



**4D Integrated
Treatment Console**

DICOM Conformance Statement



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Abstract	The 4D Integrated Treatment Console Version 7, DICOM Conformance Statement (P/N 100016768-03).	
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1. Introduction

1.1 Purpose

The definition of the DICOM standard for radiotherapy data started in 1994 and has now reached a productive state. Today, DICOM is the primary choice for exchanging data with an open standard protocol for the majority of vendors and institutions. Varian Medical Systems is committed to this notion and supports the full range of radiotherapy objects (e.g. RT Plan, RT Image, RT Treatment Record) for their V & R system.

This conformance statement specifies the conformance of the 4D Integrated Treatment Console version 7 with the DICOM V 3.0 standard.

1.2 Scope

The scope and format of this document from chapter 2 onwards are defined by Part 2 of the DICOM V3.0 standard. Some sections defined in the standard that are not applicable to the software are left out for clarity.

This Conformance Statement is applicable for 4D Console version 7.

The general DICOM conformance statement for Varian Medical Systems products is defined in [2] (see chapter 1.5). The 4D Treatment Console 6.5/7.x Conformance Statement describes only the specials and the variations as implemented in the 4D Console version 7.

1.3 Intended Audience

- Marketing and Sales.
- System Integrators of medical equipment.
- Other vendors interfacing via DICOM

1.4 Definitions

This section provides the definitions of terms, acronyms, and abbreviations, which are used throughout the document.

AE	Application Entity
DICOM	Digital Imaging and Communications in Medicine
IOD	Information Object Definition
NEMANational	Electrical Manufacturers Association
SCU	Service Class User
SCP	Service Class Provider
SOP	Service Object Pair
TCP/IP	Transmission Control Protocol / Internet Protocol
VR	Value Representation
Multi-Frame Image	Image that contains multiple two-dimensional pixel planes
UID	Unique Identifier
Management System	DICOM entity from which Treatment retrieves patient data
4DC	4D Integrated Treatment Console 7.

1.5 Related Documents

- [1] Digital Imaging and Communications in Medicine (DICOM), Parts 1-14 (2003),
National Electrical Manufacturers Association (NEMA)
Rosslyn, VA
United States of America
- [2] Vision Release 6.5, DICOM Conformance Statement' (P/N VA7202D3CS)
Varian Medical Systems International AG
Baden, Switzerland

2. Implementation Model

2.1 Application Data Flow Diagram

Three diagrams illustrating the application model, two for the SCU and one for the SCP role, are shown in Figure 1, Figure 2, and Figure 3.

The initial function to load the plan into the 4DC application is represented by *Load RT Plan* (This function is typically performed by the application after the Patient and the Plan UIDs have been received by the Management System). 4DC invokes a move command for each DICOM RT Plan. This requires the 4DC application to provide the RT Plan Storage SCP. Figure 2 shows the Service Class Providers (SCP) role supported by 4DC. 4DC then issues a move command to request and retrieve the RT Treatment Summary Record. Based on the last fraction state, a find command is executed to request the *Load Beam Record Information* (shown in Figure 1) to recover from a partial treatment.

A *Save* issued by the operator will invoke a storage command, which requires the remote application to provide a storage SCP as shown in Figure 3.

Closing the patient in 4DC will result in a *Save* if the plan data has been modified and/or treatment records and images have been created. 4DC will delete the objects temporarily stored. In case the Management System is not accessible, 4DC will save the changes into one or several DICOM Media File(s).

2.1.1 Application Data Flow Diagram

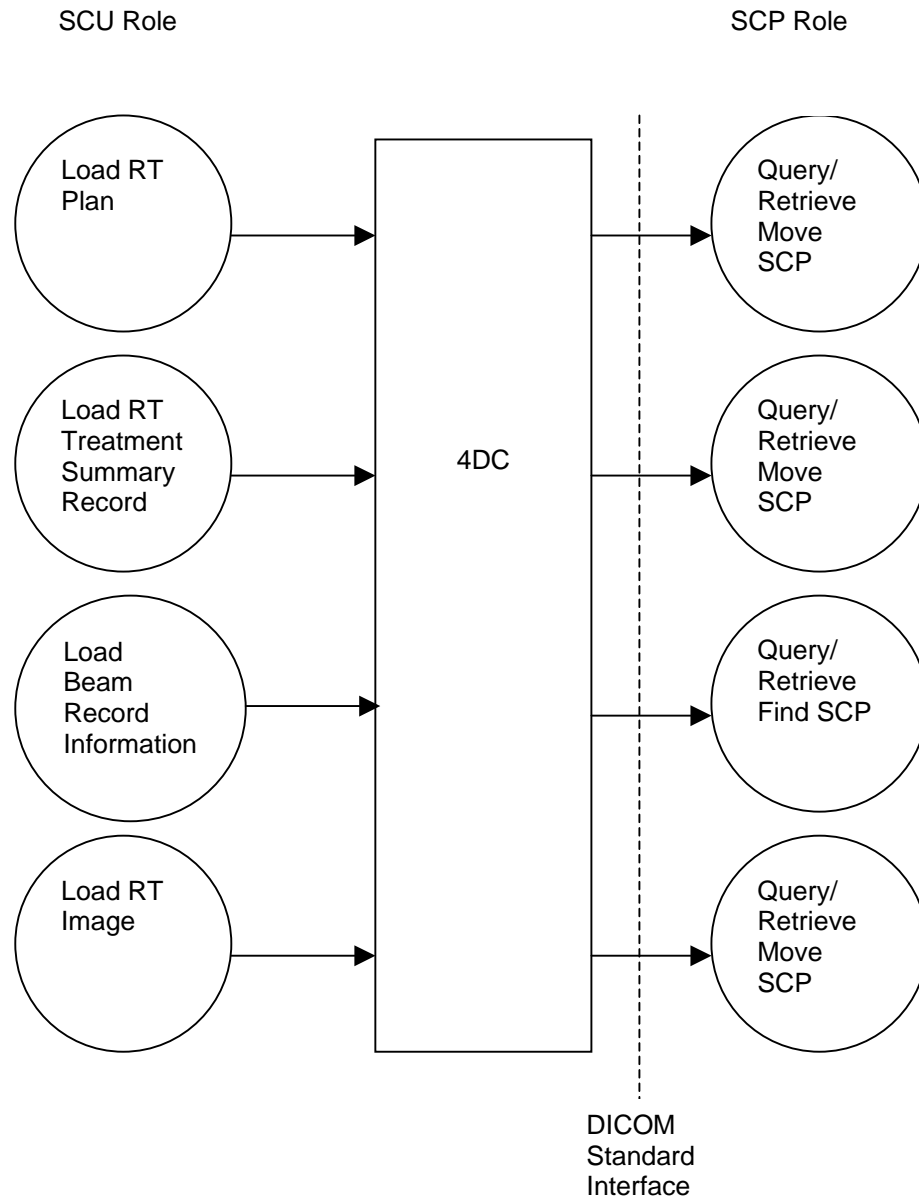


Figure 1: SCU Role Application Data Flow Diagram for loading patient data

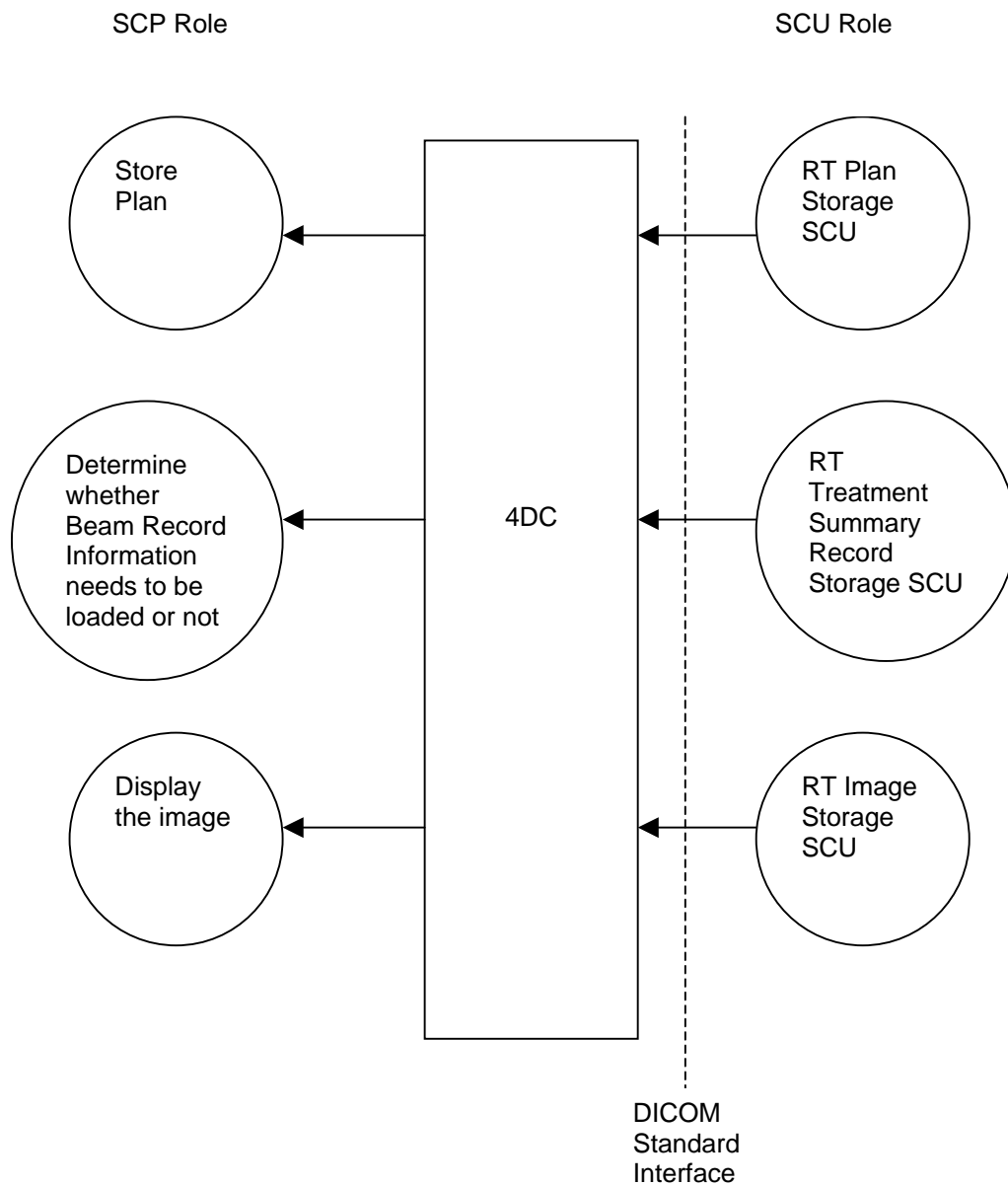


Figure 2: SCP Role Application Data Flow Diagram for loading patient data

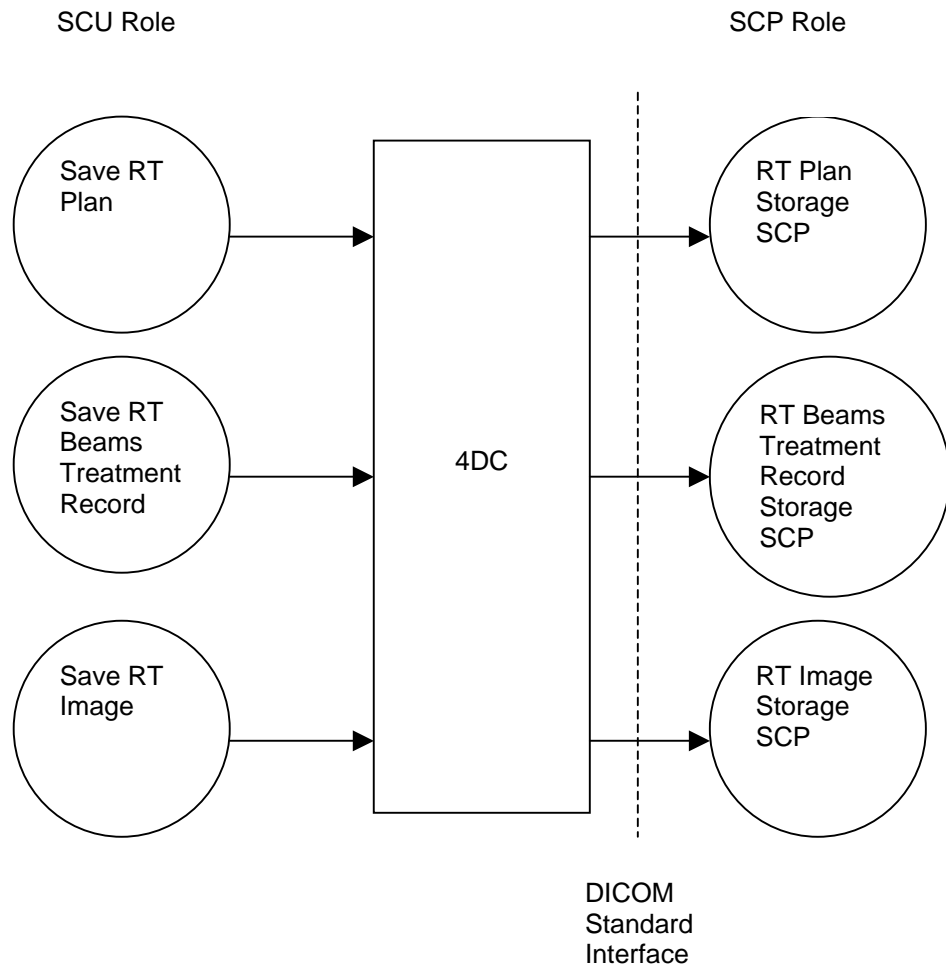


Figure 3: SCU Role Application Data Flow Diagram for saving patient data

2.2 Functional Definition of AE's

The 4DC Entity's main responsibility is to execute a patient treatment. Before treating, 4DC loads the patient data from the Management System using DICOM services. After treating, 4DC generates RT Beams Record(s) and RT Image(s). 4DC then stores them back to the Management System again using DICOM services.

4DC is also capable of modifying RT Plan(s) and/or creating new RT Plan(s).

2.3 Sequencing of Real-World Activities

4DC executes the activities for loading a patient in the following order.

- C-Find RT Plan SOP class (see chapter 3.1.2.2.3.2)
- C-Move RT Plan SOP class
- C-Move RT Treatment Summary Record SOP class

- C-Find RT Beams Record SOP class if needed (NOTE: The C-Find RT Beams Record query is only executed in order to finalize the previous treated fraction)
- C-Move RT Image SOP class (for Reference Image(s) if referred in the RT Plan)
- C-Find RT Image SOP class (for query Portal Image(s))
- C-Move RT Image SOP class (for Portal Image(s) if query returned Portal Image Instance UID(s))

The only requirement is to load the RT Plan first before the others. This sequence may be performed for more than 1 plan at the beginning of a treatment session.

The following sequence is for saving the patient to 4DC:

- C-Storage RT Plan SOP class (executed if a plan changed in 4DC)
- C-Storage RT Beams Record SOP class (executed if a beam got treated)
- C-Storage RT Image SOP class (executed if a Portal Image got acquired)

The only requirement is to save RT Plan(s) first before the RT Beam Record(s) and RT Image(s). This is because the RT Beams Record and/or RT Image may refer to the new RT Plan.

3. AE Specifications

3.1 4DC Entity Specification

The 4DC Entity provides standard conformance to the following DICOM V3.0 SOP classes:

SOP Class Name	SCU/SCP Role	SOP Class UID
Verification (Echo)	SCU / SCP	1.2.840.10008.1.1
RT Image Storage	SCU / SCP	1.2.840.10008.5.1.4.1.1.481.1
RT Plan Storage	SCU / SCP	1.2.840.10008.5.1.4.1.1.481.5
RT Treatment Summary Record Storage	SCP	1.2.840.10008.5.1.4.1.1.481.7
Study Root Query/Retrieve information model- FIND	SCU	1.2.840.10008.5.1.4.1.2.2.1
Study Root Query/Retrieve information model- MOVE	SCU	1.2.840.10008.5.1.4.1.2.2.2
RT Beams Treatment Record Storage	SCU	1.2.840.10008.5.1.4.1.1.481.4

Table 1: Supported SCU/SCP SOP Classes for 4DC Entity

3.1.1 Association Establishment Policies

3.1.1.1 General

See details in [2].

There are a total of three associations. 4DC establishes two associations while the Management System establishes one association. The first association established by 4DC is to support the C-Move and C-Find services. The second association established by 4DC is to support the C-Storage service. The association established by the Management System is for storing patient data to 4DC.

All of the association supports the C-Echo service to determine whether the association is still alive or not.

A diagram of the associations is in Figure 4.

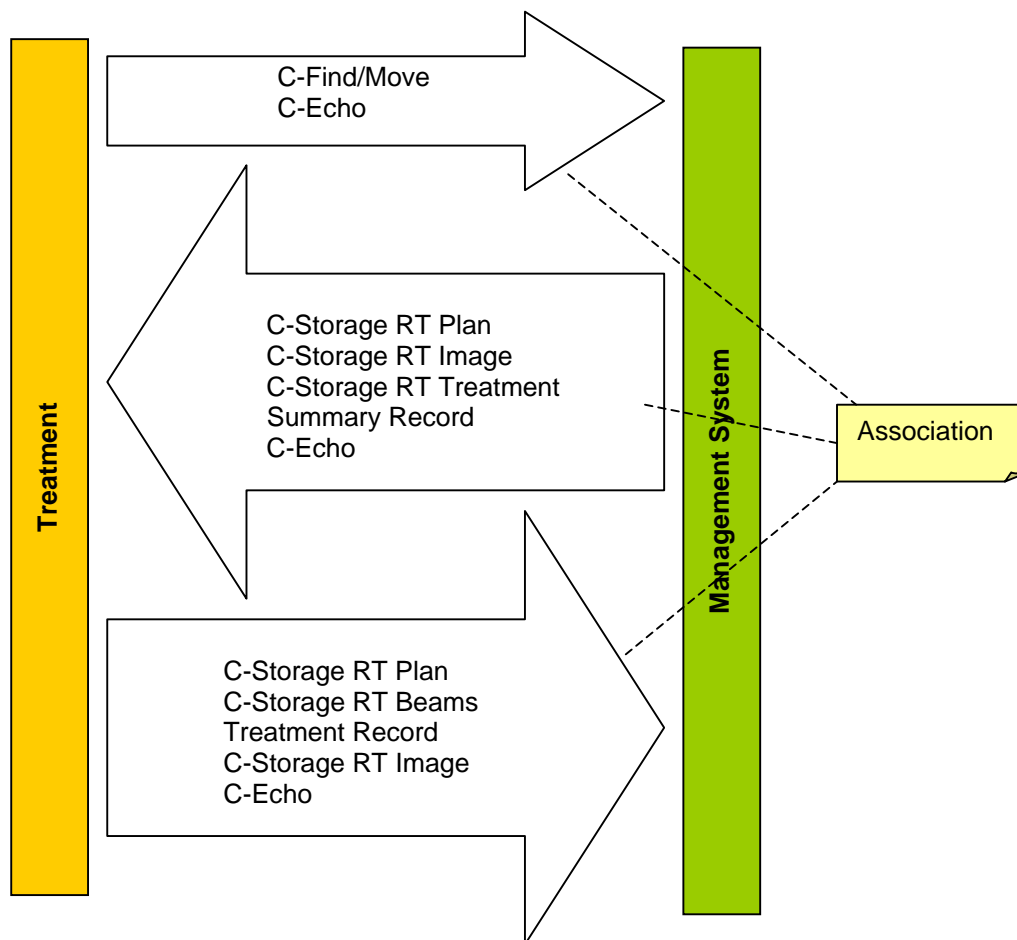


Figure 4: Associations used for 4DC

3.1.1.2 Number of Associations

In total, there are three associations established (Figure 4).

3.1.1.3 Asynchronous Nature

Asynchronous operation is not supported.

3.1.1.4 Implementation Identifying information

The following implementation class UIDs are used:

Application Entity	Implementation UID
4DC Entity SCU	1.2.246.352.70.2.1.9
4DC Entity SCP	1.2.246.352.70.2.1.10

3.1.2 Association Initiation Policy

The 4DC Entity will initiate one association for all Query/Retrieve Services (Q/R SCU) that contains the C-Find and the C-Move service.

The 4DC Entity will initiate one association for all Storage Services where it acts as a user (Storage SCU).

The Management System will initiate one association for all C-Storage services used for sending all patient data. In this association, 4DC acts as a provider (Storage SCP).

For performance reasons, 4DC maintains its associations until one of the following occurs:

- i) 4DC is terminated (this results with all associations being terminated)

or

- 2) the Echo/Verification service fails (this results with the Echo/Verification's corresponding association to be terminated)

3.1.2.1 Storage SCU

3.1.2.1.1 Associated Real-World Activity

The C-Storage service is used in 4DC to store patient data into the Management System. This service gets executed whenever the operator selects 'Close Patient' or 'Save Image'.

3.1.2.1.2 Presentation Context Table

Presentation Context Table					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		
RT Plan Storage	1.2.840.10008.5.1.4.1.1.481.5	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None
RT Beams Treatment Record Storage	1.2.840.10008.5.1.4.1.1.481.4	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None
RT Image Storage	1.2.840.10008.5.1.4.1.1.481.1	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None

Table 2: Proposed Presentation Contexts for Storage SCU

3.1.2.1.3 SOP Specific Conformance

3.1.2.1.3.1 SOP specific conformance for all Storage SOP classes

After a successful C-STORE operation, 4DC does not display any information to the user but returns to its normal state. If the C-STORE operation results with a warning or an error, 4DC displays the appropriate warning or error message to the operator.

3.1.2.1.3.2 SOP specific conformance for the RT Plan Storage SOP class

The following SOP specific conformance rules apply to 4DC:

Bolus is not supported.

Setup Fields are supported. (Note: The Field Type attribute defines whether it is a Setup field or a Treatment field (see Table 10))

4DC does not accept Arc-Dynamic Beam(s), which contain gantry rotations that is not equally spaced (e.g. 0, 10, 30, 100).

Only the first Fraction Group sequence (300A, 0070) is read. The others are discarded.

A maximum of two wedges per field are supported.

A maximum of one MLC per field is supported.

Beam energy, table parameter and rotation direction changes in the control points are not supported.

Wedge position changes are only supported for static technique (motorized wedge).

Whenever an operator changes a dose relevant attribute from the RT Plan in 4DC, a new RT Plan is created. The new RT Plan will refer to the originally loaded RT Plan through the Referenced RT Plan Sequence (300C,0002). The Referenced RT Plan Sequence (300C,0002) can only contain at most one item.

RT Plan extended interface and privatization is described in chapter 4.

3.1.2.1.3.3 SOP specific conformance for the RT Beams Treatment Record storage SOP class

Beam Limiting Device Position Sequence (300A,011A) only contains collimator jaws positions. It does not contain any MLC leaf position information. MLC leaf positions will not be reported within the RT Beams Treatment Record IOD. Beams with Treatment Delivery Type (300A,00CE) set to OPEN_PORTFILM or TRMT_PORTFILM are Image Beams. Beams with Treatment Delivery Type set to TREATMENT are Treatment Beams. All Image Beams refers to a Treatment Beam through the attribute Related Beam Number defined in chapter 4.1.2. If MU Subtraction is set for an Image Beam, the treated MU count will be deducted from the related Treatment Beam. For Treatment Beams, MU Subtraction is always set. The Treatment Termination Status (3008,002A) specifies whether the treatment was completed or partially completed. The following attributes are used to determine whether the MU Subtraction is set or not set:

Treatment Delivery Type (300A,00CE)	Related Beam Number (*)	Treatment Termination Status (3008, 002A)	MU Subtraction
OPEN_PORTFILM TRMT_PORTFILM	set	MACHINE	set
OPEN_PORTFILM TRMT_PORTFILM	set	NORMAL	not set
TREATMENT	not set	According remaining MU	set

Table 3: Treatment Termination Status

(*) Related Beam Number is a private tag added to the RT Beams Session Record module (see chapter 4.1.2)

RT Beams Treatment Record Extended Interface and privatization is described in chapter 4.

3.1.2.1.3.4 SOP specific conformance for the RT Image Storage SOP class

The 4DC Entity only stores images with the Image Type (0008,0008) set to PORTAL.

3.1.2.2 Query/Retrieve SCU

3.1.2.2.1 Associated Real-World Activity

4DC uses the Query/Retrieve information model MOVE for retrieving patient data from the Management System. After a successful query, the Management System sends the requested data with the C-Store service.

4DC uses the Query/Retrieve information model FIND for gathering information from the Management System. In order to determine whether a Beam was partially treated or completed, 4DC queries for several attributes in the RT Beams Record stored in the management.

3.1.2.2.2 Presentation Context Table

Presentation Context Table					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		
Study Root Query/ Retrieve Information Model - FIND	1.2.840.10008.5.1.4.1.2.2 .1	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None
Study Root Query/ Retrieve Information Model - MOVE	1.2.840.10008.5.1.4.1.2.2 .2	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None

Table 4: Proposed Presentation Contexts for Query/Retrieve SCU

3.1.2.2.3 SOP Specific Conformance

For all C-Move SOP classes, the query key is always the SOP Instance UID of the particular DICOM IOD that 4DC requests. There are no other matching criteria's for the C-Move key. All keys used for the C-Move service are defined in 4 and B 1.1.

The following Query/Retrieve SOP are used by 4DC as a Service Class User (SCU):

- C-Move RT Plan
- C-Move RT Treatment Summary Record
- C-Move RT Image
- C-Find RT Beams Treatment Record
- C-Find RT Plan
- C-Find RT Image

The C-Move service requires 4DC to be an SCP of the C-Storage service for the same DICOM IOD. For example whenever 4DC is a SCU of C-Move RT Plan it implies that 4DC is a SCP of C-Storage RT Plan (see Table 1).

3.1.2.2.3.1 SOP specific conformance for the C–Find RT Beams Treatment Record SOP class

The C-Find RT Beams Treatment Record SOP class will be used for calculating the remaining MU. The remaining monitor units are calculated with the *Beam Meterset (300A,0086)* in the RT Fraction Scheme module (provided from the Plan IOD) minus the *Delivered Primary Meterset (3008, 0036)* (provided from the Beam Record Information) -see Table 18). If the monitor units were overridden, the Beam Record Information contains the overridden value *Specified Meterset (3008, 0042)*. In this case, the overridden *Specified Meterset (3008, 0042)* is used instead of the *Beam Meterset (300A,0086)* to calculate the remaining monitor units.

The Treatment History key contains the matching criteria for the RT Beams Treatment Record. Whenever the key matches the particular RT Beams Treatment Record, the attributes defined in Table 18 (SCP column) gets filled in. Note that the Treatment Session Beam Sequence may contain one or more item. It is up to the Management System to decide whether for each Treatment Session Beam one Treatment History key gets send or if all Treatment Session Beam are send within one Treatment History key.

Only the last treated fraction is the fraction of interest.

3.1.2.2.3.2 SOP specific conformance for the C – Find RT Plan SOP class

Plans may be loaded into 4DC without having them scheduled for the current session. Therefore 4DC has to know how many treatment plans a patient has. This information gets retrieved with the C – Find RT Plan SOP Class. The Plan key contains the matching criteria and the placeholder for all attributes. The Plan key is defined in Table 17. The SOP Instance UID defined in the Plan key is the Plan Instance UID which will be used to load an unscheduled Plan in 4DC.

3.1.2.2.3.3 SOP specific conformance for the C – Find RT Image SOP class

Since Portal Images are not referenced within the RT Plan, 4DC queries the Portal Images from the Management System with the C – Find RT Image service SOP class. The Image key is defined in Table 16. The Referenced SOP Instance UID (i.e. the Plan Instance UID) and the Referenced Beam Number uniquely identifies the Beam, which 4DC needs to query the Portal Images from. 4DC uses the SOP Instance UID (i.e. the RT Image Instance UID) to retrieve previous acquired Portal Image. The C – Find confirmation returns as many Image keys as Portal Images stored in the Management System for that particular beam.

3.1.3 Association Acceptance Policy

The 4DC Entity accepts all association requests that request one of the supported service classes. 4DC accepts only one Management System Application Entity for the three possible associations (see Figure 4).

3.1.3.1 Storage SCP

3.1.3.1.1 Associated Real-World Activity

The patient data gets retrieved through the C- Storage service. This service is the only one that gets supported from 4DC as an SCP.

3.1.3.1.2 Presentation Context Table

Presentation Context Table					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name	UID		
Verification	1.2.840.10008.1.1	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
		DICOM Explicit VR Little Endian	1.2.840.10008.1.2.1	SCP	None
RT Plan Storage	1.2.840.10008.5.1.4.1.1.481.5	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
		DICOM Explicit VR Little Endian	1.2.840.10008.1.2.1	SCP	None
RT Plan Storage	1.2.840.10008.5.1.4.1.1.481.5	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
		DICOM Explicit VR Little Endian	1.2.840.10008.1.2.1	SCP	None
RT Treatment Summary Record Storage	1.2.840.10008.5.1.4.1.1.481.7	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
		DICOM Explicit VR Little Endian	1.2.840.10008.1.2.1	SCP	None

Table 5: Acceptable Presentation Contexts for Storage SCP

3.1.3.1.3 SOP Specific Conformance

3.1.3.1.3.1 SOP specific conformance for the Storage SOP class

4DC is not an archive system. Thus DICOM IOD's are temporarily stored during a treatment session and deleted once the session is finished.

3.1.3.1.3.2 SOP specific conformance for RT Image Storage SOP class

The 4DC Entity supports the image types DRR, PORTAL, and SIMULATOR.

To represent portal dose, RT Images of image type PORTAL are used. This is based on DICOM standard Part 3, section A.17.3 (RT Image IOD Module Table), Notes 2. The conversion between portal image pixel values and portal dose is defined by the Modality LUT module through re-scale Slope and Intercept. The unit depends on the re-scale Type. The image type in Table 6 distinguishes the two types of portal doses:

Image Type	Meaning
DERIVED\SECONDARY\PORTAL\CALCULATED_DOSE	Portal dose predicted by a treatment planning system, i.e. an estimate of the dose that will be perceived by the portal imaging device.
ORIGINAL\PRIMARY\PORTAL\ACQUIRED_DOSE	Portal dose actually measured by the portal imaging device based on its calibration.

Table 6: Image Type

RT Image Geometrical Values

RT Images (used as reference images) require a sufficient amount of geometrical parameters that will define the position of RT Images with respect to the machine. The following parameters are required for proper operation of image verification applications associated with 4DC:

X-Ray Image Receptor Translation (3002,000D)

Value must be present.

X-Ray Image Receptor Angle (3002,000E)

Value must be present.

Note: In the current release, only 0 is supported. Providing this value will ensure safe interpretation.

RT Image Position (3002,0012)

It is recommended to have this value defined. If the value is not defined, the application will assume that the image was centered on the X-Ray Image Receptor System.

Radiation Machine SAD (3002,0022) or RT Image SID (3002,0026)

At least one of the two values must be present.

Image Plane Pixel Spacing (3002,0011)

Value must be present.

Gantry Angle (300A,011E)

Value must be present. This value shall represent the angle (in IEC GANTRY system coordinates) where the physical or virtual (in case of DRR) source of radiation is located.

Note: When kV images are used as Reference Images, this value describes the projection geometry. Therefore, this value may not coincide with the Gantry Hardware Readout of the linear accelerator since the kV Image radiation source may be on a different position than the linear accelerator's target focus.

RT Orientation (3002,0010)

In the future, it is recommended to have this value defined for images that have the RT Image Plane set to NORMAL (this value is required for NON-NORMAL images). This is because the DICOM standard does not unambiguously define the position of the RT Image pixel area in the IEC Image Receptor system when this value is missing. If this value is not provided, the application assumes that the value is (1,0,0,0,-1,0).

3.1.3.1.3.3 SOP specific conformance for the RT Plan Storage SOP class

4DC will only accept the Beam Limiting Device if the verification of the treatment machine settings and the Beam Limiting Device were successful. The same rule applies to the imported Wedge, Block and Applicator data.

The following SOP specific conformance rules apply to 4DC:

Bolus is not supported.

Setup Fields are supported. (Note: The Field Type attribute defines whether it is a Setup field or a Treatment field (see Table 10))

4DC does not accept Arc-Dynamic Beam(s), which contain gantry rotations that is not equally spaced (e.g. 0, 10, 30, 100).

Only the first Fraction Group sequence (300A, 0070) is read. The others are discarded. A maximum of two wedges per field are supported.

A maximum of one MLC per field is supported.

Beam energy, table parameter and rotation direction changes in the control points are not supported.

Wedge position changes are only supported for static technique (motorized wedge).

RT Plan extended interface and privatization is described in chapter 4.

3.1.3.1.3.4 SOP specific conformance for the RT Treatment Summary Record SOP class

RT Treatment Summary Record IOD contains additional private tags defined in chapter 4.1.3.

3.1.3.2. Presentation Context Acceptance Criterion

The 4DC Entity will accept the presentation contexts listed in Table 4: Proposed Presentation Contexts for Query/Retrieve SCU.

3.1.3.3 Transfer Syntax Selection Policies

The 4DC Entity will accept the DICOM default transfer syntax (implicit VR Little Endian) for all SOP's. The 4DC Entity supports explicit VR Little Endian only for the SCP role.

4. Privatizations/Extensions/Specializations

4.1 Privatization

4.1.1 Privatization for RT Plan Storage SOP class

DICOM Extended Interface is a private module added to the RT Plan IOD. This module contains an XML stream that contains the Plan Extended Interface described in chapter 4.2.1.

Module	Tag	Description	Type	VR
DICOM Extended Interface	Extended Interface Data (3253,1000)	XML stream.	3	IS
DICOM Extended Interface	Extended Interface Length (3253,1001)	Data length of the XML stream	3	IS
DICOM Extended Interface	Extended Interface Format (3253,1002)	Extended Interface Format tag Possible value is: 'ExtendedIF'	3	IS
RT Beam/Beam Sequence	>Beam Secondary Name (3243,1009)	User-defined secondary name for Beam.	3	LO
RT Beam/Beam Sequence/Planned Verification Image Sequence	>>Imaging Device-Specific Acquisition Parameters (300A,00CC)	Type/quality used to acquire verification image. The following values are used: <u>PortImageHighQuality</u> Single port image optimized for image quality. <u>PortImageLowDose</u> Single port image optimized for low dose. <u>PortImageContinuous</u> Multiple port images acquired at highest possible rate. (300C,0008) must be 0. <u>PortImageIntegrated</u> Integrated port image with frames averaged during the entire beam on time. <u>Default Imaging Parameters (*)</u> Indicates that there is no during image planned and that the imager positions specified apply to the existing Before Image and/or After Image Beam(s).		
RT Fraction Scheme/Fraction Group Sequence/Referenced Beam Sequence	>>Maximum Treatment Time (3249,1000)	The maximum treatment time, which should not be exceeded. This item serves as a secondary safety limit besides the Beam Meterset value (300A,0086) itself. Units in [min].	3	DS

Table 7: RT Plan IOD privatization

(*) The IT Daemon stores Treatment Field data (which includes the During Image Beam) but does not store Before Image Beam and After Image Beam data. In the case where there are Before Image and/or After Image Beam(s) along with a During Image Beam, since the imager positions of the Before Image and/or After Image Beam(s) are always set equal to the During Image data, changes to the imager positions of the Before Image and After Image Beam(s) are stored in the During Beam and thus stored in IT Daemon. However, in the case where there are Before Image and/or After Image Beam(s) without a During Image Beam, changes to the Before Image and After Image Beam(s) are lost on the next retrieve from IT Daemon. To resolve this problem, the Default Imaging Parameters value was introduced. Setting Imaging Device-Specific Acquisition Parameters to Default Imaging Parameters indicates that there is no During Image Beam planned but that the imager positions contained in the Treatment Field apply to the existing Before Image and/or After Image Beam(s). The introduction of the Default Imaging Parameters value allowed imager position values of the Before Image and/or After Image Beam(s) to be stored in the Treatment Field without a During Image Beam having to be present.

4.1.2 Privatization for RT Beams Record Storage SOP class

Module	Tag	Description	Type	VR
RT Beam Session Record/Treatment Session Beam Sequence	>Treatment Machine Note (3251, 1000)	A textual description of the treatment machine details	3	LO
RT Beam Session Record/Treatment Session Beam Sequence	>Treatment Session Beam Data (3261,102A)	Extended interface in XML format (see Error! Reference source not found.).	3	OB
RT Beam Session Record/Treatment Session Beam	>Related Referenced Beam Number (3243,1026)	If TreatmentDeliveryType of the treated beam is either OPEN_PORTFILM or TRMT_PORTFILM then the Related Referenced Beam Number must be used instead of the Referenced Beam Number (300C, 0006). The Related Referenced Beam Number refers to the treatment field for which the image got taken.	3	IS

Table 8: RT Beams Record IOD privatization

The Extended Interface for the RT Beams Record IOD is described in chapter 4.2.2.

4.1.3 Privatization for Treatment Summary Record Storage SOP class

Module	Tag	Description	Type	VR
RT Treatment Summary Record	Additional Dose Value Sequence (3259,1000)	Introduces sequence of Actual Session Dose Sequence. The sequence may contain one or more items. Sequence for additional Dose Information to a Reference Point. The ReferencePoint must be connected to Referenced Plan of this TreatmentSummary Record, but also the Dose of other Plans which have the same Reference Point have influence on this values.	3	SQ
RT Treatment Summary Record/ Additional Dose Value Sequence	>Actual Session Dose (3259,1002)	Session Dose Delivered of Actual Session Required if Actual Session Dose Sequence is sent.	1C	DS
RT Treatment Summary Record/ Additional Dose Value Sequence	>Daily Dose (3259,1004)	Daily Dose of current day. Required if Actual Session Dose Sequence is sent.	1C	DS
RT Treatment Summary Record/ Additional Dose Value Sequence	>Life Time Total Dose (3259,1006)	Total Dose of Reference Point over all Plans. Required if Actual Session Dose Sequence is sent.	2C	DS
RT Treatment Summary Record	Total Number of Fractions (3265,1000)	Total number of Fractions planned for the current plan and all its former plans.	1C	SL

RT Treatment Summary Record	Last Treated Fraction (3265,1001)	<p>The index of the last fraction treated across the current plan and all its former plans. In other words: This tag will always contain the fraction, which was last treated (completely or partially). So it will be the same as in the Fraction Status Summary Sequence (3008,0240) on the last item of the sequence in the tag Referenced Fraction Number (3008,0223), as soon as the sequence is not empty any more (so after the 1st treatment has got at least 1 MU).</p> <p>In case of completing a partial treatment, the plan's current fraction number is equal to <i>Last Treated Fraction (3265, 1001)</i>.</p>	1C	SL
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Table 9: RT Treatment Summary Record IOD privatization

4.2 Extensions

This chapter describes the items not available through standard DICOM. The Extended Interface for RT Plan is supported through an additional module that gets added to the RT Plan IOD (see a4.1.1). The Extended Interface for RT Beams Record is supported through a private attribute in the Treatment Session Beam (see 4.1.2).

It should be noted that 4DC was designed to work without the extended interface. Therefore the following rules apply:

- 4DC shall not rely on the extended interface for the base functionality. It is possible to operate without RT Plan Extended interface and Treatment Session Extended Interface.
- Under no circumstances should data be presented in both Extended Interfaces and the standard DICOM definition.

4.2.1 RT Plan Extended Interface

The RT Plan Extended Interface is contained in the DICOM Extended Interface module.

Table 10 describes the extended interface. Node names with an empty data type attributes are parent XML nodes. The XML values are all text (not attributes). The data type defines which type the XML text has to be converted to.

Node Name	min occurs	Max occurs	Data Type	Node Description
ExtendedVAPlanInterface	0	1		
> Beams	0	1		
>> Beam	0	Unbounded		
>>> ReferencedBeamNumber	1	1	int	Beam identifier
>>> BeamExtension	1	1		Additional items provided from Vision to expand the features of RT Beams.
>>>> FieldType	1	1	string	TREATMENT or SETUP
>>>> RelatedTreatBeamNumber	0	1	int	Relation from the image beams to the treatment and/or setup beams.
>>>> FieldOrder	1	1	int	Order in which the fields are shown
>>>> GantryRtnExtendedStart	0	1	string	When 'true', gantry angle position is in the extended range, which means it has an over travel (a Gantry can move most typical 400' and not only 360').
>>>> GantryRtnExtendedStop	0	1	string	When 'true', gantry angle position is in the extended range, which means it has an over travel (a Gantry can move most typical 400' and not only 360').
>>>> MUSubtraction	0	1	string	MUSubtraction defines whether some MUs have to be subtracted from the related treatment beam to take images in the before phase and/or after phase. The string contains "true" or "false".
>>>> FieldSetupPhotos	0	1		
>>>>> FieldSetupPhoto	0	2		Two setup photos max
>>>>>> SetupPhotoNumber	1	1	int	Increasing number of setup photos. The value has to start from 1 and up.
>>>>>>> SetupPhotoFormat	1	1	string	The format of the pixel information. Supported values are 'JPG' and 'BMP'

>>>>> SetupPhotoPicture	1	1	hex binary	Pixel information of the photo in the corresponding format.
>>>>> PhotoModified	1	1	string	Photo has been modified. PhotoModified may have 'true' or 'false'
>>> CustomAddOns	0	1		
>>>> CustomAddOn	0	4		
>>>>> CustomAddOnType	1	1	string	Three Add On Type to choose from: BLOCK COMPENSATOR TRAY
>>>>> CustomCode	0	1	int	Codes for accessory which may be custom made or factory made (in that case the internal code in equal the custom code.)
>>>>> ReferencedAddOnNumber	0	1	int	Reference to the identification number of the Block or Compensator.
>>>>> TraySpecification	0	1		In case the CustomAddOn is a tray, it gets reported back through this node
>>>>>> TrayID	1	1	string	User-supplied identifier for tray. Max length is 16 characters.
>>>>>> SourceTrayDistance	0	1	int	The distance from source to slot. This information is needed to distinguish the slot
> ToleranceTables	0	1		
>> ToleranceTable	0	Unbounded		Additional items provided from Vision to expand the features of Tolerance Tables with AutoSetup capabilities
>>> ReferencedToleranceTableNumber	1	1	int	Refers to the tolerance table in RT Tolerance Table module
>>>> ToleranceTableExtension	1	1		
>>>>> GantryRtnSetup	0	1	string	Setup attributes may have following type: Automatic Manual Remote
>>>>> CollRtnSetup	0	1	string	
>>>>> CollXSetup	0	1	string	
>>>>> CollYSetup	0	1	string	
>>>>> PatientSupportAngleSetup	0	1	string	
>>>>> CouchLngSetup	0	1	string	
>>>>> CouchVrtSetup	0	1	string	
>>>>> CouchLatSetup	0	1	string	

>>>> TableTopEccentricAngleSetup	0	1	string	
> DoseReferences	0	1		
>> DoseReference	0	Unbounded		
>>> ReferencedDoseReferenceNumber	1	1	int	Reference to the identification number of the Dose Reference (300A,0012) in the RT Prescription module which is a representation of our reference point
>>> DoseReferenceExtension	1	1		Additional items provided from Vision to expand the features of reference points.
>>>> DailyDoseLimit	0	1	decimal	Unit is [Gy]
>>>> SessionDoseLimit	0	1	decimal	Unit is [Gy]
>>>> Breakpoints	0	1		
>>>>> Breakpoint	0	Unbounded		Breakpoint extensions. Standard DICOM does not support Breakpoints.
>>>>>> BreakpointDose	1	1	decimal	Unit is [Gy]
>>>>>> BreakpointWarning	1	1	string	Text which describes the breakpoint. Max length is 254 characters

Table 10: RT Plan Extended Interface

4.2.2 Treatment Session Extended Interface

Treatment Session Beam contains a private attribute that contains the Extended Interface as an XML stream.

Node names with an empty data type attributes are parent XML nodes. The XML values are all text (not attributes). The data type defines which type the XML text has to be converted to.

Node Name	min occurs	Max occurs	Data Type	Node Description
RTBeamSessionRecordExtendedIF	0	1		
> DoseOverrides	0	1		
>> DoseOverride	0	Unbounded		There may be as many DoseOverride nodes as Reference Points.
>>> DoseOverrideType	1	1	string	Type of dose overrides. Supported are: BREAKPOINT: Breakpoint dose limit overridden DAILYDOSE: Daily dose limit overridden SESSIONDOSE: Session dose limit overridden

				TOTALDOSE:
>>> Dose	0	1	decimal	Contains the specific overridden/authorized dose for DoseOverrideType 'BREAKPOINT' at the Reference Point referenced by Dose Reference Number. Unit is [Gy]
>>> DoseReferenceNumber	1	1	nonNegativeInteger	References the Reference Point on which the dose was applied.
>>> OperatorsName	1	1		Operator Name whom overrode/approved the specific doses.
>>>> FamilyName	0	1	string	Max length is 64 characters.
>>>> GivenName	0	1	string	Max length is 64 characters
>>>> MiddleName	0	1	string	Max length is 64 characters
>>>> Prefix	0	1	string	Max length is 64 characters
>>>> Suffix	0	1	string	Max length is 64 characters
> TraySpecifications	0	1		
>> TraySpecification	1	Unbound		As many nodes as tray applied for the treated beam.
>>> TrayID	1	1	string	That's the parameter, which needs to be defined when a tray is defined/acquired. Max length is 16 characters
>>> SourceTrayDistance	0	1	int	Radiation Source to attachment edge of tray assembly (mm).
> AdditionalOperators	0	1		

>> OperatorsName	1	2		If the 'Show Sign Off Dialog' is checked in ITAdmin -> MachineConfiguration -> Preferences, the Sign Off Dialog will be shown after closing the patient. Three OperatorsName may be entered in this dialog. The first OperatorsName will be sent through the standard attribute Operator Name (0008,1070) in the RT Beams Session Record module, the remaining two names if available will be sent here in the Extended Interface
>>> FamilyName	0	1	string	Max length is 64 characters.
>>> GivenName	0	1	string	Max length is 64 characters
>>> MiddleName	0	1	string	Max length is 64 characters
>>> Prefix	0	1	string	Max length is 64 characters
>>> Suffix	0	1	string	Max length is 64 characters

Table 11: Treatment Session Extended Interface

4.3 Specializations

This chapter describes some special features supported by the 4DC Application and the IT Daemon.

4.3.1 Undefined Values

As the management system side (VARiS/Vision applications) allows the user to let some type 1 attributes of an RT Plan to be undefined even when plans are ready for treatment, the Storage SCP of 4DC Application supports an "undefined value" for those attributes to nonetheless allow the creation of valid DICOM files.

The value of the mentioned "undefined value" is 88'888'888.

It may be used for the attributes listed in Table 12 when sending an RT Plan IOD to the 4DC Application (see Table 12):

Module	Attribute Name	Tag	Type	Remarks
RT Beams/Beam Sequence/Control Point Sequence/RT Beam Limiting Device Type	>>>Leaf/Jaw Positions	(300A,011C)	1C	Only for collimator pairs, not for MLCs
RT Beams/Beam Sequence/Control Point Sequence	>>Gantry Angle	(300A,011E)	1C	
RT Beams/Beam Sequence/Control Point Sequence	>>Beam Limiting Device Angle	(300A,0120)	1C	
RT Beams/Beam Sequence/Control Point Sequence	>>Patient Support Angle	(300A,0122)	1C	

Table 12: Tags that allow usage of “undefined value”

Note that 4DC Applications will never send back any attribute with “undefined value” 88'888'888.

4.3.2 Load and Save of Imager Positions

It is possible to transfer the imager positions between the management system (via IT Daemon) and 4DC Applications even if no verification images are planned or taken and thus “Planned Verification Image Sequence” (300A,00CA) in RT Beams Module is empty.

If the “Planned Verification Image Sequence” is empty, a pseudo verification image will be added to this sequence whose only purpose is to transmit the imager positions. This is done by adding an item to this sequence containing only the following attributes:

- X-Ray Image Receptor Angle (3002,000E)
- RT Image Position (3002,0012)
- RT Image SID (3002,0026)
- Imaging Device-Specific Acquisition Parameters (300A,00CC) containing the string “Default Imaging Parameters”

When 4DC Application sends back a plan to the management System (IT Daemon) it may omit the tag “X-Ray Image Receptor Angle” (3002,000E) because this value must be 0.0 (zero) anyway.

When imager positions are changed on 4DC Application they will be saved back to the IT Daemon when closing the patient. IT Daemon saves imager positions that are listed in the “Planned Verification Image Sequence” for sending them again to 4DC Application when the plan is requested next time.

4.3.3 RT Image Position vs. Imager Position in “Planned Verification Image Sequence”

The DICOM standard defines the “RT Image Position” (3002,0012) as “The x and y coordinates [...] of the upper left hand corner [...] of the image [...]”.

Because the size of an image to be taken is not known in advance a width and height of zero pixels is assumed in the “Planned Verification Image Sequence” of an RT Plan IOD. Therefore the position of the center of the image receptor will be used for the “RT Image Position” tag instead, because these are the same coordinates as those of the upper left hand corner of an image with zero pixels in x and y directions.

This is true for IT Daemon as well as for 4DC Application.

5. Communication profiles

5.1 Supported communications stacks

4DC Entity provides DICOM V3.0 TCP/IP Network Communication Support as defined in PS 3.8 (part 8 of the DICOM V3.0 standard).

5.1.1 TCP/IP stack

4DC Entity uses the TCP/IP stack of Microsoft Windows Operating Systems (Winsock), which is the operating system platform of the Vision applications.

5.1.1.1 Physical media support

4DC Entity can run on any physical network media that is supported by the underlying hardware and operating system (i.e. standard PCs and Windows 2000). These include, but are not limited to: thin, thick, and twisted-pair Ethernet, token ring network and FDDI

6. Configuration

4DC Entity is configured through the 4DC Administration application.

6.1 AE Title/Presentation Address Mapping

The configuration for the 4DC Entity provides a mapping of an Application Entity Title to a Presentation Address. A Presentation Address consists of a calling (local) and called (destination) AE title, a destination IP address or hostname, and a port number.

6.2 Configurable Parameters

6.2.1 4DC Entity

The configurable parameters of 4DC Entity are:

The hostname or TCP/IP address, the AE title and port number of the destination are configurable. The calling AE title and the port are configurable too.

The 4DC Entity creates a detailed log. This log should be read in case of warnings or failures and contains information about the cause of the problem.

7. Support of Extended Character Sets

Extended character sets are not supported.

Appendix A: IOD Specific Implementation Details

The following tables defines the IOD's and the supported

For the IOD Specific details see [2].

A. RT Plan IOD Module Table

IE	Module	Reference	DICOM Usage	Notes
Patient	Patient	C.7.1.1	M	
Study	General Study	C.7.2.1	M	
	Patient Study	C.7.2.2	U	Not supported
Series	RT Series	C.8.8.1	M	
Equipment	General Equipment	C.7.5.1	M	
Plan	RT General Plan	C.8.8.9	M	
	RT Prescription	C.8.8.10	U	
	RT Tolerance Tables	C.8.8.11	U	
	RT Patient Setup	C.8.8.12	U	
	RT Fraction Scheme	C.8.8.13	U	
	RT Beams	C.8.8.14	C	
	RT Brachy Application Setups	C.8.8.15	C	Not supported
	Approval	C.8.8.16	U	
	Audio	C.10.3	U	Not supported
	SOP Common	C.12.1	M	
	DICOM Extended Interface	Private module (see 4.1.1)	C	Additional features are supported with this module.

B. RT Treatment Record IOD Module Table

IE	Module	Reference	DICOM Usage	Notes
Patient	Patient	C.7.1.1	M	
Study	General Study	C.7.2.1	M	
	Patient Study	C.7.2.2	U	Not supported
Series	RT Series	C.8.8.1	M	
Equipment	General Equipment	C.7.5.1	M	
Treatment Record	RT General Treatment Record	C.8.8.17	M	
	RT Patient Setup	C.8.8.12	U	Not supported
	RT Treatment Machine Record	C.8.8.18	M	
	Measured Dose Reference Record	C.8.8.19	U	Not supported
	Calculated Dose Reference Record	C.8.8.20	U	Not supported
	RT Beams Session Record	C.8.8.21	M	
	RT Beam Summary Record	C.8.8.22	U	Not supported
	Cure	C.10.2	U	Not supported
	SOP Common	C.12.1	M	

C. RT Image IOD Module Table

IE	Module	Reference	DICOM Usage	Notes
Patient	Patient	C.7.1.1	M	
Study	General Study	C.7.2.1	M	
	Patient Study	C.7.2.2	U	Not supported
Series	RT Series	C.8.8.1	M	
Frame Of Reference	Frame of Reference	C.7.4.1	U	
Equipment	General Equipment	C.7.5.1	M	
Image	General Image	C.7.6.1	M	
	Image Pixel	C.7.6.1	M	
	Contrast/bolus	C.7.6.3	C	Not supported

	Cine	C.7.6.5	C	Not supported
	Multi-Frame	C.7.6.6	C	Not supported
	RT Image	C.8.8.2	M	
	Modality LUT	C.11.1	U	
	VOI LUT	C.11.2	U	
	Approval	C.8.8.16	U	
	Curve	C.10.2	U	
	Audio	C.10.3	U	Not supported
	SOP Common	C.12.1	M	

D. RT Treatment Summary Record Module Table

IE	Module	Reference	DICOM Usage	Notes
Patient	Patient	C.7.1.1	M	
Study	General Study	C.7.2.1	M	
	Patient Study	C.7.2.2	U	Not supported
Series	RT Series	C.8.8.1	M	
Equipment	General Equipment	C.7.5.1	M	
Treatment Record	RT General Treatment Record	C.8.8.17	M	
	RT Treatment Summary Record	C.8.8.23	M	
	Curve	C.10.2	U	Not supported
	SOP Common	C.12.1	M	

Appendix B: Query/Retrieve

B1 Study Root SOP Class Group

Table 13 shows the supported values for the tag Query/Retrieve Level (0008,0052):

Query/Retrieve Level		Value in (0008,0052)
Study Information		STUDY
Series Information		SERIES
Composite Object Instance Information	Image Information	IMAGE
	Plan Information	PLAN
	Treatment Record Information	TREATMENTRECORD
	Treatment Summary Record Information	TREATMENTSUMMARYRECORD

Table 13: Supported Query/Retrieve Levels for Query/Retrieve SCU

Note: Additional to the value IMAGE for Composite object instance Level we expect the following values for querying/retrieving the respective objects: PLAN, TREATMENTRECORD, TREATMENTSUMMARYRECORD.

B1.1 Supported Keys

The tables in the following sub section show which keys the SCU and the SCP support. Since Treatment is not SCP of any C-Find service, the SCP column indicates what the Management System shall support. A check mark in the SCU and/or SCP column indicates that SCP shall supports this key. A "M" in the SCP column indicates that the SCP uses this key for matching if a value is defined for it.

The Type column applies only to the SCU role. Type "R" means this attribute is required, Type "U" means this attribute is user-defined, and Type "O" means the attribute is optional.

B.1.1.1 Study Level

Description	Tag	Type	SCU	SCP
Query Level	(0008,0052)	R	✓	✓
Study Date	(0008,0020)	R	✓	M
Study Time	(0008,0030)	R	✓	M
Accession Number	(0008,0050)	R	✓	M
Patient's Name	(0010,0010)	R	✓	M
Patient ID	(0010,0020)	R	✓	M
Study ID	(0020,0010)	R	✓	M
Study Instance UID	(0020,000D)	U	✓	M

Table 14: Study key**B1.1.2 Series Level**

Description	Tag	Type	SCU	SCP
Query Level	(0008,0052)	R	✓	✓
Modality	(0008,0060)	R	✓	M
Series Number	(0020,0011)	R	✓	M
Series Instance UID	(0020,000E)	U	✓	M
Study Instance UID	(0020,000D)	U	✓	M

Table 15: Series key

B1.1.3 Composite object instance Level**B1.1.3.1.1 Image**

Description	Tag	Type	SCU	SCP
Query Level	(0008,0052)	R	✓	✓
Image Number	(0020,0013)	R	✓	M
SOP Instance UID	(0008,0018)	U	✓	M
Series Instance UID	(0020,000E)	U	✓	M
Study Instance UID	(0020,000D)	U	✓	M
Image Type	(0008,0008)	O	✓	M
Image Date	(0008,0023)	O	✓	M
Image Time	(0008,0033)	O	✓	M
Referenced SOP Class UID	(0008,1150)	O	✓	M
Referenced SOP Instance UID	(0008,1155)	O	✓	M
Referenced Beam Number	(300C,0006)	O	✓	M
Patient ID	(0010,0020)	O	✓	
Field Typ	(3257,1000)	O	✓	

Table 16: Image key**B1.1.3.1.2 Plan**

Description	Tag	Type	SCU	SCP
Query Level	(0008,0052)	R	✓	✓
SOP Instance UID	(0008,0018)	U	✓	M
Series Instance UID	(0020,000E)	U	✓	M
Study Instance UID	(0020,000D)	U	✓	M
Patient's Name	(0010,0010)	O	✓	M
Patient ID	(0010,0020)	O	✓	M
Plan Label	(300A,0002)	O	✓	M
Plan Date	(300A,0006)	O	✓	M
Plan Time	(300A,0007)	O	✓	✓
Number of Beams	(300A,0080)	O	✓	✓
Referenced RT Plan Sequence	(300C,0002)	O	✓	✓
>Referenced SOP Class UID	(0008,1150)	O	✓	✓
>Referenced SOP Instance UID	(0008,1155)	O	✓	✓
>RT Plan Relationship	(300A,0055)	O	✓	✓
Field Type	(3257,1000)	O	✓	
Plan Type	(3257,1001)	O		✓

Table 17: Plan Key

B.1.1.3.1.3 Treatment Record

Description	Tag	Type	SCU	SCP
Query Level	(0008,0052)	R	✓	✓
SOP Instance UID	(0008,0018)	U	✓	M
Series Instance UID	(0020,000E)	U	✓	M
Study Instance UID	(0020,000D)	U	✓	M
Referenced SOP Class UID	(0008,1150)	O	✓	M
Referenced SOP Instance UID	(0008,1155)	O	✓	M
Treatment Date	(3008,0250)	O	✓	M
Treatment Time	(3008,0251)	O	✓	M
Referenced Fraction Group Number	(300C,0022)	O	✓	✓
Treatment Session Beam Sequence	(3008,0020)	O	✓	✓
>Referenced Beam Number	(300C,0006)	O	✓	✓
>Treatment Delivery Type	(300A,00CE)	O	✓	✓
>Treatment Termination Status	(3008,002A)	O	✓	✓
>Delivered Primary Meterset	(3008,0036)	O	✓	✓
>Current Fraction Number	(3008,0022)	O	✓	✓
>Referenced Calculated Dose Reference Sequence	(3008,0090)	O	✓	✓
>>Referenced Dose Reference Number	(300C,0051)	O	✓	✓
>>Calculated Dose Reference Value	(3008,0076)	O	✓	✓
>Control Point Delivery Sequence	(3008,0040)	O	✓	✓
>>Referenced Control Point Index	(300C,00F0)	O	✓	✓
>>Specified Meterset	(3008,0042)	O	✓	✓
>>Override Sequence	(3008,0060)	O	✓	✓
>>>Override Parameter Pointer	(3008,0062)	O	✓	✓

Table 18: Treatment Record key

B1.1.3.1.4 Treatment Summary Record

Description	Tag	Type	SCU	SCP
Query Level	(0008,0052)	R	✓	✓
Referenced SOP Class UID	(0008,1150)	O	✓	M
Referenced SOP Instance UID	(0008,1155)	O	✓	M
Current Treatment Status	(3008,0200)	O	✓	✓
Number of Fractions Delivered	(3008,005A)	O	✓	✓
Treatment Summary Calculated Dose Reference Sequence	(3008,0050)	O	✓	✓
>Referenced Dose Reference Number	(300C,0051)	O	✓	✓
>Dose Reference Description	(300A,0016)	O	✓	✓
>Cumulative Dose to Dose Reference	(3008,0052)	O	✓	✓

Table 19: Treatment Summary Record key