jaw specified for the first Beam in an RT Plan	300A,00B8	0	300A,00B0\300A,00B6	1\2
Code value attribute for the first item in View Code Sequence	0008,0100	1	0054,0220	1

10.X.1.2 Private Attribute References

The Selector Sequence Pointer Private Creator (0072,0054) and the Selector Attribute Private Creator (0072,0056) each has a value that corresponds to the Private Creator Data Element

numbers (gggg,00pp), where gggg is odd and pp ranges from 10 to FF. These identify a block of Private Data Elements within the block (gggg,ppxx). When the Selector Attribute (0072,0026) or Selector Sequence Pointer (0072,0052) points to a Private Data Element (gggg,ppxx), it shall have the value (gggg,00xx).

Modify PS3.3 Figure A.1-1 COMPOSITE INSTANCE IOD INFORMATION MODEL by adding the "Plan" information entity:

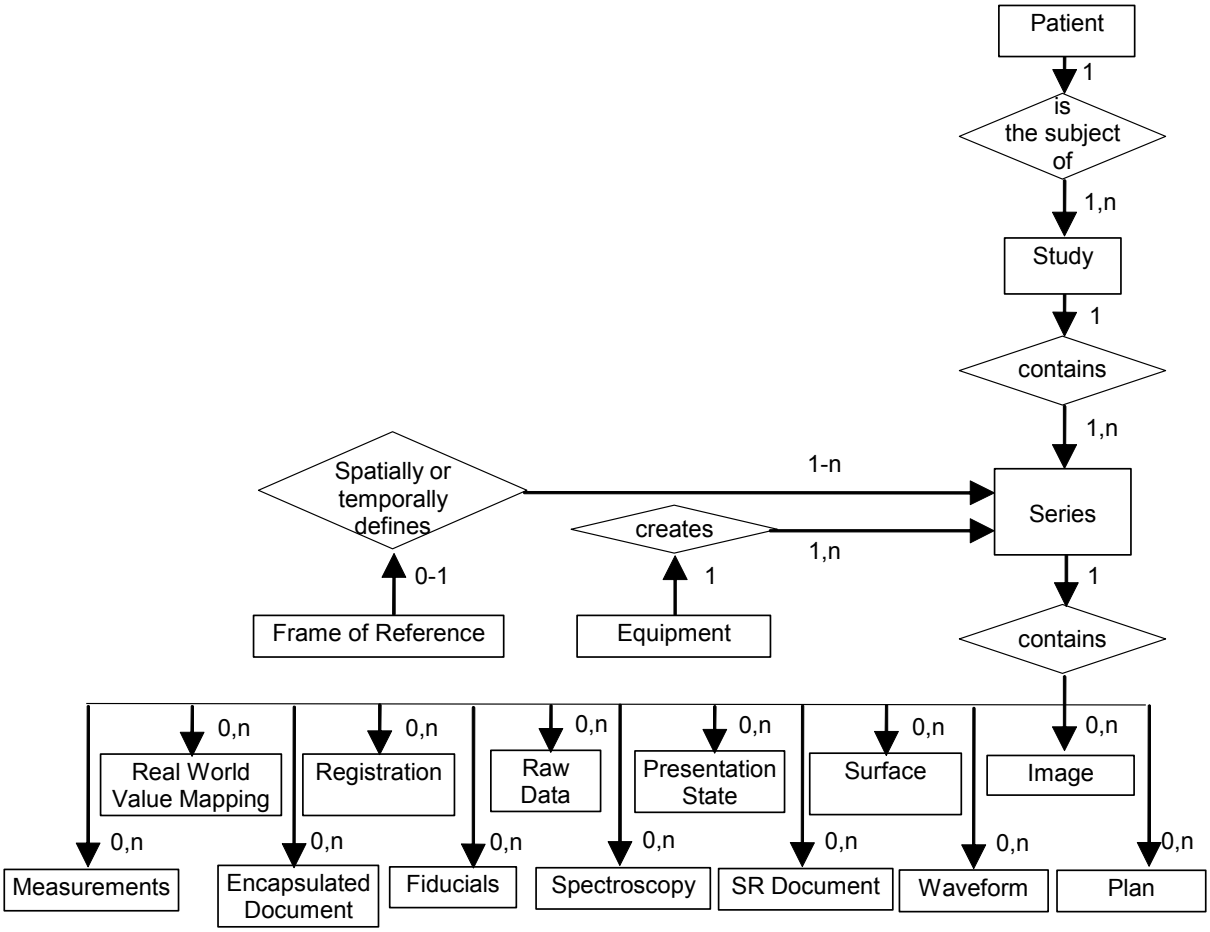


Figure A.1-1
DICOM COMPOSITE INSTANCE IOD INFORMATION MODEL

Add the following column in PS3.3 Table A.1-3 COMPOSITE INFORMATION OBJECT MODULES OVERVIEW – RADIOTHERAPY

IODs Modules	RT Beams Delivery Instruction
Patient	**M**
Clinical Trial Subject	**U**
General Study	**M**
Patient Study	**U**
Clinical Trial Study	**U**
Study Content	
General Series	**M**
Clinical Trial Series	**U**
RT Series	
Frame Of Reference	
General Equipment	**M**
General Image	
Image Plane	
Image Pixel	
Multi-frame	
RT Dose	
RT DVH	
Structure Set	
ROI Contour	
RT Dose ROI	
RT ROI Observations	
RT General Treatment Record	
RT Treatment Machine Record	
Measured Dose Reference Record	
Calculated Dose Reference Record	
RT Beams Session Record	
RT Ion Beams Session Record	
RT Brachy Session Record	
RT Treatment Summary Record	
RT General Plan	
RT Prescription	

RT Tolerance Tables	
RT Patient Setup	
RT Fraction Scheme	
RT Beams	
RT Ion Beams	
RT Brachy Application Setups	
RT Beams Delivery Instruction	**M**
Approval	
Overlay Plane	
Multi-frame Overlay	
Modality LUT	
Common Instance Reference	**C**
SOP Common	**M**

Add the following sections after PS3.3 Annex A, Section A.20:

A.TT RT BEAMS DELIVERY INSTRUCTION INFORMATION OBJECT DEFINITION

A.tt.1 RT Beams Delivery Instruction IOD Description

The RT Beams Delivery Instruction IOD contains all the parameters needed to deliver a radiation therapy treatment fraction that are not already described in the referenced RT Plan IOD.

A.tt.2 RT Beams Delivery Instruction IOD Entity-Relationship Model

The E-R Model in Section A.tt-1 depicts those components of the DICOM Information Model that directly reference the RT Beams Delivery Instruction IOD. The Frame of Reference IE, and the IEs at the level of the Image IE in Section A.1.2 other than the Instruction IE are not components of the RT Beams Delivery Instruction IOD.

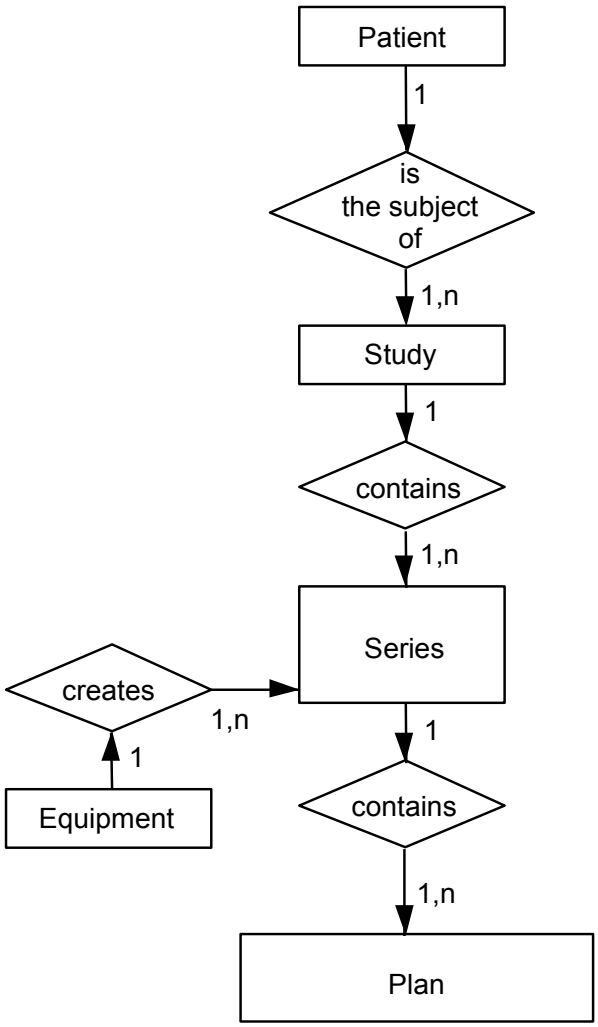


Figure A.tt-1 — DICOM RT Beams Delivery Instruction IOD information model

A.tt.3 RT Beams Delivery Instruction IOD Module Table

Table A.tt.3-1 — RT BEAMS DELIVERY INSTRUCTION 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
Equipment	General Equipment	C.7.5.1	M
Plan	RT Beams Delivery Instruction	C.8.8.aa	M
	Common Instance Reference Module	C.12.2	C – Required if not conveyed by a Unified Procedure Step. May be present otherwise.
	SOP Common	C.12.1	M

A.tt.4 RT Beams Delivery Instruction IOD Content Constraints

A.tt.4.1 Modality

The value of modality (0008,0060) shall be PLAN.

Add the following sections after PS3.3 Annex B, Section B.25

B.TT RT CONVENTIONAL MACHINE VERIFICATION OBJECT DEFINITION

B.TT.1 IOD Description

The RT Conventional Machine Verification IOD describes the attributes that are required by an external Machine Parameter Verifier (MPV) when performing verification of a conventional (photon or electron) radiation therapy treatment, prior to delivery.

B.TT.2 IOD Modules

Table B.TT.2-1
RT CONVENTIONAL MACHINE VERIFICATION IOD MODULES

Module	Reference	Module Description
SOP Common	C.12.1	Contains SOP Common Information
RT General Machine Verification	C.XX.1	Contains general delivery verification information
RT Conventional Machine Verification	C.XX.2	Contains delivery verification information specific to conventional (photon or electron) machines

B.UU RT ION MACHINE VERIFICATION OBJECT DEFINITION

B.UU.1 IOD Description

The RT Ion Machine Verification IOD describes the attributes that are required by an external Machine Parameter Verifier (MPV) when performing verification of an ion radiation therapy treatment, prior to delivery.

B.UU.2 IOD Modules

Table B.UU.2-1
RT ION MACHINE VERIFICATION IOD MODULES

Module	Reference	Module Description
SOP Common	C.12.1	Contains SOP Common Information
RT General Machine Verification	C.XX.1	Contains general delivery verification information
RT Ion Machine Verification	C.XX.3	Contains delivery verification information specific to ion machines

Add the following in PS3.3 Section C.7.3.1.1.1 Modality

C.7.3.1.1.1 Modality

PLAN = Plan

Add the following after PS3.3 Annex C, Section C.8.8.23:

C.8.8.aa RT Beams Delivery Instruction Module

The RT Beams Delivery Instruction Module contains additional information required by a Treatment Delivery System (TDS) when specifying delivery of an external beam radiotherapy treatment. This information is supplied by a Treatment Management System (TMS) when it creates an RT Beams Delivery Instruction SOP Instance, a composite SOP Instance in turn referenced by a Unified Procedure Step (UPS) in the Unified Procedure Step model.

The RT Beams Delivery Instruction Module consists of a sequence of one or more beam tasks, where each beam task may also specify one or more Delivery Verification images to be acquired prior to, during, or after the treatment delivery.

Table C.8.8.aa-1 RT BEAMS DELIVERY INSTRUCTION MODULE ATTRIBUTES

Attribute Name	Tag	Type	Description
Referenced RT Plan Sequence	(300C,0002)	1	Reference to a single RT Plan or RT Ion Plan SOP Instance (whose UID is also supplied in the Input Information Sequence – see PS3.4) containing all the Beams and the Fraction Group referenced in this SOP Instance.
>Include 'SOP Instance Reference Macro' Table 10-11			
Beam Task Sequence	(0074,1020)	1	Specification of beams to be delivered and/or verified. One or more Items may be included in this sequence.
>Beam Task Type	(0074,1022)	1	Indication whether beam is to be verified, treated (delivered), or both. Enumerated Values: VERIFY = Beam verification only TREAT = Beam treatment only VERIFY_AND_TREAT = Beam verification and treatment
>Treatment Delivery Type	(300A,00CE)	1	Delivery Type of treatment. Enumerated Values: TREATMENT = normal patient treatment CONTINUATION = continuation of interrupted treatment

Attribute Name	Tag	Type	Description
>Primary Dosimeter Unit	(300A,00B3)	1C	Measurement unit of machine dosimeter. Enumerated Values: MU = Monitor Unit MINUTE = minute NP = Number of Particles This value shall be the same as in the referenced RT Plan. It applies only to the Continuation Start Meterset (0074,0120) and Continuation End Meterset (0074,0121). Required if Delivery Type (300A,00CE) is CONTINUATION.
>Continuation Start Meterset	(0074,0120)	1C	Meterset within Beam referenced by Referenced Beam Number (300C,0006) at which treatment delivery starts, in units specified by Primary Dosimeter Unit (300A,00B3). Required if Delivery Type (300A,00CE) is CONTINUATION.
>Continuation End Meterset	(0074,0121)	1C	Meterset within Beam referenced by Referenced Beam Number (300C,0006) at which treatment delivery ends, in units specified by Primary Dosimeter Unit (300A,00B3). Required if Delivery Type (300A,00CE) is CONTINUATION.
>Current Fraction Number	(3008,0022)	1	The index of the fraction that is to be delivered or completed in this session. See C.8.8.aa.1.
>Referenced Fraction Group Number	(300C,0022)	1C	Indicates which fraction group of the referenced plan is to be treated in the treatment session. Only one Fraction Group shall be specified per Delivery Instruction SOP Instance. Required if the referenced plan has more than one Fraction Group Sequence (300A,0070) item.
>Referenced Beam Number	(300C,0006)	1	Uniquely identifies the Beam which is specified by Beam Number (300A,00C0) within Beam Sequence (300A,00B0) in RT Beams Module of referenced RT Plan or RT Ion Plan.
>Beam Order Index	(0074,1024)	3	Identifies required ordering of beam delivery, monotonically increasing by 1, starting from 1.
>Table Top Vertical Adjusted Position	(0074,0126)	2	Adjusted Table Top Vertical position in the IEC TABLE TOP coordinate system in mm for patient setup. See C.8.8.aa.2.
>Table Top Longitudinal Adjusted Position	(0074,0127)	2	Adjusted Table Top Longitudinal position in the IEC TABLE TOP coordinate system in mm for patient setup. See C.8.8.aa.2.

Attribute Name	Tag	Type	Description
>Table Top Lateral Adjusted Position	(0074,0128)	2	Adjusted Table Top Lateral position in the IEC TABLE TOP coordinate system in mm for patient setup. See C.8.8.aa.2.
>Patient Support Adjusted Angle	(0074,102A)	2	Adjusted Patient Support angle for patient setup, i.e. orientation of the IEC PATIENT SUPPORT coordinate system with respect to the IEC FIXED REFERENCE coordinate system in degrees. See C.8.8.aa.2.
>Table Top Eccentric Adjusted Angle	(0074,102B)	2	Adjusted Table Top (non-isocentric) angle for patient setup, i.e. orientation of the IEC TABLE TOP ECCENTRIC coordinate system with respect to the IEC PATIENT SUPPORT system in degrees. See C.8.8.aa.2.
>Table Top Pitch Adjusted Angle	(0074,102C)	2	Adjusted Table Top Pitch Angle for patient setup, i.e. the rotation of the IEC TABLE TOP coordinate system about the X-axis of the IEC TABLE TOP coordinate system in degrees. See C.8.8.aa.2.
>Table Top Roll Adjusted Angle	(0074,102D)	2	Adjusted Table Top Roll Angle for patient setup, i.e. the rotation of the IEC TABLE TOP coordinate system about the Y-axis of the IEC TABLE TOP coordinate system in degrees. See C.8.8.aa.2.
>Table Top Vertical Setup Displacement	(300A,01D2)	2	Vertical Displacement in the IEC TABLE TOP coordinate system in mm relative to initial Setup Position, i.e. vertical offset between patient positioning performed using setup and treatment position.
>Table Top Longitudinal Setup Displacement	(300A,01D4)	2	Longitudinal Displacement in the IEC TABLE TOP coordinate system in mm relative to initial Setup Position, i.e. longitudinal offset between patient positioning performed using setup and treatment position.
>Table Top Lateral Setup Displacement	(300A,01D6)	2	Lateral Displacement in the IEC TABLE TOP coordinate system in mm relative to initial Setup Position, i.e. lateral offset between patient positioning performed using setup and treatment position.
>Delivery Verification Image Sequence	(0074,1030)	2C	Beam verification images to be acquired for current beam. Required if Beam Task Type (0074,1022) is VERIFY or VERIFY_AND_TREAT. Only a single Item shall be permitted in this sequence if Beam Task Type (0074,1022) is VERIFY. One or more Items may be included in this sequence if Beam Task Type (0074,1022) is VERIFY_AND_TREAT.

Attribute Name	Tag	Type	Description
>>Verification Image Timing	(0074,1032)	1	Indicates the temporal relationship of the verification image with respect to the current treatment beam delivery. Value shall be DURING_BEAM for Beams with a Beam Task Type (0074,1022) of VERIFY. Enumerated Values: BEFORE_BEAM DURING_BEAM AFTER_BEAM
>>Start Cumulative Meterset Weight	(300C,0008)	1C	Cumulative Meterset Weight within current Beam at which image acquisition will start. Required if Verification Image Timing (0074,1032) is DURING_BEAM.
>>Meterset Exposure	(3002,0032)	2C	Treatment machine Meterset duration over which image is to be acquired, specified in Monitor units (MU) or minutes as defined by Primary Dosimeter Unit (300A,00B3) specified in the Referenced RT Plan Sequence (300C,0002). Required if Verification Image Timing (0074,1032) is BEFORE_BEAM or AFTER_BEAM. See C.8.8.aa.3.
>>End Cumulative Meterset Weight	(300C,0009)	2C	Cumulative Meterset Weight within current Beam at which image acquisition will end. Required if Verification Image Timing (0074,1032) is DURING_BEAM.
>>Double Exposure Flag	(0074,1034)	1	Indicates whether the current verification image is a single or double exposure. Enumerated Values: SINGLE = single exposure DOUBLE = double exposure
>>Double Exposure Ordering	(0074,1036)	1C	Indicates the ordering of the open (double exposure) field with respect to the primary (collimated) field in a double exposure. Defined terms: OPEN_FIRST = Open field first OPEN_SECOND = Open field second Required if Double Exposure Flag (0074,1034) is DOUBLE.
>>Double Exposure Meterset	(0074,1038)	2C	If this field is present, an additional exposure with the indicated Meterset is requested. Required if Double Exposure Flag (0074,1034) is DOUBLE.

Attribute Name	Tag	Type	Description
>>Double Exposure Field Delta	(0074,103A)	2C	Offsets of field-defining edges in mm for the double exposure in the IEC BEAM LIMITING DEVICE coordinate system in the IEC order X1, X2, Y1, Y2. Negative values for X1 and Y1 indicate an enlarged field, negative values for X2 and Y2 indicate a reduced field. Required if Double Exposure Flag (0074,1034) is DOUBLE. See C.8.8.aa.4.
>>X-Ray Image Receptor Translation	(3002,000D)	2	Position in (x,y,z) coordinates in mm of origin of the IEC X-RAY IMAGE RECEPTOR System in the IEC GANTRY coordinate system.
>>Related Reference RT Image Sequence	(0074,1040)	3	Uniquely identifies Reference Images to which planned verification image is related. All items in this sequence shall be RT Image SOP Instances.
>>>Include 'SOP Instance Reference Macro' Table 10-11			

C.8.8.aa.1 Current Fraction Number

For beams with a Treatment Delivery Type (300A,00CE) of CONTINUATION, the Current Fraction Number (3008,0022) is that of the original fraction to be completed by the current beam.

C.8.8.aa.2 Adjusted Table Positions and Angles

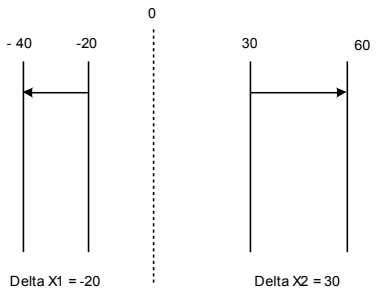
Adjusted Table positions and angles serve as a facility to communicate a shift (often systematic) that has been detected from previous treatments. They define a new initial patient position, which is near and aligned to the actual patient position during beam delivery. These attributes do not affect the original relationship between the beams and the planning image patient anatomy.

C.8.8.aa.3 Meterset Exposure

Meterset Exposure (3002,0032) can be interpreted as the „maximum" meterset duration in cases where an automatic exposure is taken.

C.8.8.aa.4 Double Exposure Field Delta

The following diagram illustrates the case where the second X aperture in a double exposure is larger than the initial aperture. In this case $\Delta X1$ is negative and $\Delta X2$ is positive. If a field edge is defined by a multileaf collimator, then the field delta is to be applied to the most open leaf, such that all leaves can be moved to that position.



Add the following to PS3.3, Annex C:

C.XX RADIOTHERAPY WORKFLOW MODULES

C.XX.1 RT General Machine Verification Module

Table C.XX-1 specifies the attributes used to convey the parameters used in external verification of both conventional radiotherapy (photon or electron) and ion treatment deliveries.

Table C.XX-1
RT GENERAL MACHINE VERIFICATION MODULE ATTRIBUTES

Attribute Name	Tag	Description
Referenced RT Plan Sequence	(300C,0002)	A reference to an RT Plan SOP Class/Instance pair. Only a single item shall be permitted in this sequence.
>Include 'SOP Instance Reference Macro' Table C.10-11		
Referenced Fraction Group Number	(300C,0022)	Identifier of Fraction Group within referenced RT Plan.
Patient ID	(0010,0020)	Primary hospital identification number or code for the patient.
Include Issuer of Patient ID Macro Table 10-18		
Treatment Verification Status	(3008,002C)	Conditions under which treatment was verified by a verification system. Enumerated Values: VERIFIED = treatment verified VERIFIED_OVR = treatment verified with at least one out-of-range value overridden NOT_VERIFIED = treatment failed verification (one or more values out of range and not overridden)
Failed Parameters Sequence	(0074,1048)	List of parameters that failed verification by the MPV. Zero or more items shall be included in this Sequence. See C.XX.1.1.
>Include Selector Attribute Macro' Table 10.X-1		
Overridden Parameters Sequence	(0074,104A)	List of parameters that were overridden by the user. Zero or more items shall be included in this Sequence. See C.XX.1.1.
> Include Selector Attribute Macro' Table 10.X-1		
>Operators' Name	(0008,1070)	Name of operator who authorized override of overridden parameter.
>Override Reason	(3008,0066)	User-defined description of reason for override of overridden parameter.
General Machine Verification Sequence	(0074,1042)	Sequence containing general machine verification parameters.
>Specified Primary Meterset	(3008,0032)	Desired machine setting of primary

Attribute Name	Tag	Description
		meterset. The units shall match those specified by Primary Dosimeter Unit (300A,00B3) in the plan specified in the Referenced RT Plan Sequence (300C,0002).
>Specified Secondary Meterset	(3008,0033)	Desired machine setting of secondary meterset. The units shall match those specified for Specified Secondary Meterset (3008,0033) in the plan specified in the Referenced RT Plan Sequence (300C,0002).
>Specified Treatment Time	(3008,003A)	Treatment Time set in seconds.
>Beam Limiting Device Leaf Pairs Sequence	(3008,00A0)	Beam limiting device (collimator) jaw or leaf (element) leaf pair values. One or more items may be included in this Sequence.
>>RT Beam Limiting Device Type	(300A,00B8)	Type of beam limiting device (collimator). Enumerated Values: X = symmetric jaw pair in IEC X direction Y = symmetric jaw pair in IEC Y direction ASYMX = asymmetric jaw pair in IEC X direction ASYMY = asymmetric pair in IEC Y direction MLCX = multileaf (multi-element) jaw pair in IEC X direction MLCY = multileaf (multi-element) jaw pair in IEC Y direction
>>Number of Leaf/Jaw Pairs	(300A,00BC)	Number of leaf (element) or jaw pairs (equal to 1 for standard beam limiting device jaws).
>Recorded Wedge Sequence	(3008,00B0)	Treatment wedges present during delivered Beam.
>>Wedge Number	(300A,00D2)	Identification number of the Wedge. The value of Wedge Number (300A,00D2) shall be unique within the wedge sequence.
>>Wedge ID	(300A,00D4)	User-supplied identifier for wedge.
>>Wedge Angle	(300A,00D5)	Nominal wedge angle delivered in degrees.
>>Wedge Orientation	(300A,00D8)	Orientation of wedge, i.e. orientation of the IEC WEDGE FILTER coordinate system with respect to the IEC BEAM LIMITING DEVICE coordinate system, in degrees.
>>Accessory Code	(300A,00F9)	An identifier for the accessory intended to be read by a device such as a bar-code reader.
>Recorded Compensator Sequence	(3008,00C0)	Treatment compensators associated

Attribute Name	Tag	Description
		with current Beam.
>>Compensator ID	(300A,00E5)	User-supplied identifier for compensator.
>>Accessory Code	(300A,00F9)	An identifier for the accessory intended to be read by a device such as a bar-code reader.
>>Referenced Compensator Number	(300C,00D0)	Uniquely identifies compensator specified by Compensator Number (300A,00E4) within Beam referenced by Referenced Beam Number (300C,0006).
>Recorded Block Sequence	(3008,00D0)	Blocks associated with current Beam.
>>Block Tray ID	(300A,00F5)	User-supplied identifier for block tray or Electron Insert.
>>Accessory Code	(300A,00F9)	An identifier for the accessory intended to be read by a device such as a bar-code reader.
>>Referenced Block Number	(300C,00E0)	Uniquely identifies block specified by Block Number (300A,00FC) within Beam referenced by Referenced Beam Number (300C,0006).
>Treatment Machine Name	(300A,00B2)	User-defined name identifying treatment machine to be used for beam delivery. See C.8.8.25.2.
>Beam Name	(300A,00C2)	User-defined name for Beam.
>Radiation Type	(300A,00C6)	Particle type of Beam. Defined Terms: PHOTON ELECTRON NEUTRON PROTON ION
>Number of Wedges	(300A,00D0)	Number of wedges associated with current Beam.
>Number of Compensators	(300A,00E0)	Number of compensators associated with current Beam.
>Number of Boli	(300A,00ED)	Number of boli used with current Beam.
>Number of Blocks	(300A,00F0)	Number of shielding blocks or Electron Inserts associated with Beam.
>Applicator Sequence	(300A,0107)	Applicators associated with Beam.
>>Accessory Code	(300A,00F9)	An identifier for the accessory intended to be read by a device such as a bar-code reader.
>>Applicator ID	(300A,0108)	User or machine supplied identifier for Applicator.
>>Applicator Type	(300A,0109)	Type of Applicator. Defined Terms: ELECTRON_SQUARE = square electron applicator ELECTRON_RECT = rectangular

Attribute Name	Tag	Description
		electron applicator ELECTRON_CIRC = circular electron applicator ELECTRON_SHORT = short electron applicator ELECTRON_OPEN = open (dummy) electron applicator INTRAOPERATIVE = intraoperative (custom) applicator STEREOTACTIC = stereotactic applicator
>Number of Control Points	(300A,0110)	Number of control points in Beam.
>Patient Setup Sequence	(300A,0180)	Patient setup data for current plan.
>>Patient Setup Number	(300A,0182)	Identification number of the Patient Setup.
>>Fixation Device Sequence	(300A,0190)	Fixation Devices used in Patient Setup.
>>>Accessory Code	(300A,00F9)	An identifier for the accessory intended to be read by a device such as a bar-code reader.
>>>Fixation Device Type	(300A,0192)	Type of Fixation Device used during Patient Setup. Defined Terms: BITEBLOCK HEADFRAME MASK MOLD CAST HEADREST BREAST_BOARD BODY_FRAME VACUUM_MOLD WHOLE_BODY_POD RECTAL_BALLOON
>Referenced Beam Number	(300C,0006)	References Beam specified by Beam Number (300A,00C0) in Ion Beam Sequence (300A,03A2) in RT Ion Beams Module within the referenced RT Ion Plan.
>Referenced Bolus Sequence	(300C,00B0)	Boli associated with Beam.
>>Referenced ROI Number	(3006,0084)	Uniquely identifies ROI representing the Bolus specified by ROI Number (3006,0022) in Structure Set ROI Sequence (3006,0020) in Structure Set Module within RT Structure Set in Referenced Structure Set Sequence (300C,0060) in RT General Plan Module.

Attribute Name	Tag	Description
>>Accessory Code	(300A,00F9)	An accessory identifier to be read by a device such as a bar code reader.

C.XX.1.1 Failed Parameters and Overridden Parameters

Each Verify Failed Parameter or Overridden Parameter is used to specify a verification attribute that was either unverified (out of range), or overridden explicitly by the user. To uniquely identify both the context and value item of the attribute occurrence, a special notation is used, described in Section 10.X.

If a Verify Failed Parameter or Overridden Parameter refers to an attribute occurrence within a Control Point Sequence, then that attribute occurrence was failed or overridden during the administration of the beam segment immediately ***prior*** to the specified control point.

C.XX.2 RT Conventional Machine Verification Module

Table C.XX-2 specifies the attributes used to convey the parameters used in external verification of a conventional radiotherapy (photon or electron) treatment delivery.

Table C.XX-2
RT CONVENTIONAL MACHINE VERIFICATION MODULE ATTRIBUTES

Attribute Name	Tag	Description
Conventional Machine Verification Sequence	(0074,1044)	Sequence containing conventional machine verification parameters.
>Conventional Control Point Verification Sequence	(0074,104C)	Beam control points for current treatment beam.
>>Nominal Beam Energy	(300A,0114)	Nominal Beam Energy at control point.
>>Dose Rate Set	(300A,0115)	Dose Rate to be set on treatment machine for segment beginning at current control point (e.g. MU/min).
>>Wedge Position Sequence	(300A,0116)	Wedge Positions for the current control point. See C.8.8.14.5.
>>>Wedge Position	(300A,0118)	Position of Wedge at current Control Point. Enumerated Values: IN OUT
>>>Referenced Wedge Number	(300C,00C0)	Uniquely references Wedge described by Wedge Number (300A,00D2) in Wedge Sequence (300A,00D1).
>>Beam Limiting Device Position Sequence	(300A,011A)	Beam limiting device (collimator) jaw or leaf (element) positions.
>>>RT Beam Limiting Device Type	(300A,00B8)	Type of beam limiting device (collimator). The value of this attribute shall correspond to RT Beam Limiting Device Type (300A,00B8) defined in an item of Beam Limiting Device Sequence (300A,00B6) Enumerated Values: X = symmetric jaw pair in IEC X direction Y = symmetric jaw pair in IEC Y direction ASYMX = asymmetric jaw pair in IEC X direction ASYMY = asymmetric pair in IEC Y direction MLCX = multileaf (multi-element) jaw pair in IEC X direction MLCY = multileaf (multi-element) jaw pair in IEC Y direction
>>>Leaf/Jaw Positions	(300A,011C)	Positions of beam limiting device (collimator) leaf (element) or jaw pairs in mm in the IEC BEAM LIMITING DEVICE coordinate axis appropriate to

Attribute Name	Tag	Description
		RT Beam Limiting Device Type (300A,00B8), e.g. X-axis for MLCX, Y-axis for MLCY. Contains 2N values, where N is the Number of Leaf/Jaw Pairs (300A,00BC) in Beam Limiting Device Sequence (300A,00B6). Values shall be listed in the IEC leaf (element) subscript order 101, 102, ... 1N, 201, 202, ... 2N.
>>Gantry Angle	(300A,011E)	Gantry angle in degrees of radiation source, i.e. orientation of the IEC GANTRY coordinate system with respect to the IEC FIXED REFERENCE coordinate system.
>>Gantry Rotation Direction	(300A,011F)	Direction of Gantry Rotation when viewing gantry from isocenter, for segment following Control Point. See C.8.8.14.8. Enumerated Values: CW = clockwise CC = counter-clockwise NONE = no rotation
>>Beam Limiting Device Angle	(300A,0120)	Beam Limiting Device angle in degrees, i.e. orientation of the IEC BEAM LIMITING DEVICE coordinate system with respect to the IEC GANTRY coordinate system.
>>Beam Limiting Device Rotation Direction	(300A,0121)	Direction of Beam Limiting Device Rotation when viewing beam limiting device (collimator) from radiation source, for segment following Control Point. See C.8.8.14.8. Enumerated Values: CW = clockwise CC = counter-clockwise NONE = no rotation
>>Patient Support Angle	(300A,0122)	Patient Support angle in degrees, i.e. orientation of the IEC PATIENT SUPPORT (turntable) coordinate system with respect to the IEC FIXED REFERENCE coordinate system.
>>Patient Support Rotation Direction	(300A,0123)	Direction of Patient Support Rotation when viewing table from above, for segment following Control Point. See C.8.8.14.8. Enumerated Values: CW = clockwise CC = counter-clockwise NONE = no rotation

Attribute Name	Tag	Description
>>Table Top Eccentric Axis Distance	(300A,0124)	Distance (positive) in mm from the IEC PATIENT SUPPORT vertical axis to the IEC TABLE TOP ECCENTRIC vertical axis.
>>Table Top Eccentric Angle	(300A,0125)	Table Top (non-isocentric) angle, i.e. orientation of the IEC TABLE TOP ECCENTRIC coordinate system with respect to the IEC PATIENT SUPPORT coordinate system, in degrees.
>>Table Top Eccentric Rotation Direction	(300A,0126)	Direction of Table Top Eccentric Rotation when viewing table from above, for segment following Control Point. See C.8.8.14.8. Enumerated Values: CW = clockwise CC = counter-clockwise NONE = no rotation
>>Table Top Vertical Position	(300A,0128)	Table Top Vertical position in mm in the IEC TABLE TOP coordinate system. See C.8.8.14.6.
>>Table Top Longitudinal Position	(300A,0129)	Table Top Longitudinal position in mm in the IEC TABLE TOP coordinate system. See C.8.8.14.6.
>>Table Top Lateral Position	(300A,012A)	Table Top Lateral position in mm in the IEC TABLE TOP coordinate system. See C.8.8.14.6.
>>Table Top Pitch Angle	(300A,0140)	Table Top Pitch Angle in degrees, i.e. the rotation of the IEC TABLE TOP coordinate system about the X-axis of the IEC TABLE TOP coordinate system. See C.8.8.25.6.2.
>>Table Top Pitch Rotation Direction	(300A,0142)	Direction of Table Top Pitch Rotation when viewing the table along the positive X-axis of the IEC TABLE TOP coordinate system, for segment following Control Point. See C.8.8.14.8 and C.8.8.25.6.2. Enumerated Values: CW = clockwise CC = counter-clockwise NONE = no rotation
>>Table Top Roll Angle	(300A,0144)	Table Top Roll Angle in degrees, i.e. the rotation of the IEC TABLE TOP coordinate system about the Y-axis of the IEC TABLE TOP coordinate system. See C.8.8.25.6.2.
>>Table Top Roll Rotation Direction	(300A,0146)	Direction of Table Top Roll Rotation when viewing the table along the positive Y-axis of the IEC TABLE TOP

Attribute Name	Tag	Description
		coordinate system, for segment following Control Point. See C.8.8.14.8 and C.8.8.25.6.2. Enumerated Values: CW = clockwise CC = counter-clockwise NONE = no rotation.
>>Referenced Control Point Index	(300C,00F0)	Uniquely identifies Control Point specified by Control Point Index (300A,0112) within the Beam referenced by Referenced Beam Number (300C,0006).

C.XX.3 RT Ion Machine Verification Module

Table C.XX-3 specifies the Attributes used to convey the parameters used in external verification of a radiotherapy ion treatment delivery.

Table C.XX-3
RT ION MACHINE VERIFICATION MODULE ATTRIBUTES

Attribute Name	Tag	Description
Ion Machine Verification Sequence	(0074,1046)	Sequence containing ion machine verification parameters.
>Ion Control Point Verification Sequence	(0074,104E)	Beam control points for current ion treatment beam.
>>Meterset Rate Set	(3008,0045)	The specified speed of delivery of the specified dose in units specified by Primary Dosimeter Unit (300A,00B3) in referenced RT Plan per minute.
>>Nominal Beam Energy	(300A,0114)	Nominal Beam Energy at control point.
>>Beam Limiting Device Position Sequence	(300A,011A)	Beam limiting device (collimator) jaw or leaf (element) positions.
>>>RT Beam Limiting Device Type	(300A,00B8)	Type of beam limiting device (collimator). The value of this attribute shall correspond to RT Beam Limiting Device Type (300A,00B8) defined in an item of Beam Limiting Device Sequence (300A,00B6) Enumerated Values: X = symmetric jaw pair in IEC X direction Y = symmetric jaw pair in IEC Y direction ASYMX = asymmetric jaw pair in IEC X direction ASYMY = asymmetric pair in IEC Y direction MLCX = multileaf (multi-element) jaw pair in IEC X direction MLCY = multileaf (multi-element) jaw pair in IEC Y direction
>>>Leaf/Jaw Positions	(300A,011C)	Positions of beam limiting device (collimator) leaf (element) or jaw pairs in mm in the IEC BEAM LIMITING DEVICE coordinate axis appropriate to RT Beam Limiting Device Type (300A,00B8), e.g. X-axis for MLCX, Y-axis for MLCY. Contains 2N values, where N is the Number of Leaf/Jaw Pairs (300A,00BC) in Beam Limiting Device Sequence (300A,00B6). Values shall be listed in the IEC leaf (element) subscript order 101, 102, ... 1N, 201, 202, ... 2N.
>>Gantry Angle	(300A,011E)	Gantry angle of radiation source in degrees, i.e. orientation of the IEC

Attribute Name	Tag	Description
		GANTRY coordinate system with respect to the IEC FIXED REFERENCE coordinate system.
>>Gantry Rotation Direction	(300A,011F)	Direction of Gantry Rotation when viewing gantry from isocenter, for segment following Control Point. See C.8.8.14.8. Enumerated Values: CW = clockwise CC = counter-clockwise NONE = no rotation
>>Beam Limiting Device Angle	(300A,0120)	Beam Limiting Device angle in degrees, i.e. orientation of the IEC BEAM LIMITING DEVICE coordinate system with respect to the IEC GANTRY coordinate system.
>>Beam Limiting Device Rotation Direction	(300A,0121)	Direction of Beam Limiting Device Rotation when viewing beam limiting device (collimator) from radiation source, for segment following Control Point. See C.8.8.14.8. Enumerated Values: CW = clockwise CC = counter-clockwise NONE = no rotation
>>Patient Support Angle	(300A,0122)	Patient Support angle in degrees, i.e. orientation of the IEC PATIENT SUPPORT (turntable) coordinate system with respect to the IEC FIXED REFERENCE coordinate system.
>>Patient Support Rotation Direction	(300A,0123)	Direction of Patient Support Rotation when viewing table from above, for segment following Control Point. See C.8.8.14.8. Enumerated Values: CW = clockwise CC = counter-clockwise NONE = no rotation
>>Table Top Vertical Position	(300A,0128)	Table Top Vertical position in mm in the IEC TABLE TOP coordinate system. See C.8.8.14.6.
>>Table Top Longitudinal Position	(300A,0129)	Table Top Longitudinal position in mm in the IEC TABLE TOP coordinate system. See C.8.8.14.6.
>>Table Top Lateral Position	(300A,012A)	Table Top Lateral position in mm in the IEC TABLE TOP coordinate system. See C.8.8.14.6.
>>Table Top Pitch Angle	(300A,0140)	Table Top Pitch Angle in degrees, i.e. the rotation of the IEC TABLE TOP

Attribute Name	Tag	Description
		coordinate system about the X-axis of the IEC TABLE TOP coordinate system. See C.8.8.25.6.2.
>>Table Top Pitch Rotation Direction	(300A,0142)	Direction of Table Top Pitch Rotation when viewing the table along the positive X-axis of the IEC TABLE TOP coordinate system, for segment following Control Point. See C.8.8.14.8 and C.8.8.25.6.2. Enumerated Values: CW = clockwise CC = counter-clockwise NONE = no rotation
>>Table Top Roll Angle	(300A,0144)	Table Top Roll Angle in degrees, i.e. the rotation of the IEC TABLE TOP coordinate system about the Y-axis of the IEC TABLE TOP coordinate system. See C.8.8.25.6.2.
>>Table Top Roll Rotation Direction	(300A,0146)	Direction of Table Top Roll Rotation when viewing the table along the positive Y-axis of the IEC TABLE TOP coordinate system, for segment following Control Point. See C.8.8.14.8 and C.8.8.25.6.2. Enumerated Values: CW = clockwise CC = counter-clockwise NONE = no rotation.
>>Head Fixation Angle	(300A,0148)	Angle in degrees of the head fixation for eye treatments with respect to the Table Top Pitch Angle (300A,0140) coordinate system. Positive head fixation angle is the same direction as positive Table Top Pitch. See C.8.8.25.6.4.
>>Gantry Pitch Angle	(300A,014A)	Gantry Pitch Angle in degrees of the radiation source, i.e. the rotation of the IEC GANTRY coordinate system about the X-axis of the IEC GANTRY coordinate system. See C.8.8.25.6.5.
>>Gantry Pitch Rotation Direction	(300A,014C)	Direction of Gantry Pitch Angle when viewing along the positive X-axis of the IEC GANTRY coordinate system, for segment following Control Point. See C.8.8.14.8 and C.8.8.25.6.5. Enumerated Values: CW = clockwise CC = counter-clockwise NONE = no rotation
>>Snout Position	(300A,030D)	Axial position in mm of the snout,

Attribute Name	Tag	Description
		measured from isocenter to the downstream side of the snout (without consideration of variable length elements such as blocks, MLC and/or compensators).
>>Range Shifter Settings Sequence	(300A,0360)	Range Shifter settings for the current control point.
>>>Range Shifter Setting	(300A,0362)	Machine specific setting attribute for the range shifter. See C.8.8.25.5.
>>>Referenced Range Shifter Number	(300C,0100)	Uniquely references Range Shifter described by Range Shifter Number (300A,0316) in Range Shifter Sequence (300A,0314).
>>Lateral Spreading Device Settings Sequence	(300A,0370)	Lateral Spreading Device settings for the current control point.
>>>Lateral Spreading Device Setting	(300A,0372)	Machine specific setting attribute for the lateral spreading device. See C.8.8.25.5.
>>>Referenced Lateral Spreading Device Number	(300C,0102)	Uniquely references Lateral Spreading Device described by Lateral Spreading Device Number (300A,0334) in Lateral Spreading Device Sequence (300A,0332).
>>Range Modulator Settings Sequence	(300A,0380)	Range Modulator Settings for current control point.
>>>Range Modulator Gating Start Value	(300A,0382)	Start position, defining the range modulator position at which the beam is switched on.
>>>Range Modulator Gating Stop Value	(300A,0384)	Stop position, defining the range modulator position at which the beam is switched off.
>>>Referenced Range Modulator Number	(300C,0104)	Uniquely references Range Modulator described by Range Modulator Number (300A,0344) in Range Modulator Sequence (300A,0342).
>>Ion Wedge Position Sequence	(300A,03AC)	Wedge positions for current control point.
>>>Wedge Thin Edge Position	(300A,00DB)	Closest distance in mm from the central axis of the beam along a wedge axis to the thin edge as projected to the machine isocentric plane. Value is positive is the wedge does not cover the central axis, negative if it does. See C.8.8.25.6.4.
>>>Wedge Position	(300A,0118)	Position of Wedge at current Control Point. Enumerated Values: IN OUT
>>Referenced Control Point Index	(300C,00F0)	Uniquely identifies Control Point specified by Control Point Index

Attribute Name	Tag	Description
		(300A,0112 within the Beam referenced by Referenced Beam Number (300C,0006).
>Recorded Snout Sequence	(3008,00F0)	Snouts associated with Beam.
>>Accessory Code	(300A,00F9)	An accessory identifier to be read by a device such as a bar code reader.
>>Snout ID	(300A,030F)	User or machine supplied identifier for Snout.
>Recorded Range Shifter Sequence	(3008,00F2)	Range shifters recorded with Beam.
>>Accessory Code	(300A,00F9)	An accessory identifier to be read by a device such as a bar code reader.
>>Range Shifter ID	(300A,0318)	User or machine supplied identifier for Range Modulator.
>>Referenced Range Shifter Number	(300C,0100)	Uniquely identifies range shifter specified by Range Shifter Number (300A,0316) within Beam referenced by Referenced Beam Number (300C,0006).
>Recorded Lateral Spreading Device Sequence	(3008,00F4)	Lateral spreading devices associated with Beam.
>>Accessory Code	(300A,00F9)	An accessory identifier to be read by a device such as a bar code reader.
>>Lateral Spreading Device ID	(300A,0336)	User or machine supplied identifier for Lateral Spreading Device.
>>Referenced Lateral Spreading Device Number	(300C,0102)	Uniquely identifies lateral spreading device specified by Lateral Spreading Device Number (300A,0334) within Beam referenced by Referenced Beam Number (300C,0006).
>Recorded Range Modulator Sequence	(3008,00F6)	Range modulators associated with Beam.
>>Accessory Code	(300A,00F9)	An accessory identifier to be read by a device such as a bar code reader.
>>Range Modulator ID	(300A,0346)	User or machine supplied identifier for Range Modulator.
>>Range Modulator Type	(300A,0348)	Type of Range Modulator. See C.XX.3.1 for Defined Terms.
>>Beam Current Modulation ID	(300A,034C)	User-supplied identifier for the beam current modulation pattern.
>>Referenced Range Modulator Number	(300C,0104)	Uniquely references Range Modulator described by Range Modulator Number (300A,0344) in Range Modulator Sequence (300A,0342).
>Radiation Mass Number	(300A,0302)	Mass number of radiation.
>Radiation Atomic Number	(300A,0304)	Atomic number of radiation.
>Radiation Charge State	(300A,0306)	Charge state of radiation.
>Scan Mode	(300A,0308)	The method of beam scanning to be used during treatment. Defined Terms:

Attribute Name	Tag	Description
		NONE = No beam scanning is performed. UNIFORM = The beam is scanned between control points to create a uniform lateral fluence distribution across the field. MODULATED = The beam is scanned between control points to create a modulated lateral fluence distribution across the field.
>Number of Range Shifters	(300A,0312)	Number of range shifters associated with current beam.
>Number of Lateral Spreading Devices	(300A,0330)	Number of lateral spreading devices associated with current beam.
>Number of Range Modulators	(300A,0340)	Number of range modulators associated with current beam.
>Patient Support Type	(300A,0350)	Defined terms: TABLE = Treatment delivery system table CHAIR = Treatment delivery system chair See C.8.8.25.6.3.
>Patient Support ID	(300A,0352)	User-specified identifier for manufacturer specific patient support devices.
>Patient Support Accessory Code	(300A,0354)	A Patient Support accessory identifier to be read by a device such as a bar code reader.
>Fixation Light Azimuthal Angle	(300A,0356)	Azimuthal angle in degrees of the fixation light coordinate around the IEC BEAM LIMITING DEVICE Y-axis. Used for eye treatments. See C.8.8.25.6.4.
>Fixation Light Polar Angle	(300A,0358)	Polar angle in degrees of the fixation light coordinate. Used for eye treatments. See C.8.8.25.6.4.

C.XX.3.1 Range Modulator Type

Defined Terms for Range Modulator Type (300A,0348) are as follows:

FIXED = fixed modulation width and weights using ridge filter or constant speed wheel with constant beam current

WHL_FIXEDWEIGHTS = selected wheel/track (Range Modulator ID) is spinning at constant speed. Modulation width is adjusted by switching constant beam current on and off at wheel steps indicated by Range Modulator Interrupt Values

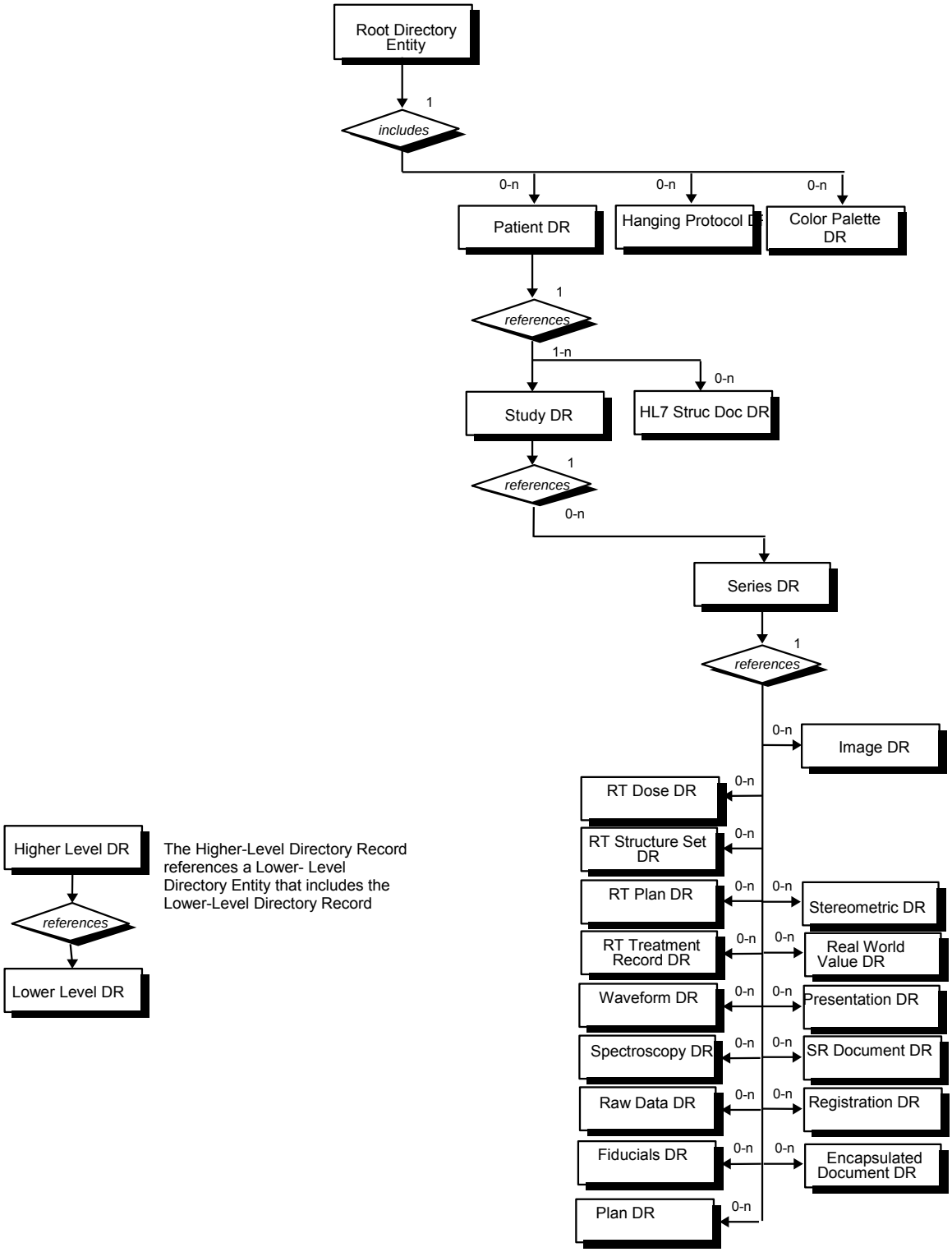
WHL_MODWEIGHTS = selected wheel/track (Range Modulator ID) is spinning at constant speed. Weight per wheel step is adjusted by modulating beam current according to selected Beam Current Modulation ID (300A,034C).

Make the following additions to PS3.3, Annex F, Table F.4-1:

Table F.4-1
RELATIONSHIP BETWEEN DIRECTORY RECORDS

Directory Record Type	Section	Directory Record Types which may be included in the next lower-level directory Entity
(Root Directory Entity)	—	PATIENT, HANGING PROTOCOL, PALETTE, PRIVATE
PATIENT	F.5.1	STUDY, HL7 STRUC DOC, PRIVATE
STUDY	F.5.2	SERIES, PRIVATE
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,** PRIVATE
IMAGE	F.5.4	PRIVATE
RT DOSE	F.5.19	PRIVATE
RT STRUCTURE SET	F.5.20	PRIVATE
RT PLAN	F.5.21	PRIVATE
RT TREAT RECORD	F.5.22	PRIVATE
PRESENTATION	F.5.23	PRIVATE
WAVEFORM	F.5.24	PRIVATE
SR DOCUMENT	F.5.25	PRIVATE
KEY OBJECT DOC	F.5.26	PRIVATE
SPECTROSCOPY	F.5.27	PRIVATE
RAW DATA	F.5.28	PRIVATE
REGISTRATION	F.5.29	PRIVATE
FIDUCIAL	F.5.30	PRIVATE
HANGING PROTOCOL	F.5.31	PRIVATE
ENCAP DOC	F.5.32	PRIVATE
HL7 STRUC DOC	F.5.33	PRIVATE
VALUE MAP	F.5.34	PRIVATE
STEREOMETRIC	F.5.35	PRIVATE
PALETTE	F.5.36	PRIVATE
PLAN	**F.5.X**	**PRIVATE**
PRIVATE	F.6.1	PRIVATE, (any of the above as privately defined)

Add the "Plan DR" box at the bottom of PS3.3, Annex F, Figure F.4-1:



Add the following to PS3.3, Annex F, Section F.5.X:

F.5.X Plan Directory Record Definition

The Directory Record is based on the specification of Section F.3. It is identified by a Directory Record Type of Value "PLAN". Table F.5-X lists the set of keys with their associated Types for such a Directory Record Type. The description of these keys may be found in the Modules related to the Instance-level IEs of Plan IODs. This Directory Record shall be used to reference one of the class of Plan SOP Instances having a Modality (0008,0060) of “PLAN”, such as the RT Beams Delivery Instruction IOD. This type of Directory Record may reference a Lower-Level Directory Entity that includes one or more Directory Records as defined in Table F.4-1.

Table F.5-X
PLAN 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.
Any other Attribute of the Instance-level IE Modules		3	

Note: Because Referenced SOP Instance UID in File (0004,1511) may be used as a "pseudo" Directory Record Key (See Table F.3-3), it is not duplicated in this list of keys.

Part 4 Addendum

Add the following to PS3.4, Annex B.5, Table B.5-1

SOP Class Name	SOP Class UID	IOD Specification (defined in PS 3.3)
RT Beams Delivery Instruction Storage	**1.2.840.10008.5.1.4.34.7**	**RT Beams Delivery Instruction**

Add the following SOP Class to PS3.4, Annex I.4, Table I.4-1

Table I.4-1
Media Storage Standard SOP Classes

SOP Class Name	SOP Class UID	IOD Specification
RT Beams Delivery Instruction Storage	**1.2.840.10008.5.1.4.34.7**	**RT Beams Delivery Instruction**

Add the following annex to PS3.4:

Annex Y RT Machine Verification Service Classes (Normative)

Y.1 SCOPE

The RT Machine Verification Service Classes define an application-level class-of-service which facilitates the independent verification of geometric and dosimetric settings on a radiation delivery system prior to delivery of a radiation treatment. The service classes are intended for use with both conventional (e.g. photon, electron) as well as particle therapy (e.g. proton, ion) treatments.

Y.2 RT MACHINE VERIFICATION MODEL

Y.2.1 RT Machine Verification Data Flow

In the RT Machine Verification Model, the Service Class User (SCU) of the applicable Machine Verification Service Class is the radiation delivery system used to administer the treatment. The Machine Parameter Verifier (MPV) acts in the role of Service Class Provider (SCP).

The communication states between the SCU and SCP can be described in two levels shown in Figure *Y*.2-1: A) the Plan Level and B) the Beam Level.

The first level (A in the diagram) is the Plan Level. The SCU initializes external verification of a new plan using the N-CREATE command. The MPV then retrieves the data necessary to perform verification through DICOM or other means. In general, there is a close relationship between an MPV and a Treatment Management System (TMS) or Archive. If DICOM is the protocol used to retrieve this data, this might be done using one or more C-MOVEs on the Archive.

The second level (B in the diagram) is the Beam Level. The SCU uses the N-SET command request to instruct the SCP on the specified attributes to be verified. The SCU then requests that the verification start using an N-ACTION command. The SCP compares the values of the specified attributes against the values of the attributes from the referenced plan, and signals the status of the verification using N-EVENT-REPORT command with the Treatment Verification Status (3008,002C) attribute indicating the verification result. The MPV"s use of tolerance values in the verification process shall be described in a Conformance Statement. The SCU may then optionally request the beam"s verification parameters using an N-GET.

Finally, when all beams have been delivered or abandoned, the SCU terminates the verification session at the Plan Level using an N-DELETE.

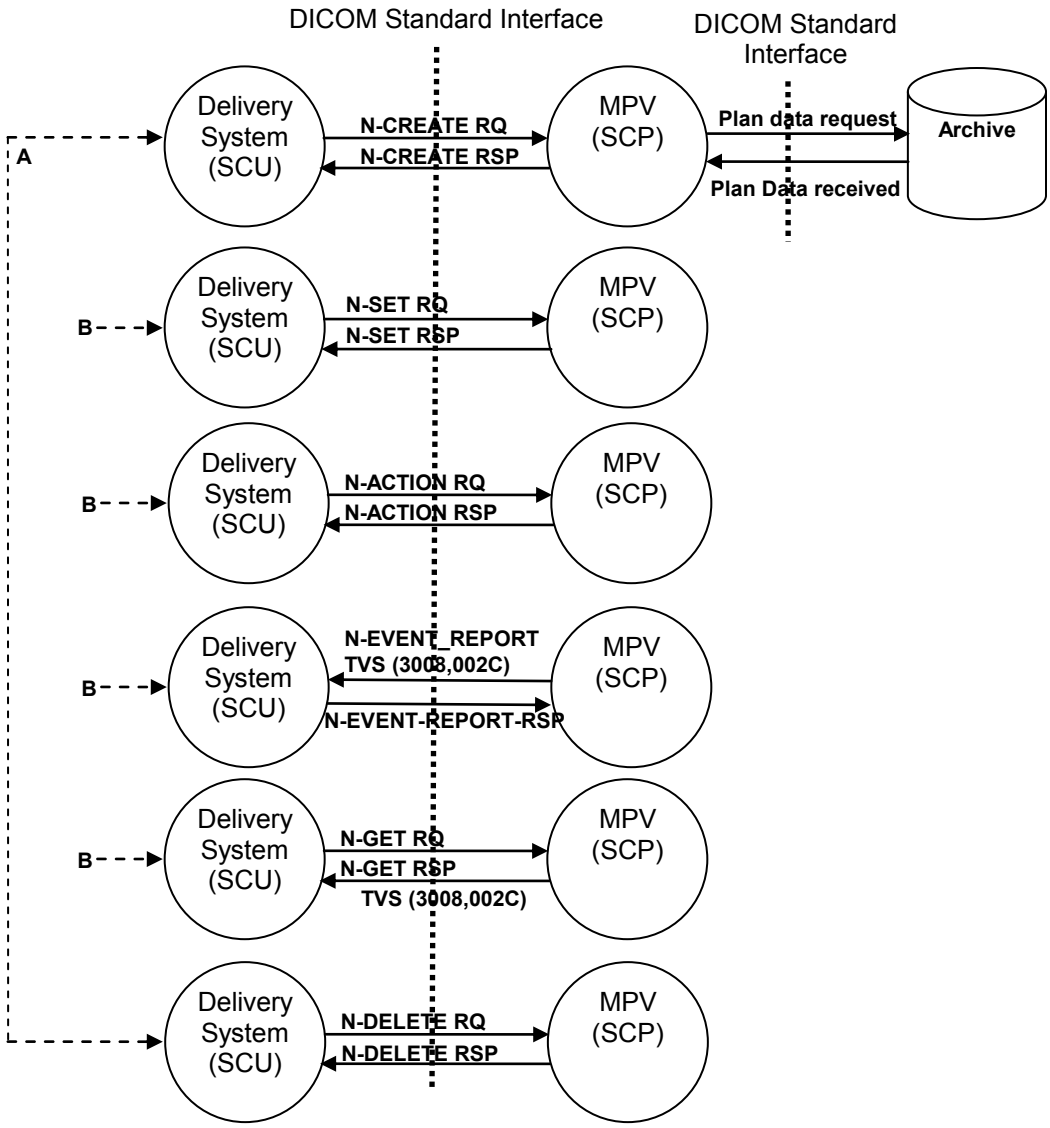


Figure Y.2-1 RT Verification Data Flow

Y.3 MACHINE VERIFICATION SOP CLASS DEFINITIONS

Y.3.1. IOD Description

The Machine Verification IODs are abstractions of the information needed to verify the correct setup of a treatment delivery system prior to radiation treatment.

Y.3.2. DIMSE Service Group

Table *Y*.3-1 shows DIMSE Services applicable to the IODs.

Table Y.3.2-1

DIMSE Service Group

DIMSE Service Element	Usage SCU/SCP
N-CREATE	M/M
N-SET	M/M
N-GET	M/M
N-ACTION	M/M
N-DELETE	M/M
N-EVENT-REPORT	M/M

The meaning of the Usage SCU/SCP is described in Section H.2.4.

This Section describes the behavior of the DIMSE Services which are specific for this IOD. The general behavior of the DIMSE services is specified in PS 3.7.

Y.3.2.1 N-CREATE AND N-SET

The N-CREATE is used to create an instance of the applicable Machine Verification SOP Class.

The N-SET is used to communicate parameters for verification to an MPV by setting attributes on an instance of the applicable Machine Verification SOP Class.

All attributes in the table relating to the number of a certain item (e.g. Number of Wedges, Number of Control Points) specify the number in the N-SET command. The numbering in the Beams Verification Request is not necessarily the same as the numbering in the referenced RT Plan.

Y.3.2.1.1 Attributes

The attribute list of the N-CREATE and N-SET for the RT Conventional Machine Verification SOP Class is shown in Table *Y*.3.2.1-1. See Section 5.4 for usage notation.

Table Y.3.2.1-1

N-CREATE AND N-SET ATTRIBUTE LIST – RT CONVENTIONAL MACHINE VERIFICATION SOP CLASS

Attribute Name	Tag	N-CREATE Usage SCU/SCP	N-SET Usage SCU/SCP
RT General Machine Verification Module			
Referenced RT Plan Sequence	(300C,0002)	1/1 (only a single Item shall be permitted)	Not allowed
>Referenced SOP Class UID	(0008,1150)	1/1	Not allowed
>Referenced SOP Instance UID	(0008,1155)	1/1	Not allowed
Referenced Fraction Group Number	(300C,0022)	1C/1 (required if plan has	Not allowed

		more than one fraction group)	
Patient ID	(0010,0020)	1/1	Not allowed
Include 'Issuer of Patient ID Macro' DICOM Supplement 96 Table UUU.2.5-2e			
Treatment Verification Status	(3008,002C)	Not allowed	Not allowed
Failed Parameters Sequence	(0074,1048)	Not allowed	Not allowed
Overridden Parameters Sequence	(0074,104A)	Not allowed	Not allowed
General Machine Verification Sequence	(0074,1042)	2/2 (sequence shall contain zero items)	1/1 (only a single Item shall be permitted)
>Specified Primary Meterset	(3008,0032)	-/-	3/3
>Specified Secondary Meterset	(3008,0033)	-/-	3/3
>Specified Treatment Time	(3008,003A)	-/-	3/3
>Beam Limiting Device Leaf Pairs Sequence	(3008,00A0)	-/-	3/3
>>RT Beam Limiting Device Type	(300A,00B8)	-/-	1/1
>>Number of Leaf/Jaw Pairs	(300A,00BC)	-/-	1/1
>Recorded Wedge Sequence	(3008,00B0)	-/-	2C/2C (required if MPV is capable of verifying wedges). See Y.3.2.1.1.1.
>>Wedge Number	(300A,00D2)	-/-	1/1
>>Wedge ID	(300A,00D4)	-/-	3/3
>>Wedge Angle	(300A,00D5)	-/-	3/3
>>Wedge Orientation	(300A,00D8)	-/-	3/3
>>Accessory Code	(300A,00F9)	-/-	3/3
>Recorded Compensator Sequence	(3008,00C0)	-/-	2C/2C (required if MPV is capable of verifying compensators). See Y.3.2.1.1.1.
>>Compensator ID	(300A,00E5)	-/-	3/3
>>Accessory Code	(300A,00F9)	-/-	3/3
>>Referenced Compensator Number	(300C,00D0)	-/-	1/1
>Recorded Block Sequence	(3008,00D0)	-/-	2C/2C (required if MPV is capable of verifying blocks). See Y.3.2.1.1.1.
>>Block Tray ID	(300A,00F5)	-/-	3/3
>>Accessory Code	(300A,00F9)	-/-	3/3
>>Referenced Block Number	(300C,00E0)	-/-	1/1
>Treatment Machine Name	(300A,00B2)	-/-	1/1
>Beam Name	(300A,00C2)	-/-	3/3
>Radiation Type	(300A,00C6)	-/-	1/1
>Number of Wedges	(300A,00D0)	-/-	1/1
>Number of Compensators	(300A,00E0)	-/-	1/1
>Number of Boli	(300A,00ED)	-/-	1/1
>Number of Blocks	(300A,00F0)	-/-	1/1
>Applicator Sequence	(300A,0107)	-/-	2C/2C (required if MPV is capable of verifying applicators). See Y.3.2.1.1.1.
>>Accessory Code	(300A,00F9)	-/-	3/3

>>Applicator ID	(300A,0108)	-/-	3/3
>>Applicator Type	(300A,0109)	-/-	1/1
>Number of Control Points	(300A,0110)	-/-	1/1 (value shall be 1)
>Patient Setup Sequence	(300A,0180)	-/-	3/3 (one or more Items may be included)
>>Patient Setup Number	(300A,0182)	-/-	1/1
>>Fixation Device Sequence	(300A,0190)	-/-	2C/2C (required if MPV is capable of verifying fixation devices). See Y.3.2.1.1.1.
>>>Accessory Code	(300A,00F9)	-/-	3/3
>>>Fixation Device Type	(300A,0192)	-/-	1/1
>Referenced Beam Number	(300C,0006)	-/-	1/1
>Referenced Bolus Sequence	(300C,00B0)	-/-	2C/2C (required if MPV is capable of verifying bolus). See Y.3.2.1.1.1.
>>Referenced ROI Number	(3006,0084)	-/-	1/1
>>Accessory Code	(300A,00F9)	-/-	3/3
All other attributes in RT General Machine Verification Module	-	-/-	3/3
RT Conventional Machine Verification Module			
Conventional Machine Verification Sequence	(0074,1044)	2/2 (sequence shall contain zero items)	1/1 (only a single Item shall be permitted)
>Conventional Control Point Verification Sequence	(0074,104C)	-/-	1/1 (only a single Item shall be permitted)
>>Nominal Beam Energy	(300A,0114)	-/-	3/3
>>Dose Rate Set	(300A,0115)	-/-	3/3
>>Wedge Position Sequence	(300A,0116)	-/-	1C/1C (required if Number of Wedges (300A,00D0) is non-zero, one or more Items may be included)
>>>Wedge Position	(300A,0118)	-/-	1/1
>>>Referenced Wedge Number	(300C,00C0)	-/-	1/1
>>Beam Limiting Device Position Sequence	(300A,011A)	-/-	1C/1C (required if Beam Limiting Device Leaf Pairs Sequence (3008,00A0) is sent, one or more Items may be included)
>>>RT Beam Limiting Device Type	(300A,00B8)	-/-	1/1
>>>Leaf/Jaw Positions	(300A,011C)	-/-	1/1
>>Gantry Angle	(300A,011E)	-/-	3/3
>>Gantry Rotation Direction	(300A,011F)	-/-	2/2
>>Beam Limiting Device Angle	(300A,0120)	-/-	3/3
>>Beam Limiting Device Rotation Direction	(300A,0121)	-/-	3/3

>>Patient Support Angle	(300A,0122)	-/-	3/3
>>Patient Support Rotation Direction	(300A,0123)	-/-	3/3
>>Table Top Eccentric Axis Distance	(300A,0124)	-/-	3/3
>>Table Top Eccentric Angle	(300A,0125)	-/-	3/3
>>Table Top Eccentric Rotation Direction	(300A,0126)	-/-	3/3
>>Table Top Vertical Position	(300A,0128)	-/-	3/3
>>Table Top Longitudinal Position	(300A,0129)	-/-	3/3
>>Table Top Lateral Position	(300A,012A)	-/-	3/3
>>Table Top Pitch Angle	(300A,0140)	-/-	3/3
>>Table Top Pitch Rotation Direction	(300A,0142)	-/-	3/3
>>Table Top Roll Angle	(300A,0144)	-/-	3/3
>>Table Top Roll Rotation Direction	(300A,0146)	-/-	3/3
>>Referenced Control Point Index	(300C,00F0)	-/-	1/1
All other attributes in RT Conventional Machine Verification Module	-	-/-	3/3

The attribute list of the N-CREATE and N-SET for the RT Ion Machine Verification SOP Class is shown in Table *Y*.3.2.1-2.

Table Y.3.2.1-2

N-CREATE AND N-SET ATTRIBUTE LIST – RT ION MACHINE VERIFICATION SOP CLASS

Attribute Name	Tag	N-CREATE Usage SCU/SCP	N-SET Usage SCU/SCP
RT General Machine Verification Module			
Referenced RT Plan Sequence	(300C,0002)	1/1 (only a single Item shall be permitted)	Not allowed
>Referenced SOP Class UID	(0008,1150)	1/1	Not allowed
>Referenced SOP Instance UID	(0008,1155)	1/1	Not allowed
Referenced Fraction Group Number	(300C,0022)	1C/1 (required if plan has more than one fraction group)	Not allowed
Patient ID	(0010,0020)	1/1	Not allowed
Include 'Issuer of Patient ID Macro' DICOM Supplement 96 Table UUU.2.5-2e			
Treatment Verification Status	(3008,002C)	Not allowed	Not allowed
Failed Parameters Sequence	(0074,1048)	Not allowed	Not allowed
Overridden Parameters Sequence	(0074,104A)	Not allowed	Not allowed
General Machine Verification Sequence	(0074,1042)	2/2 (sequence shall contain zero items)	1/1 (only a single Item shall be permitted)
>Specified Primary Meterset	(3008,0032)	-/-	3/3
>Specified Secondary Meterset	(3008,0033)	-/-	3/3
>Specified Treatment Time	(3008,003A)	-/-	3/3
>Beam Limiting Device Leaf Pairs Sequence	(3008,00A0)	-/-	3/3 See Y.3.2.1.1.1.
>>RT Beam Limiting Device Type	(300A,00B8)	-/-	1/1
>>Number of Leaf/Jaw Pairs	(300A,00BC)	-/-	1/1

>Recorded Wedge Sequence	(3008,00B0)	-/-	2C/2C (required if MPV is capable of verifying wedges). See Y.3.2.1.1.1.
>>Wedge Number	(300A,00D2)	-/-	1/1
>>Wedge ID	(300A,00D4)	-/-	3/3
>>Wedge Angle	(300A,00D5)	-/-	3/3
>>Wedge Orientation	(300A,00D8)	-/-	3/3
>>Accessory Code	(300A,00F9)	-/-	3/3
>Recorded Compensator Sequence	(3008,00C0)	-/-	2C/2C (required if MPV is capable of verifying compensators). See Y.3.2.1.1.1.
>>Compensator ID	(300A,00E5)	-/-	3/3
>>Accessory Code	(300A,00F9)	-/-	3/3
>>Referenced Compensator Number	(300C,00D0)	-/-	1/1
>Recorded Block Sequence	(3008,00D0)	-/-	2C/2C (required if MPV is capable of verifying blocks). See Y.3.2.1.1.1.
>>Block Tray ID	(300A,00F5)	-/-	3/3
>>Accessory Code	(300A,00F9)	-/-	3/3
>>Referenced Block Number	(300C,00E0)	-/-	1/1
>Treatment Machine Name	(300A,00B2)	-/-	1/1
>Beam Name	(300A,00C2)	-/-	3/3
>Radiation Type	(300A,00C6)	-/-	1/1
>Number of Wedges	(300A,00D0)	-/-	1/1
>Number of Compensators	(300A,00E0)	-/-	1/1
>Number of Boli	(300A,00ED)	-/-	1/1
>Number of Blocks	(300A,00F0)	-/-	1/1
>Applicator Sequence	(300A,0107)	-/-	2C/2C (required if MPV is capable of verifying applicators). See Y.3.2.1.1.1.
>>Accessory Code	(300A,00F9)	-/-	3/3
>>Applicator ID	(300A,0108)	-/-	3/3
>>Applicator Type	(300A,0109)	-/-	1/1
>Number of Control Points	(300A,0110)	-/-	1/1 (value shall be 1)
>Patient Setup Sequence	(300A,0180)	-/-	3/3 See Y.3.2.1.1.1.
>>Patient Setup Number	(300A,0182)	-/-	1/1
>>Fixation Device Sequence	(300A,0190)	-/-	2C/2C (required if MPV is capable of verifying fixation devices). See Y.3.2.1.1.1.
>>>Accessory Code	(300A,00F9)	-/-	3/3
>>>Fixation Device Type	(300A,0192)	-/-	1/1
>Referenced Beam Number	(300C,0006)	-/-	1/1
>Referenced Bolus Sequence	(300C,00B0)	-/-	2C/2C (required if MPV is capable of

			verifying bolus). See Y.3.2.1.1.1.
>>Referenced ROI Number	(3006,0084)	-/-	1/1
>>Accessory Code	(300A,00F9)	-/-	3/3
All other attributes in RT General Machine Verification Module	-	-/-	3/3
RT Ion Machine Verification Module			
Ion Machine Verification Sequence	(0074,1046)	2/2 (sequence shall contain zero items)	1/1 (only a single Item shall be permitted)
>Ion Control Point Verification Sequence	(0074,104E)	-/-	1/1 (only a single Item shall be permitted)
>>Meterset Rate Set	(3008,0045)	-/-	3/3
>>Nominal Beam Energy	(300A,0114)	-/-	3/3
>>Beam Limiting Device Position Sequence	(300A,011A)	-/-	1C/1C (required if Beam Limiting Device Leaf Pairs Sequence (3008,00A0) is sent, one or more Items may be included)
>>>RT Beam Limiting Device Type	(300A,00B8)	-/-	1/1
>>>Leaf/Jaw Positions	(300A,011C)	-/-	1/1
>>Gantry Angle	(300A,011E)	-/-	3/3
>>Gantry Rotation Direction	(300A,011F)	-/-	2/2
>>Beam Limiting Device Angle	(300A,0120)	-/-	3/3
>>Beam Limiting Device Rotation Direction	(300A,0121)	-/-	3/3
>>Patient Support Angle	(300A,0122)	-/-	3/3
>>Patient Support Rotation Direction	(300A,0123)	-/-	3/3
>>Table Top Vertical Position	(300A,0128)	-/-	3/3
>>Table Top Longitudinal Position	(300A,0129)	-/-	3/3
>>Table Top Lateral Position	(300A,012A)	-/-	3/3
>>Table Top Pitch Angle	(300A,0140)	-/-	3/3
>>Table Top Pitch Rotation Direction	(300A,0142)	-/-	3/3
>>Table Top Roll Angle	(300A,0144)	-/-	3/3
>>Table Top Roll Rotation Direction	(300A,0146)	-/-	3/3
>>Head Fixation Angle	(300A,0148)	-/-	3/3
>>Gantry Pitch Angle	(300A,014A)	-/-	3/3
>>Gantry Pitch Rotation Direction	(300A,014C)	-/-	3/3
>>Snout Position	(300A,030D)	-/-	3/3
>>Range Shifter Settings Sequence	(300A,0360)	-/-	1C/1C (required if Number of Range Shifters (300A,0312) is non-zero, one or more Items may be included)
>>>Range Shifter Setting	(300A,0362)	-/-	1/1
>>>Referenced Range Shifter Number	(300C,0100)	-/-	1/1

>>Lateral Spreading Device Settings Sequence	(300A,0370)	-/-	1C/1C (required if Number of Lateral Spreading Devices (300A,0330) is non-zero, one or more Items may be included)
>>>Lateral Spreading Device Setting	(300A,0372)	-/-	1/1
>>>Referenced Lateral Spreading Device Number	(300C,0102)	-/-	1/1
>>Range Modulator Settings Sequence	(300A,0380)	-/-	1C/1C (required if Number of Range Modulators (300A,0340) is non-zero, one or more Items may be included)
>>>Range Modulator Gating Start Value	(300A,0382)	-/-	1/1
>>>Range Modulator Gating Stop Value	(300A,0384)	-/-	1/1
>>>Referenced Range Modulator Number	(300C,0104)	-/-	1/1
>>Ion Wedge Position Sequence	(300A,03AC)	-/-	1C/1C (required if Number of Wedges (300A,00D0) is non-zero, one or more Items may be included)
>>>Wedge Thin Edge Position	(300A,00DB)	-/-	1C/1C (required if Wedge Type (300A,00D3) of the wedge referenced by Referenced Wedge Number (300C,00C0) is PARTIAL_STANDARD or PARTIAL_MOTORIZ)
>>>Wedge Position	(300A,0118)	-/-	1/1
>>Referenced Control Point Index	(300C,00F0)	-/-	1/1
>Recorded Snout Sequence	(3008,00F0)	-/-	1C/1C (required if Snout Sequence is included in the RT Ion Plan referenced within the Referenced RT Plan Sequence (300C,0002); only a single Item is permitted in this sequence)
>>Accessory Code	(300A,00F9)	-/-	3/3
>>Snout ID	(300A,030F)	-/-	3/3
>Recorded Range Shifter Sequence	(3008,00F2)	-/-	2C/2C (required if MPV is

			capable of verifying range shifters). See Y.3.2.1.1.1.
>>Accessory Code	(300A,00F9)	-/-	3/3
>>Range Shifter ID	(300A,0318)	-/-	3/3
>>Referenced Range Shifter Number	(300C,0100)	-/-	1/1
>Recorded Lateral Spreading Device Sequence	(3008,00F4)	-/-	2C/2C (required if MPV is capable of verifying lateral spreading devices). See Y.3.2.1.1.1.
>>Accessory Code	(300A,00F9)	-/-	3/3
>>Lateral Spreading Device ID	(300A,0336)	-/-	3/3
>>Referenced Lateral Spreading Device Number	(300C,0102)	-/-	1/1
>Recorded Range Modulator Sequence	(3008,00F6)	-/-	2C/2C (required if MPV is capable of verifying range modulators). See Y.3.2.1.1.1.
>>Accessory Code	(300A,00F9)	-/-	3/3
>>Range Modulator ID	(300A,0346)	-/-	3/3
>>Range Modulator Type	(300A,0348)	-/-	1/1
>>Beam Current Modulation ID	(300A,034C)	-/-	1C/1C (required if Range Modulator Type (300A,0348) is WHL_MODWEIGHTS)
>>Referenced Range Modulator Number	(300C,0104)	-/-	1/1
>Radiation Mass Number	(300A,0302)	-/-	1C/1C (required if Radiation Type (300A,00C6) is ION)
>Radiation Atomic Number	(300A,0304)	-/-	1C/1C (required if Radiation Type (300A,00C6) is ION)
>Radiation Charge State	(300A,0306)	-/-	1C/1C (required if Radiation Type (300A,00C6) is ION)
>Scan Mode	(300A,0308)	-/-	1/1
>Number of Range Shifters	(300A,0312)	-/-	1/1
>Number of Lateral Spreading Devices	(300A,0330)	-/-	1/1
>Number of Range Modulators	(300A,0340)	-/-	1/1
>Patient Support Type	(300A,0350)	-/-	3/3
>Patient Support ID	(300A,0352)	-/-	3/3
>Patient Support Accessory Code	(300A,0354)	-/-	3/3
>Fixation Light Azimuthal Angle	(300A,0356)	-/-	3/3
>Fixation Light Polar Angle	(300A,0358)	-/-	3/3
All other attributes in RT Ion	-	-/-	3/3

Machine Verification Module			

Y.3.2.1.1.1 Beam Modifiers

If the MPV *is not* capable of performing the type of verification required by the attribute, then the attribute shall not be present. If the MPV *is* capable of performing the type of verification required by the attribute, then the attribute will be zero length if there are no such modifiers, and valued with one or more items if there are one or more such modifiers.

Y.3.2.1.2 Status

The status values for N-CREATE which are specific for these SOP Classes are defined as follows:

Table Y.3.2.1.2-1

RT ION MACHINE VERIFICATION SOP CLASS N-CREATE STATUS VALUES

Status	Meaning	Code
Success	Machine Verification successfully created	0000
Failure	No such object instance – Referenced RT Plan not found	C227
	The Referenced Fraction Group Number does not exist in the referenced plan	C221
	No beams exist within the referenced fraction group	C222
	SCU already verifying and cannot currently process this request.	C223

The status values for N-SET which are specific for these SOP Classes are defined as follows:

Table Y.3.2.1.2-2

RT ION MACHINE VERIFICATION SOP CLASS N-SET STATUS VALUES

Status	Meaning	Code
Success	Machine Verification successfully updated	0000
Failure	Referenced Beam Number not found within the referenced Fraction Group	C224
	Referenced device or accessory not supported	C225
	Referenced device or accessory not found within the referenced beam	C226

Y.3.2.1.3 Behavior

Y.3.2.1.3.1 N-CREATE

The SCU uses N-CREATE to request the SCP to create an applicable Machine Verification SOP Instance. The SCP shall create the SOP Instance and shall initialize Attributes of the SOP Class.

The General Machine Verification Sequence, Conventional Machine Verification Sequence, and Ion Machine Verification Sequence are created with an empty value, and specification of the contained attributes is deferred until the N-SET operation.

The SCP shall return the status code of the requested SOP Instance creation. The meaning of success, warning and failure status codes is defined in Section Y.3.2.1.2.

Y.3.2.1.3.2 N-SET

The SCU uses the N-SET to request the SCP to update an applicable Machine Verification instance. The SCU shall specify the SOP Instance to be updated and shall specify the list of

attributes for which the Attribute Values are to be set. The attributes in the Conventional/Ion Control Point Verification Sequence represent the Treatment Delivery System"s actual geometric values at the time the N-SET request is issued and therefore, the Conventional/Ion Control Point Verification Sequence shall always contain one sequence item. The Referenced Control Point Index shall be zero for NORMAL treatments, and may be greater than zero for CONTINUATION treatments.

Within an attribute sequence such as the General Machine Verification Sequence, Conventional Machine Verification Sequence, and Ion Machine Verification Sequence, values for all required attributes must be supplied with each N-SET, or else the missing attributes will have any previously set values removed from the SOP Instance. Existing parameters may be cleared by sending an empty sequence or attribute. The MPV"s Conformance Statement shall specify the set of attributes that it requires for verification.

The SCU shall set the new values for the specified Attributes of the specified SOP Instance. The SCP shall then compare the values of Attributes of the specified SOP Instance to the values of the same Attributes found in the RT Plan referenced in N-CREATE. Values shall be compared using the tolerance values also found in the referenced RT Plan. The result of this comparison shall be available for use when the SCU requests the Treatment Verification Status using an N-GET.

Y.3.2.2 N-GET

The N-GET is used to get the verification status and results of the applicable Machine Verification SOP Class.

Y.3.2.2.1 Verification Parameters Selector Attribute Macro

Table Y.3.3.2.2.1-1 describes N-GET support requirements for the Selector Attribute Macro. See Section 5.4 for requirements type code meaning.

Table Y.3.2.2.1-1
Verification Parameters Selector Attribute Macro

Attribute Name	Tag	Req. Type N-GET (SCU/SCP)
Selector Attribute	(0072,0026)	-/1
Selector Value Number	(0072,0028)	-/1
Selector Sequence Pointer	(0072,0052)	-/1
Selector Sequence Pointer Private Creator	(0072,0054)	-/1
Selector Sequence Pointer Items	(0074,1057)	-/1
Selector Attribute Private Creator	(0072,0056)	-/1

Y.3.2.2.2 Attributes

The attribute list of the N-GET for the RT Conventional Machine Verification SOP Class and RT Ion Machine Verification SOP Class is shown in Table *Y*.3.2.2.2-1. See Section 5.4 for usage notation.

Table Y.3.2.2.2-1

N-GET ATTRIBUTE LIST– RT CONVENTIONAL MACHINE VERIFICATION SOP CLASS AND RT ION MACHINE VERIFICATION SOP CLASS

Attribute Name	Tag	Usage SCU/SCP
Referenced RT Plan Sequence	(300C,0002)	-/1
>Referenced SOP Class UID	(0008,1150)	-/1
>Referenced SOP Instance UID	(0008,1155)	-/1
Referenced Fraction Group Number	(300C,0022)	-/1
Patient ID	(0010,0020)	-/1
Include 'Issuer of Patient ID Macro' DICOM Supplement 96 Table UUU.2.5-2e		
Treatment Verification Status	(3008,002C)	-/1
Failed Parameters Sequence	(0074,1048)	-/2 (zero or more items shall be included in this Sequence)
>Include 'Verification Parameters Selector Attribute Macro' Table Y.3.2.2.1-1		
Overridden Parameters Sequence	(0074,104A)	-/2 (zero or more items shall be included in this Sequence)
>Include 'Verification Parameters Selector Attribute Macro' Table Y.3.2.2.1-1		
>Operators' Name	(0008,1070)	-/2

>Override Reason	(3008,0066)	-/2
All other attributes	-	3/2

Y.3.2.2.3 Status

The status values which are specific for these SOP Classes are defined as follows:

Table Y.3.2.2.3-1

RT CONVENTIONAL MACHINE AND RT ION MACHINE VERIFICATION SOP CLASS N-GET STATUS VALUES

Status	Meaning	Code
Success	Treatment Verification Status of the applicable Machine Verification instance successfully returned.	0000
Failure	No such object instance – applicable Machine Verification instance not found	C112

Y.3.2.2.4 Behavior

The SCU uses N-GET to retrieve from the SCP the verification status and results of the applicable Machine Verification SOP Instance.

The SCP shall return the Treatment Verification Status (3008,002C) attribute as well as the status code of the requested SOP Instance update. Treatment Verification Status shall have one of the following values:

VERIFIED = treatment verified

VERIFIED_OVR = treatment verified with at least one out-of-range value overridden

NOT_VERIFIED = verification of treatment was not successful

The VERIFIED state indicates that all required parameters have been checked and no out-of-range values have been detected. The VERIFIED_OVR state indicates that the treatment failed to verify due to one or more out-of-range values which were then overridden. NOT_VERIFIED indicates that one of more of the out-of-range values has not yet been overridden and the treatment cannot go ahead. This could be because at least one out-of-range value was detected, or one or more values required for verification were not supplied. The site- and vendor-specific configuration of the MPV determines the attributes and ranges required for successful verification.

If the Treatment Verification Status is VERIFIED_OVR, one or more parameter occurrences shall be returned in Overridden Parameters Sequence (0074,104A), otherwise the sequence shall be empty.

If the Treatment Verification Status is NOT_VERIFIED, one or more parameter occurrences shall be returned in Failed Parameters Sequence (0074,1048), otherwise the sequence shall be empty.

See PS 3.3 Section C.XX.1.1 for specification of how the attribute tags and position within a sequence are encoded.

The SCP shall return the status code of the requested action. The meanings of success, warning and failure status codes are defined in Section Y.3.2.2.3.

Y.3.2.3 N-ACTION

The N-ACTION is used to initiate parameter verification of an instance of the applicable Machine Verification SOP Class.

Y.3.2.3.1 Attributes

The action types of the N-ACTION are defined as shown in Table Y.3.2.3-1.

Table Y.3.2.3-1

ACTION EVENT INFORMATION

Action Type Name	Action Type ID	Attribute	Tag	Usage SCU/SCP
Request Beam Verification	1	None	-	-

Y.3.2.3.2 Status

The status values which are specific for these SOP Classes are defined as follows:

Table Y.3.2.3-2

RT CONVENTIONAL MACHINE AND RT ION MACHINE VERIFICATION SOP CLASS N-ACTION STATUS VALUES

Status	Meaning	Code
Success	Machine Parameter Verification of the applicable Machine Verification instance successfully initiated.	0000
Failure	No such object instance – Machine Verification requested instance not found.	C112

Y.3.2.3.3 Behavior

The SCU uses N-ACTION to instruct the SCP to initiate machine parameter verification of the applicable Machine Verification SOP Instance.

Y.3.2.4 N-DELETE

The N-DELETE is used to delete an instance of the applicable Machine Verification SOP Class.

Y.3.2.4.1 Attributes

There are no specific attributes.

Y.3.2.4.2 Status

There are no specific status codes.

Y.3.2.4.3 Behavior

The SCU uses the N-DELETE to request the SCP to delete an applicable Machine Verification SOP Instance. The SCU shall specify in the N-DELETE request primitive the SOP Instance UID of the applicable Machine Verification instance.

The SCP shall delete the specified SOP Instance, such that subsequent operations of the same SOP Instance will fail.

The SCP shall return the status code of the requested SOP Instance deletion. The meanings of success, warning, and failure status classes are defined in PS3.7 Annex C.

If an N-DELETE is not issued, the SOP Class instance may be deleted on the SCP by a manual or automatic operation. This behavior is beyond the scope of the standard.

Y.3.2.5 N-EVENT-REPORT

The N-EVENT-REPORT is used by the MPV to notify the TDS of the status of the verification task (successful or otherwise), or to notify the TDS that a verification is pending (in progress). The encoding of Notification Event Information is defined in PS 3.7.

Y.3.2.5.1 Attributes

The arguments of the N-EVENT-REPORT are defined as shown in Table Y.3.2.5-1.

Table Y.3.2.5-1

NOTIFICATION EVENT INFORMATION

Event Type Name	Event Type ID	Attribute	Tag	Usage SCU/SCP
Pending	1	None	-	-
Done	2	Treatment Verification Status	(3008,002C)	-/1

Y.3.2.5.2 Status

There are no specific status codes.

Y.3.2.5.3 Behavior

The SCP uses the N-EVENT-REPORT to inform the SCU of the verification status. See PS3.17 Section ZZZ.3.

If the Event Type ID = 1 then the verification is still in progress, and the SCU must wait until another event is received. See PS 3.17 Section 3.2.2.

If the Event Type ID = 2 then the verification process has been completed. The SCU may use the returned value of the Treatment Verification Status (3008,002C) to determine whether or not the beam is ready to be delivered, or if a machine adjustment or override needs to be made. See PS 3.17 Section ZZZ.3.2.2.

Part 6 Addendum

Add the following data elements to PS3.6:

6 Registry of DICOM data elements

Tag	Name	Keyword	VR	VM
(0074,1026)	Table Top Vertical Adjusted Position	TableTopVerticalAdjustedPosition	FD	1
(0074,1027)	Table Top Longitudinal Adjusted Position	TableTopLongitudinalAdjustedPosition	FD	1
(0074,1028)	Table Top Lateral Adjusted Position	TableTopLateralAdjustedPosition	FD	1
(0074,102A)	Patient Support Adjusted Angle	PatientSupportAdjustedAngle	FD	1
(0074,102B)	Table Top Eccentric Adjusted Angle	TableTopEccentricAdjustedAngle	FD	1
(0074,102C)	Table Top Pitch Adjusted Angle	TableTopPitchAdjustedAngle	FD	1
(0074,102D)	Table Top Roll Adjusted Angle	TableTopRollAdjustedAngle	FD	1
(0074,1057)	Selector Sequence Pointer Items	SelectorSequencePointerItems	IS	1-n
(0074,0120)	Continuation Start Meterset	ContinuationStartMeterset	FD	1
(0074,0121)	Continuation End Meterset	ContinuationEndMeterset	FD	1

Retire the following data elements:

6 Registry of DICOM data elements

(0074,1024)	Beam Order Index	BeamOrderIndex	**IS**	1
(0074,1038)	Double Exposure Meterset	DoubleExposureMeterset	**DS**	1
(0074,103A)	Double Exposure Field Delta	DoubleExposureFieldDelta	**DS**	4

Add the following data elements to PS3.6:

6 Registry of DICOM data elements

(0074,1324)	Beam Order Index	BeamOrderIndex	**UL**	1
(0074,1338)	Double Exposure Meterset	DoubleExposureMeterset	**FD**	1
(0074,133A)	Double Exposure Field Delta	DoubleExposureFieldDelta	**FD**	4

Change the Value Multiplicity of the following data elements to PS3.6:

6 Registry of DICOM data elements

(0072,0052)	Selector Sequence Pointer	SelectorSequencePointer	AT	1**-n**
(0072,0054)	Selector Sequence Pointer Private Creator	SelectorSequencePointerPrivateCreator	LO	1**-n**

Add the following to PS3.6 Annex A:

Table A-1
UID VALUES

1.2.840.10008.5.1.4.34.1	RT Beams Delivery Instruction Storage – Trial (Retired)	SOP Class	PS 3.4
1.2.840.10008.5.1.4.34.2	RT Conventional Machine Verification - Trial (Retired)	SOP Class	PS 3.4
1.2.840.10008.5.1.4.34.3	RT Ion Machine Verification - Trial (Retired)	SOP Class	PS 3.4
1.2.840.10008.5.1.4.34.7	RT Beams Delivery Instruction Storage	SOP Class	PS 3.4
1.2.840.10008.5.1.4.34.8	RT Conventional Machine Verification	SOP Class	PS 3.4
1.2.840.10008.5.1.4.34.9	RT Ion Machine Verification	SOP Class	PS 3.4

Add the following data elements to PS3.6, Annex A:

Table A-3
CONTEXT GROUP UID VALUES

Context UID	Context Identifier	Context Group Name
1.2.840.10008.6.1.931	9241	Radiotherapy General Workitem Definition
1.2.840.10008.6.1.932	9242	Radiotherapy Acquisition Workitem Definition
1.2.840.10008.6.1.933	9243	Radiotherapy Registration Workitem Definition

Add the following to PS3.16, Annex B:

CID 9241 RADIOTHERAPY GENERAL WORKITEM DEFINITION

Context ID 9241

Radiotherapy General Workitem Definition

Type: Extensible Version: yyyymmdd

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	121701	RT Patient Setup
DCM	121722	RT Patient Position Adjustment
DCM	121723	RT Patient Position In-treatment-session Review
DCM	121724	RT Treatment Simulation with Internal Verification
DCM	121725	RT Treatment Simulation with External Verification
DCM	121726	RT Treatment with Internal Verification
DCM	121727	RT Treatment with External Verification
DCM	121728	RT Treatment QA with Internal Verification
DCM	121729	RT Treatment QA with External Verification
DCM	121730	RT Machine QA

CID 9242 RADIOTHERAPY ACQUISITION WORKITEM DEFINITION

Context ID 9242

Radiotherapy Acquisition Workitem Definition

Type: Extensible Version: yyyymmdd

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	121702	RT Patient Position Acquisition, single plane MV
DCM	121703	RT Patient Position Acquisition, dual plane MV
DCM	121704	RT Patient Position Acquisition, single plane kV
DCM	121705	RT Patient Position Acquisition, dual plane kV
DCM	121706	RT Patient Position Acquisition, dual plane kV/MV
DCM	121707	RT Patient Position Acquisition, CT kV
DCM	121708	RT Patient Position Acquisition, CT MV
DCM	121709	RT Patient Position Acquisition, Optical
DCM	121710	RT Patient Position Acquisition, Ultrasound
DCM	121711	RT Patient Position Acquisition, Spatial Fiducials

CID 9243 RADIOTHERAPY REGISTRATION WORKITEM DEFINITION

Context ID 9243

Radiotherapy Registration Workitem Definition

Type: Extensible Version: yyyymmdd

Coding Scheme Designator (0008,0102)	Code Value (0008,0100)	Code Meaning (0008,0104)
DCM	121712	RT Patient Position Registration, single plane
DCM	121713	RT Patient Position Registration, dual plane
DCM	121714	RT Patient Position Registration, 3D CT general
DCM	121715	RT Patient Position Registration, 3D CT marker-based
DCM	121716	RT Patient Position Registration, 3D CT volume-based
DCM	121717	RT Patient Position Registration, 3D on 2D reference
DCM	121718	RT Patient Position Registration, 2D on 3D reference
DCM	121719	RT Patient Position Registration, Optical
DCM	121720	RT Patient Position Registration, Ultrasound
DCM	121721	RT Patient Position Registration, Spatial Fiducials

Add the following to the table in PS3.16, Annex D:

DICOM CONTROLLED TERMINOLOGY DEFINITIONS (NORMATIVE)

Code Value	Code Meaning	Definition	Notes
121701	RT Patient Setup	Process of placing patient in the anticipated treatment position, including specification and location of positioning aids, and other treatment delivery accessories	
121702	RT Patient Position Acquisition, single plane MV	Acquisition of patient positioning information prior to treatment delivery, using single-plane megavoltage imaging	
121703	RT Patient Position Acquisition, dual plane MV	Acquisition of patient positioning information prior to treatment delivery, using dual-plane megavoltage imaging	
121704	RT Patient Position Acquisition, single plane kV	Acquisition of patient positioning information prior to treatment delivery, using single-plane kilovoltage imaging	
121705	RT Patient Position Acquisition, dual plane kV	Acquisition of patient positioning information prior to treatment delivery, using dual-plane kilovoltage imaging	
121706	RT Patient Position Acquisition, dual plane kV/MV	Acquisition of patient positioning information prior to treatment delivery, using dual-plane combination kilovoltage and megavoltage imaging	
121707	RT Patient Position Acquisition, CT kV	Acquisition of patient positioning information prior to treatment delivery, using kilovoltage CT imaging	
121708	RT Patient Position Acquisition, CT MV	Acquisition of patient positioning information prior to treatment delivery, using megavoltage CT imaging	
121709	RT Patient Position Acquisition, Optical	Acquisition of patient positioning information prior to treatment delivery, using optical imaging	
121710	RT Patient Position Acquisition, Ultrasound	Acquisition of patient positioning information prior to treatment delivery, using ultrasound imaging	

121711	RT Patient Position Acquisition, Spatial Fiducials	Acquisition of patient positioning information prior to treatment delivery, using spatial fiducials	
121712	RT Patient Position Registration, single plane	Registration of intended and actual patient position prior to treatment delivery, using single-plane images	
121713	RT Patient Position Registration, dual plane	Registration of intended and actual patient position prior to treatment delivery, using dual-plane images	
121714	RT Patient Position Registration, 3D CT general	Registration of intended and actual patient position prior to treatment delivery, using 3D CT images and an unspecified registration approach	
121715	RT Patient Position Registration, 3D CT marker-based	Registration of intended and actual patient position prior to treatment delivery, using 3D CT images and a marker-based registration approach	
121716	RT Patient Position Registration, 3D CT volume-based	Registration of intended and actual patient position prior to treatment delivery, using 3D CT images and a volume-based registration approach	
121717	RT Patient Position Registration, 3D on 2D reference	Registration of intended and actual patient position prior to treatment delivery, using 3D verification images and 2D reference images	
121718	RT Patient Position Registration, 2D on 3D reference	Registration of intended and actual patient position prior to treatment delivery, using 2D verification images and 3D reference images	
121719	RT Patient Position Registration, Optical	Registration of intended and actual patient position prior to treatment delivery, using optical images	
121720	RT Patient Position Registration, Ultrasound	Registration of intended and actual patient position prior to treatment delivery, using ultrasound images	
121721	RT Patient Position Registration, Spatial Fiducials	Registration of intended and actual patient position prior to treatment delivery, using spatial fiducials	
121722	RT Patient Position Adjustment	Adjustment of patient position such that the patient is correctly positioned for treatment.	
121723	RT Patient Position In-treatment-session Review	Review of patient positioning information in the process of delivering a treatment session	
121724	RT Treatment Simulation with Internal Verification	Simulated radiotherapy treatment delivery using verification integral to the Treatment Delivery System	
121725	RT Treatment Simulation with External Verification	Simulated radiotherapy treatment delivery using verification by a external Machine Parameter Verifier	

121726	RT Treatment with Internal Verification	Radiotherapy treatment delivery using verification integral to the Treatment Delivery System	
121727	RT Treatment with External Verification	Radiotherapy treatment delivery using verification by a external Machine Parameter Verifier	
121728	RT Treatment QA with Internal Verification	Quality assurance of a radiotherapy treatment delivery using verification integral to the Treatment Delivery System	
121729	RT Treatment QA with External Verification	Quality assurance of a radiotherapy treatment delivery using verification by a external Machine Parameter Verifier	
121730	RT Machine QA	Quality assurance of a Treatment Delivery Device	

Part 17 Addendum

Add the following to PS3.17:

Annex ZZZ Unified Procedure Step in Radiotherapy (Informative)

ZZZ.1 PURPOSE OF THIS ANNEX

This annex provides examples of message sequencing when using the Unified Procedure Step SOP Classes in a radiotherapy context. This section is not intended to provide an exhaustive set of use cases but rather an informative example. There are other valid message sequences that could be used to obtain an equivalent outcome and there are other valid combinations of actors that could be involved in the workflow management.

The current use cases assume that tasks are always scheduled by the scheduler prior to being performed. It does not address the use case of an emergency or otherwise unscheduled treatment, where the procedure step will be created by a different device. However, Unified Procedure Step does provide a convenient mechanism for doing this.

The use cases addressed in this annex are:

- Treatment Delivery Normal Flow – Treatment Delivery System (TDS) performs the treatment delivery that was scheduled by the Treatment Management System (TMS). Both the “internal verification” and “external verification” flavors are modeled in these use cases.

- Treatment Delivery – Override or Additional Information Required. Operating in the external verification mode, the Machine Parameter Verifier (MPV) detects an out-of-tolerance parameter of missing information, and requests the user to override the parameter or supply or correct the missing information. This use case addresses the situation where the „verify“ function is split from the TDS, but does not address verification of a subset of parameters by an external delivery accessory such as a patient positioner.

ZZZ.2 USE CASE ACTORS

The following actors are used in the use cases below:

- ***User****:* Human being controlling the delivery of the treatment.

- ***Archive****:* Stores SOP Instances (images, plans, structures, dose distributions, etc).

- ***Treatment Management System (TMS)****:* Manages worklists and tracks performance of procedures. This role is commonly filled by a Treatment Management System (Oncology Information System) in the Oncology Department. Acts as a UPS Pull SCP. The TMS has a user interface which may potentially be located in the treatment delivery control area. In addition, TMS terminals may be located throughout the institution.

- ***Treatment Delivery System (TDS)****:* Performs the treatment delivery specified by the worklist, updating a UPS, and stores treatment records and related SOP Instances such as verification images. Acts as a UPS Pull SCU. The TDS user interface is dedicated to the safe and effective delivery of the treatment, and is located in the treatment control area, typically just outside the radiation bunker.

- ***Machine Parameter Verifier (MPV)****:* Oversees and potentially inhibits delivery of the treatment. This role is commonly filled by a Treatment Management System in the Oncology Department, when the TDS is in the external verification mode. The MPV does not itself act as a UPS Pull SCU, but communicates directly with the TDS, which acts as a UPS Pull SCU. The MPV user interface may be shared with the TMS (in the treatment delivery control area), or could be located on a separate console.

ZZZ.3 USE CASES

ZZZ.3.1 Treatment Delivery Normal Flow – Internal Verification

ZZZ.3.1.1 Message Sequencing

Figure ZZZ.3.1.1-1 illustrates a message sequence example in the case where a treatment procedure delivery is requested and performed by a delivery device that has internal verification capability. In the example, no „setup verification" is performed, i.e. the patient is assumed to be in the treatment position. Unified Procedure Step (UPS) is used to request delivery of a session of radiation therapy (commonly known as a "fraction") from a specialized Application Entity (a "Treatment Delivery System"). That entity performs the requested delivery, completing normally. Further examples could be constructed for discontinued, emergency (unscheduled) and interrupted treatment delivery use cases, but are not considered in this informative section (see DICOM Part 17 for generic examples).

In this example the Treatment Delivery System conforms to the UPS Pull SOP Class as an SCU, and the Treatment Management System conforms to the UPS Pull SOP Class as an SCP. In alternative implementations requiring on-the-fly scheduling and notification, other UPS SOP classes could be implemented.

Italic text in Figure ZZZ.3.1.1-1 denotes messages that will typically be conveyed by means other than DICOM services.

ZZZ.3.1.2 Transactions and Message Flow

This section describes in detail the interactions illustrated in Figure ZZZ.3.1.1-1.

1. „List Procedures for Delivery" on TDS console

   The User uses a control on the user interface of the TDS to indicate that he or she wishes to see the list of patients available for treatment.

2. Query UPS

   The TDS queries the TMS for Unified Procedure Steps (UPS"s) matching its search criteria. For example, all worklist items with a Unified Procedure Step Status of "SCHEDULED", and Input Readiness State (0040,4041) of "READY". This is conveyed using the C-FIND request primitive of the UPS Pull SOP Class.

3. Receive 0-n UPS

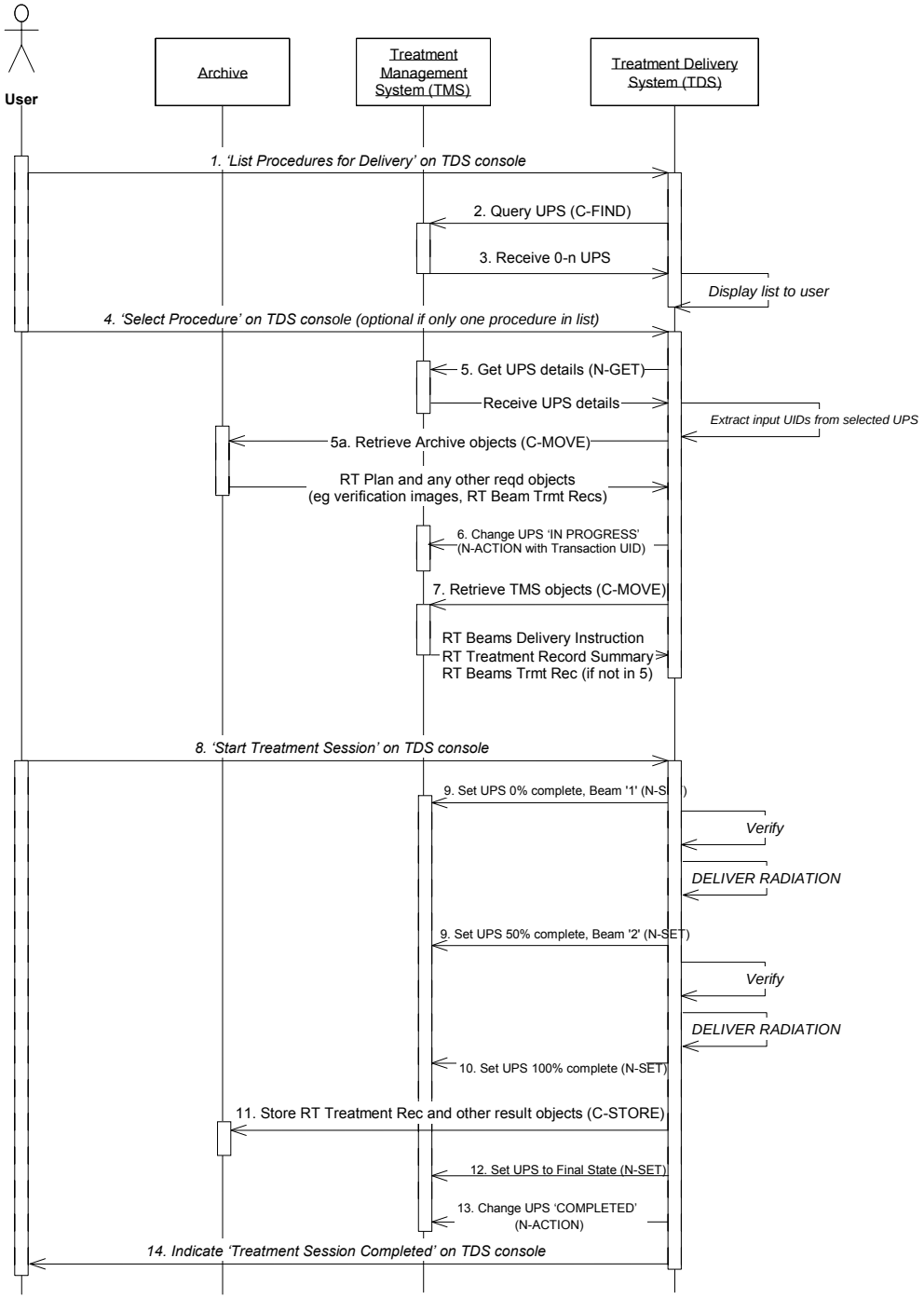
   The TDS receives the set of Unified Procedure Steps (UPS"s) resulting from the Query UPS message. The Receive UPS is conveyed via one or more C-FIND response primitives of the UPS Pull SOP Class. Each response (with status pending) contains the requested attributes of a single Unified Procedure Step (UPS).

   The TMS returns a list of one or more UPS"s based on its own knowledge of the planned tasks for the querying device. Two real-world scenarios are common in this step:

   - There is no TMS Console located in the treatment area, and selection of the delivery to be performed has not been made. In this case, the TMS returns a list of potentially many UPS"s (for different patients), and the User picks from the list the UPS that they wish to deliver.

   - The User has direct access to the TMS in the treatment area, and has already selected the delivery to be performed on the console of the TMS, located in the treatment room area. In this case, a single UPS is returned. The TDS may either display the single item for confirmation, or proceed directly to loading the patient details.

Figure ZZZ.3.1.1-1 Treatment Delivery Normal Flow – Internal Verification Message Sequence



A returned set of UPS"s may have more than one UPS addressing a given treatment delivery. For example, in the case where a patient position verification is required prior to delivery, there might be a UPS with Requested Procedure Code Sequence item having a Code Value of 121708 (“RT Patient Position Acquisition, CT MV”), another UPS with a Code Value of 121714 (“RT Patient Position Registration, 3D CT general”), another UPS with a Code Value of 121722 (“RT Patient Position Adjustment”),and a fourth UPS whose Requested Procedure Code Sequence item would have a Code Value of 121726 (“RT Treatment With Internal Verification”).

4. „Select Procedure" on TDS console

   The User selects one of the scheduled procedures specified on the TDS console. If exactly one UPS was returned from the UPS query described above, then this step can be omitted.

5. Get UPS Details and Retrieve Archive Objects

   The TDS may request the details of one or more procedure steps. This is conveyed using the N-GET primitive of the UPS Pull SOP Class, and is required when not all necessary information can be obtained from the query response alone.

   The TDS then retrieves the required SOP Classes from the Input Information Sequence of the returned UPS query response. In response to a C-MOVE Request on those objects (5a), the Archive then transmits to the TDS the SOP Instances to be used as input information during the task. These SOP Instances might include an RT Plan SOP Instance, and verification images (CT Image or RT Image). They might also include RT Beams Treatment Record SOP Instances if the Archive is used to store these SOP Instances rather than the TMS. The TDS knows of the existence and whereabouts of these SOP Instances by virtue of the fully-specified locations in the N-GET response.

   Although the TDS could set the UPS to „IN PROGRESS" prior to retrieving the archive instances, this example shows the archive instances being retrieved prior to the UPS being „locked" with the N-ACTION step. This avoids the UPS being set „IN PROGRESS" if the required instances are not available, and therefore avoids the need to schedule another (different) procedure step in this case, as required by the UPS State Diagram (Supplement 96 Figure F.X.1-1). However, some object instances dynamically created to service performing of the UPS step should be supplied after setting the UPS „IN PROGRESS" (see Step 7).

6. Change UPS State to IN PROGRESS

   The TDS sets the UPS (which is managed by the TMS) to have the Unified Procedure Step Status of „IN PROGRESS" upon starting work on the item. The SOP Instance UID of the UPS will normally have been obtained in the worklist item. This is conveyed using the N-ACTION primitive of the UPS Pull SOP Class with an action type “UPS Status Change”. This message allows the TMS to update its worklist and permits other Performing Devices to detect that the UPS is already being worked on..

   The UPS is updated in this step before the required dynamic SOP Instances are obtained from the TMS (see Step 7). In radiation therapy, it is desirable to signal as early as possible that a patient is about to undergo treatment, to allow the TMS to begin other activities related to the patient delivery. If the TMS implements the UPS Watch SOP Class, other systems will be able to subscribe for notifications regarding the progress of the procedure step.

7. Retrieve TMS Objects

   In response to a C-MOVE Request, the TMS transmits to the TDS the RT Beams Delivery Instruction and possibly RT Treatment Summary Record SOP Instances to be used as input information during the task. These SOP Instances may be created “on-the-fly” by the TMS (since it was the TMS itself that transmitted the UIDs in the UPS). The RT Treatment Summary SOP Instance may be required by the TDS to determine the delivery context, although the UPS does specify a completion delivery (following a previous delivery interruption). RT Beams Treatment Record instances might also be retrieved from the TMS in this step if the TMS is used to manage these SOP Instances rather than the Archive.

8. „Start Treatment Session" on TDS console

   The User uses a control on the user interface of the TDS to indicate that he or she wishes to commence the treatment delivery session. A Treatment Session may involve fulfillment of more than one UPS, in which case Steps 4-13 may be repeated.

9. Set UPS Progress and Beam Number, Verify, and Deliver Radiation

   For each beam, the TDS updates the UPS on the TMS just prior to starting the radiation delivery sequencing. This is conveyed using the N-SET primitive of the UPS Pull SOP Class.

   The completion percentage of the entire UPS is indicated in the Unified Procedure Step Progress attribute. The algorithm used to calculate this completion percentage is not specified here, but should be appropriate for user interface display.

   The Referenced Beam Number of the beam about to be delivered is specified by encoding it as a string value in the Procedure Step Progress Description (0074,1006).

   The TDS then performs internal verifications to determine that the machine is ready to deliver the radiation, and then delivers the therapeutic radiation for the specified beam. In the current use case, it is assumed that the radiation completes normally, delivering the entire scheduled fraction. Other use cases, such as voluntary interruption by the User, or interruption by the TDS, will be described elsewhere.

   If there is more than one beam to be delivered, the verification, UPS update, and radiation delivery is repeated once per beam.

   This example does not specify whether or not treatment should be interrupted or terminated if a UPS update operation fails. The successful transmittal of updates is not intended as a gating requirement for continuation of the delivery, but could be used as such if the TDS considers that interrupting treatment is clinically appropriate at that moment of occurrence.

10. Set UPS to Indicate Radiation Complete

    The TDS may then update the UPS Progress Information Sequence upon completion of the final beam (although this is not required), and set any other attributes of interest to the SCP. This is conveyed using the N-SET primitive of the UPS Pull SOP Class.

11. Store Results

    The TDS stores any generated results to the Archive. This would typically be achieved using the Storage and/or Storage Commitment Service Classes and may contain one or more RT Beams Treatment Records or RT Treatment Summary Records, RT Images (portal verification images), CT Images (3D verification images), RT Dose (reconstructed

or measured data), or other relevant Composite SOP Instances. References to the results and their storage locations are associated with the UPS in the Set UPS to Final State message (below). The RT Beams Treatment Record instances might be stored to the TMS instead, if the TMS is used to manage these SOP Instances rather than the Archive.

The required SOP Instances are stored to the Archive in this step before the UPS is status is set to COMPLETED. In radiation therapy, it is desirable to ensure that the entire procedure is complete, including storage of important patient data, before indicating that the step completed successfully. For some systems, such as those using Storage Commitment, this may not be possible, in which case another service such as Instance Availability Notification (not shown here) would have to be used to notify the TMS of SOP Instance availability. For the purpose of this example, it is assumed that the storage commitment response occurs in a short time frame.

12. Set UPS Attributes to Meet Final State Requirements

    The TDS then updates the UPS with any further attributes required to conform to the UPS final state requirements. Also, references to the results SOP Instances stored in Step 11 are supplied in the Output Information Sequence. This is conveyed using the N-SET primitive of the UPS Pull SOP Class.

13. Change UPS State to COMPLETED

    The TDS changes the Unified Procedure Step Status of the UPS to COMPLETED upon completion of the scheduled step and storage or results. This is conveyed using the N-ACTION primitive of the UPS Pull SOP Class with an action type “UPS Status Change”. This message informs the TMS that the UPS is now complete.

14. Indicate „Treatment Session Completed“ on TDS Console

    The TDS then signals to the User via the TDS user interface that the requested procedure has completed successfully, and all generated SOP Instances have been stored.

ZZZ.3.2 Treatment Delivery Normal Flow – External Verification

ZZZ.3.2.1 Message Sequencing

Figure ZZZ.3.2.1-1 illustrates a message sequence example in the case where a treatment procedure delivery is requested and performed by a conventional delivery device requiring an external verification capability.

In the case where external verification is requested (i.e. where the UPS Requested Procedure Code Sequence item has a value of “RT Treatment With External Verification”), the information contained in the UPS and potentially other required delivery data must be communicated to the Machine Parameter Verifier (MPV). In many real-world situations the Oncology Information System fulfils both the role of the TMS and the MPV, hence this communication is internal to the device and not standardized. If separate physical devices perform the two roles, the communication may also be non-standard, since these two devices must be very closely coupled.

Elements in bold indicate the additional messages required when the Machine Parameter Verifier is charged with validating the beam parameters for each beam, prior to radiation being administered. These checks can be initiated by the User on a beam-by-beam basis („manual sequencing“, shown with the optional „Deliver Beam x“ messages), or can be performed by the Machine Parameter Verifier without intervention („automatic sequencing“). The TDS would typically store an RT Treatment Record SOP Instance after each beam.

This example illustrates the case where photon or electron beams are being delivered. If ion beams are to be delivered, instances of the RT Conventional Machine Verification IOD will be replaced with instances of the RT Ion Machine Verification IOD.

Delivery of individual beams can be explicitly requested by the User (as shown in this example), or sequenced automatically by the TDS.

ZZZ.3.2.2 Transactions and Message Flow

This section describes in detail the additional interactions illustrated in Figure ZZZ.3.2.1-1.

After the TDS has retrieved the necessary treatment SOP Instances (Step 7), the following step is performed:

7a. Communicate UPS and Required Delivery Data to MPV

The MPV must receive information about the procedure to be performed, and any other data required in order to carry out its role. This communication typically occurs outside the DICOM standard, since the TMS and MPV are tightly coupled (and may be the same physical device). In cases where standardized network communication of these parameters is required, this could be achieved using DICOM storage of RT Plan and RT Delivery Instruction SOP Instances, or alternatively by use of the UPS Push SOP Class.

After the User has initiated the treatment session on the TDS console (Step 8), the following steps are then performed:

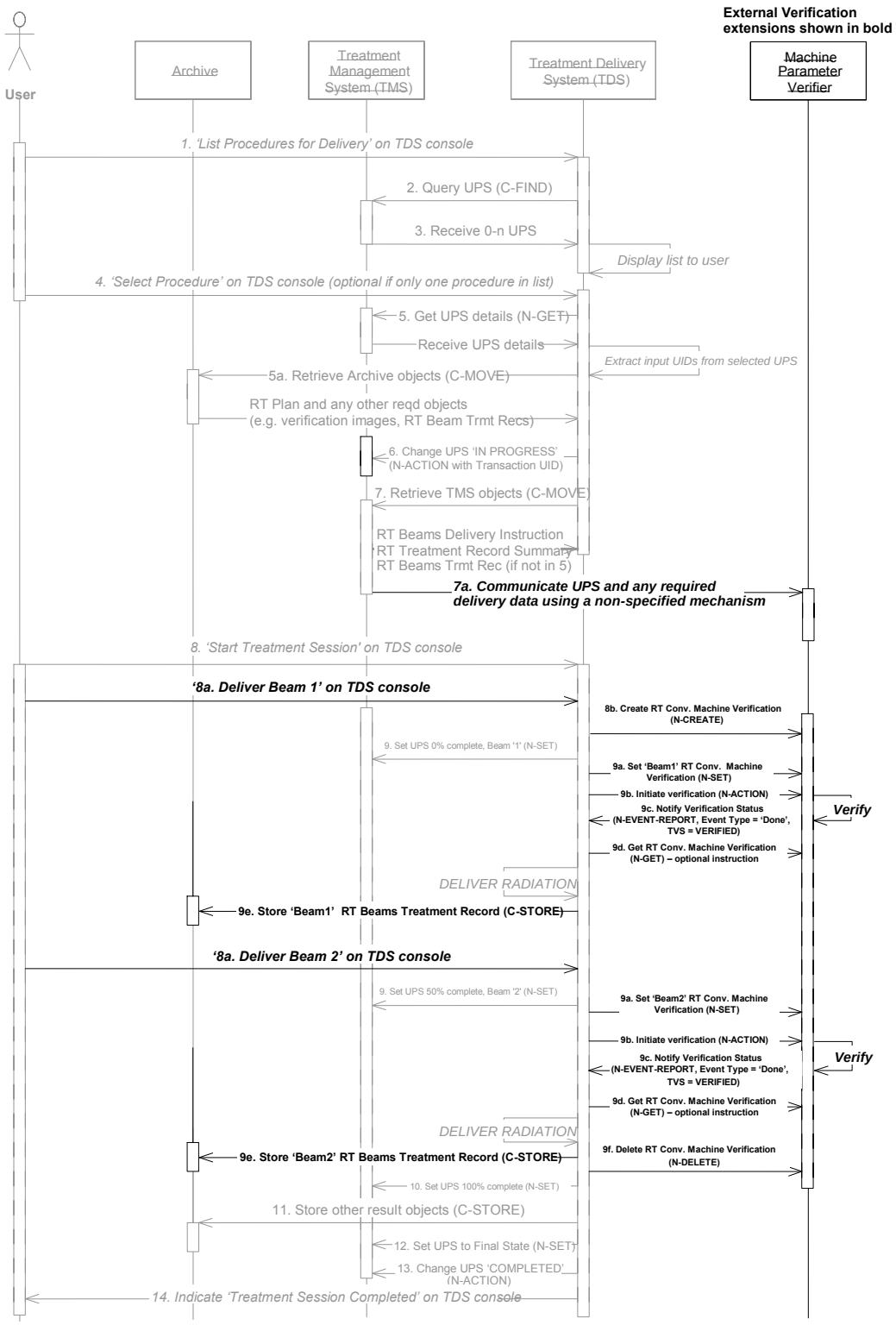
8a. „Deliver Beam x“ on TDS console

In some implementations, parameter verification for each beam may be initiated manually by the User (as shown in this example). In other approaches, the TDS may initiate these verifications automatically.

8b. Create RT Conventional Machine Verification Instance

The TDS creates a new RT Conventional Machine Verification instance on the MPV prior to beam parameter verification of the first beam to be delivered. This is conveyed using the N-CREATE primitive of the RT Conventional Machine Verification SOP Class.

Figure ZZZ.3.2.1-1 Treatment Delivery Normal Flow – External Verification Message Sequence



After the TDS has signaled the UPS current Referenced Beam Number and completion percentage for a given beam (9), the following sequence of steps is performed:

9a. Set „Beam x" RT Conventional Machine Verification Instance

The TDS sets the RT Conventional Machine Verification SOP Instance to transfer the necessary verification parameters. This is conveyed using the N-SET primitive of the RT Conventional Machine Verification SOP Class. The Referenced Beam Number (300C,0006) attribute is used to specify the beam to be delivered. It is the responsibility of the SCU to keep track of the verification parameters such that the complete list of required attributes can be specified within the top-level sequence items.

9b. Initiate Verification

The TDS sets the RT Conventional Machine Verification SOP Instance to indicate that the TDS is ready for external verification to occur. This is conveyed using the N-ACTION primitive of the RT Conventional Machine Verification SOP Class.

9c. Verify Machine Parameters

The MPV then attempts to verify the treatment parameters for „Beam x". The MPV sends one or more N-EVENT-REPORT signals to the TDS during the verification process. The permissible event types for these signals in this context are „Pending" (zero or more times, not shown in this use case), and „Done" when the verification is complete (successful or otherwise).

9d. Get RT Conventional Machine Verification (optional step)

The TDS may then request attributes of the RT Conventional Machine Verification instance. This is conveyed using the N-GET primitive of the RT Conventional Machine Verification SOP Class. If verification has occurred normally and the N-EVENT-REPORT contained a Treatment Verification Status of VERIFIED (this use case), then this step is not necessary unless the TDS wishes to record additional parameters associated with the verification process.

The TDS then delivers the therapeutic radiation. In the current use case, it is assumed that the radiation completes normally, delivering the entire scheduled fraction. Other use cases, such as voluntary interruption by the User, or interruption by the TDS or MPV, are not described here. If the delivery requires an override of additional information, a different message flow occurs. This is illustrated in the use case described in the next section.

9e. Store „Beam x" RT Beams Treatment Record to Archive

The TDS stores an RT Beams Treatment Record to the Archive (or potentially the TMS as described in Section ZZZ.3.1.2 Transactions and Message Flow). The RT Beams Treatment Record is therefore not stored in Step 11 for the external verification case (since it has already been stored in the step on a per-beam basis).

For each subsequent beam in the sequence of beams being delivered, steps 8a (optional), 9, 9a, 9b, 9c, 9d (optional), and 9e are then repeated, i.e. N-SET, N-ACTION, and N-GET operations are performed on the same instance of the RT Conventional Machine Verification SOP Class, which persists throughout the beam session.

9f. Delete RT Conventional Machine Verification Instance

When all beams have been processed, the TDS deletes the RT Conventional Machine Verification SOP Instance to indicate to the MPV that verification is no longer required.

This is conveyed using the N-DELETE primitive of the RT Conventional Machine Verification SOP Class.

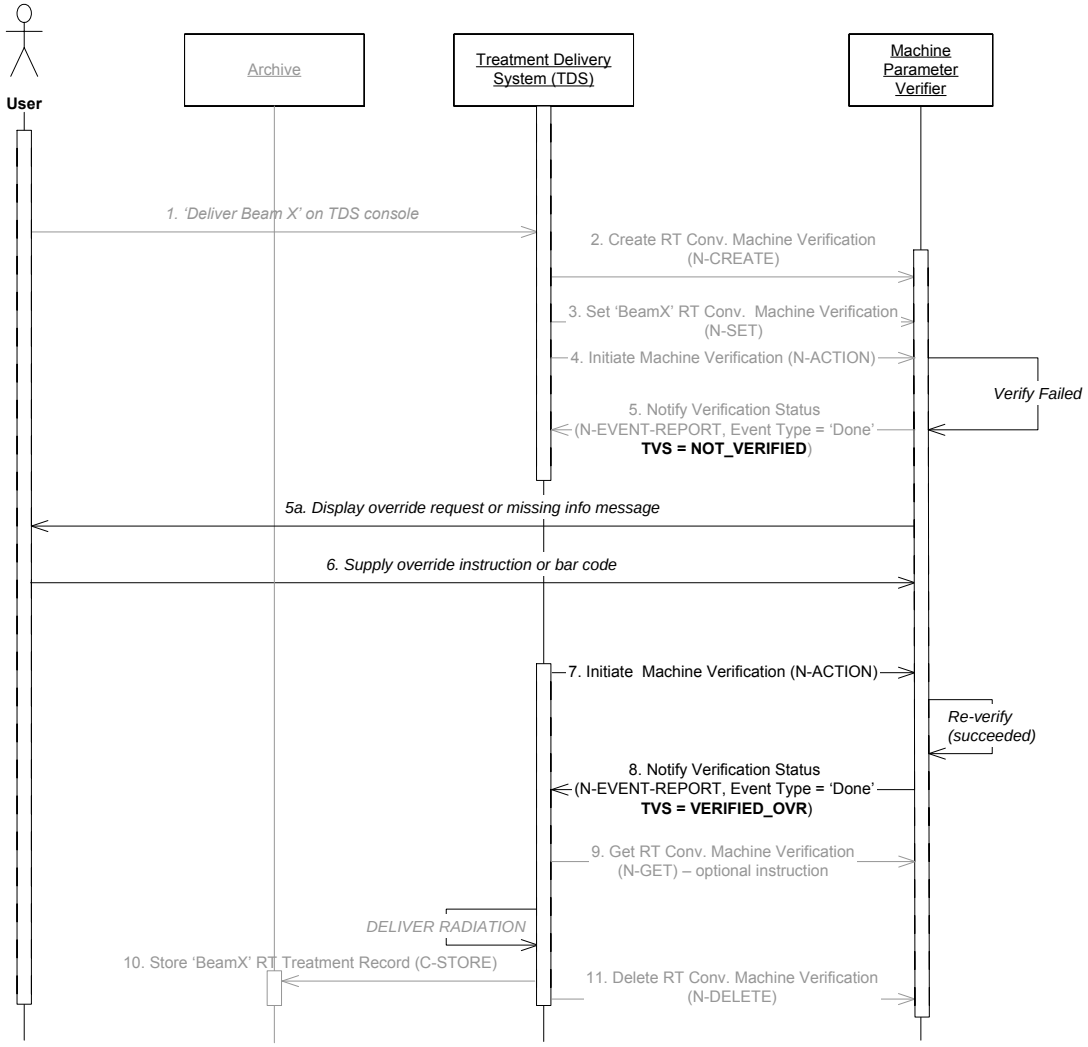
ZZZ.3.3 Treatment-Delivery with External Verification - Override or Additional Info Required

ZZZ.3.3.1 Message Sequencing

Figure ZZZ.3.3.1-1 illustrates a message sequence example for the external verification model in the case where the Machine Parameter Verifier (MPV) either detects that an override is required, or requires additional information (such as a bar code) before authorizing treatment.

The steps in this use case replace Steps 8a to 9f in Use Case ZZZ.3.2, for the case where only a single beam is delivered.

Figure ZZZ.3.3.1-1 Treatment Delivery Message Sequence- Override or Additional Information Required



ZZZ.3.3.2 Transactions and Message Flow

This section describes in detail the interactions illustrated in Figure ZZZ.3.3.1-1.

1. „Deliver Beam x" on TDS console (optional step)

   See use case ZZZ.3.2.

2. Create RT Conventional Machine Verification Instance

   See use case ZZZ.3.2.

3. Set „Beam x" RT Conventional Machine Verification Instance

   See use case ZZZ.3.2.

4. Initiate Machine Verification

   See use case ZZZ.3.2.

5. Verify Machine Parameters

   The MPV then attempts to verify the treatment parameters for „Beam x". The MPV determines that one or more treatment parameters are out-of-tolerance, or that information such as a bar code is missing. It sends an N-EVENT-REPORT signal to the TDS with an Event Type of Done and an RT Machine Verification Status of NOT_VERIFIED. The MPV also shows the reason for the override/information request on its display (5a).

6. Supply Override Instruction or Bar Code

   The User observes on the MPV console that an override or missing information is required, and supplies the override approval or missing information to the MPV via its user interface, or equivalent proxy.

7. Initiate Machine Verification

   The TDS performs another N-ACTION on the RT Conventional Machine Verification SOP Instance to indicate that the TDS is once again ready for treatment verification. See use case ZZZ.3.2. This may be initiated by the user (as shown in this example), or may be initiated automatically by the TDS using a polling approach.

8. Re-verify Machine Parameters

   The MPV verifies the treatment parameters, and determines that all parameters are now within tolerance and all required information is supplied. It sends an N-EVENT-REPORT signal to the TDS with an Event Type of Done and an RT Machine Verification Status of VERIFIED_OVR.

   Note: If another verification failure occurs, the override cycle can be repeated as many times as necessary.

9. Get RT Conventional Machine Verification (optional step)

   See use case ZZZ.3.2. If an N-GET is requested, the parameters that were overridden are available in Overridden Parameters Sequence (0074,104A).

   The TDS then delivers the therapeutic radiation.

10. Store „Beam x" RT Beams Treatment Record to Archive

    See use case ZZZ.3.2. Overridden parameters are ultimately captured in the treatment record.

11. Delete RT Conventional Machine Verification Instance

    See use case ZZZ.3.2.

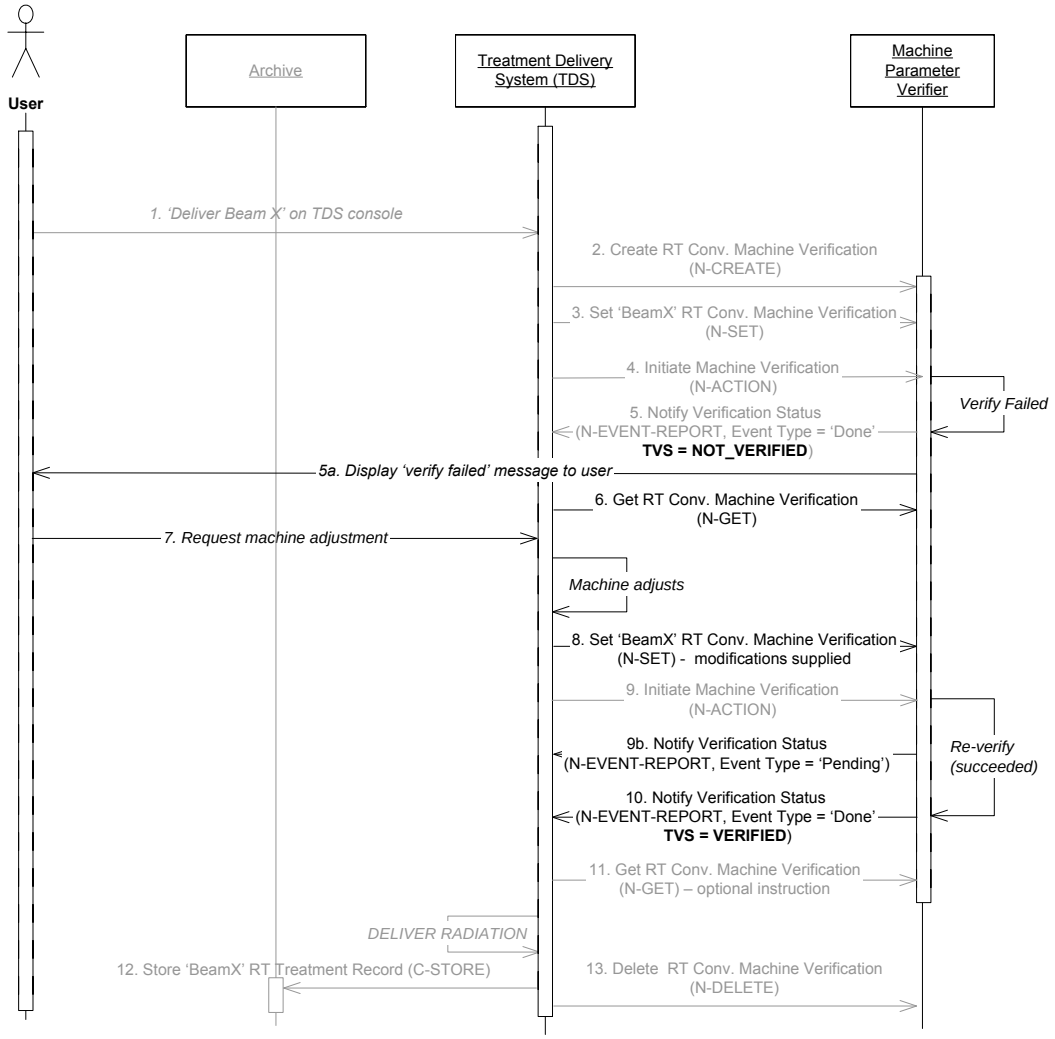
ZZZ.3.4 Treatment-Delivery with External Verification – Machine Adjustment Required

ZZZ.3.4.1 Message Sequencing

Figure ZZZ.3.4.1-1 illustrates a message sequence example for the external verification model in the case where the Machine Parameter Verifier (MPV) detects that one or more machine adjustments are required before authorizing treatment, and the TDS has been configured to retrieve the failure information and make the required adjustments.

The steps in this use case replace Steps 8a to 9f in Use Case ZZZ.3.2, for the case where only a single beam is delivered.

Figure ZZZ.3.4.1-1 Treatment Delivery Message Sequence – Machine Adjustment Required



ZZZ.3.4.2 Transactions and Message Flow

This section describe in detail the interactions illustrated in Figure ZZZ.3.4.1-1.

1. „Deliver Beam x" on TDS console (optional step)

   See use case ZZZ.3.2.

2. Create RT Conventional Machine Verification Instance

   See use case ZZZ.3.2.

3. Set „Beam x" RT Conventional Machine Verification Instance

   See use case ZZZ.3.2.

4. Initiate Machine Verification

   See use case ZZZ.3.2.

5. Verify Machine Parameters

   The MPV then attempts to verify the treatment parameters for „Beam x". The MPV determines that one or more treatment parameters are out-of-tolerance. It sends an N-EVENT-REPORT signal to the TDS with an Event Type of Done and an RT Machine Verification Status of NOT_VERIFIED. It may also display the verification status and information to the user (5a).

6. Get RT Conventional Machine Verification

   The TDS then requests the failed verification parameters of the verification process. This is conveyed using the N-GET primitive of the RT Conventional Machine Verification SOP Class. The MPV replies with an N-GET-RESPONSE having a Treatment Verification Status of NOT_VERIFIED. The reason(s) for the failure is encoded in the Failed Parameters Sequence (0074,1048) attribute of the response.

7. Request machine adjustment

   As illustrated in this example, some implementations may require that the User observes the failed verification parameters on the MPV console and manually request the required machine adjustment. In this case the User makes the request to the TDS via its user interface. In other implementations the TDS makes the adjustments automatically and request verification without User intervention.

8. Adjust TDS and Set „Beam x" RT Conventional Machine Verification Instance

   The TDS adjusts one or more of its parameters as requested, then sets the RT Conventional Machine Verification SOP Instance to indicate that the TDS is once again ready for treatment delivery. This is conveyed using the N-SET primitive of the RT Conventional Machine Verification SOP Class. The N-SET command provides values for all applicable parameters (not just those that have been modified) since if one or more parameters within a top-level sequence is supplied, then all the applicable parameters within that sequence must also be supplied (otherwise DICOM requires their values to be cleared).

9. Initiate Machine Verification

   The TDS performs another N-ACTION on the RT Conventional Machine Verification SOP Instance to request that the MPV re-perform treatment verification. See use case ZZZ.3.2.

   As an optional step, the MPV may notify the TDS that the verification is in process at any time, by sending an N-EVENT-REPORT signal to the TDS with an Event Type of Pending (9a).

10. Re-verify Machine Parameters

    The MPV verifies the treatment parameters, and determines that the required adjustments have been made, i.e. all parameters are now within tolerance. It sends an N-EVENT-REPORT signal to the TDS with an Event Type of Done and an RT Conventional Machine Verification Status of VERIFIED.

    Note: If another verification failure occurs, the override cycle can be repeated as many times as necessary.

11. Get RT Conventional Machine Verification (optional step)

    See use case ZZZ.3.2.

    The TDS then delivers the therapeutic radiation.

12. Store „Beam x" RT Beams Treatment Record to Archive

    See use case ZZZ.3.2.

13. Delete RT Conventional Machine Verification Instance

    See use case ZZZ.3.2.