GE Medical Systems

Technical Publications

2391564-100
Revision 1

4DCT Review

Conformance Statement

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REVISION HISTORY

REV	DATE	REASON FOR CHANGE
A	Jul, 2003	Initial release
0	Aug, 2003	Modifications according to HII CSAE -H03147
1	Aug, 2003	Corrected BUCge96172, BUCge96234

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4DCT Review Conformance Statement for DICOM V3.0

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SECTION 1 INTRODUCTION

1-1 Overview

This DICOM Conformance Statement is divided into sections as described below:

SECTION 1, *Introduction*, which describes the overall structure, intent and references for this Conformance Statement.

SECTION 2, *Network Conformance Statement*, which specifies the GEMS equipment compliance to the DICOM requirements for the implementation of Networking features.

SECTION 3, *Secondary Capture Information Object Implementation,* which defines the GEMS equipment compliance to DICOM requirements for the implementation of a Secondary Capture information object.

SECTION 4, *RT Structure Set Information Object Implementation,* which defines the requirements for RT Structure Set information object imported into 4DCT Review.

SECTION 5, *CT Image Information Object Requirements,* which defines the requirements for CT Images used as input to 4DCT Review.

1-2 Overall DICOM Conformance Statement Document Structure

The Documentation Structure of the GEMS Conformance Statements and their relationship with the DICOM v3.0 Conformance Statements is shown in **ILLUSTRATION** 1-1.

This document specifies the DICOM v3.0 implementation for the 4DCT Review application. It forms part of the following document set:

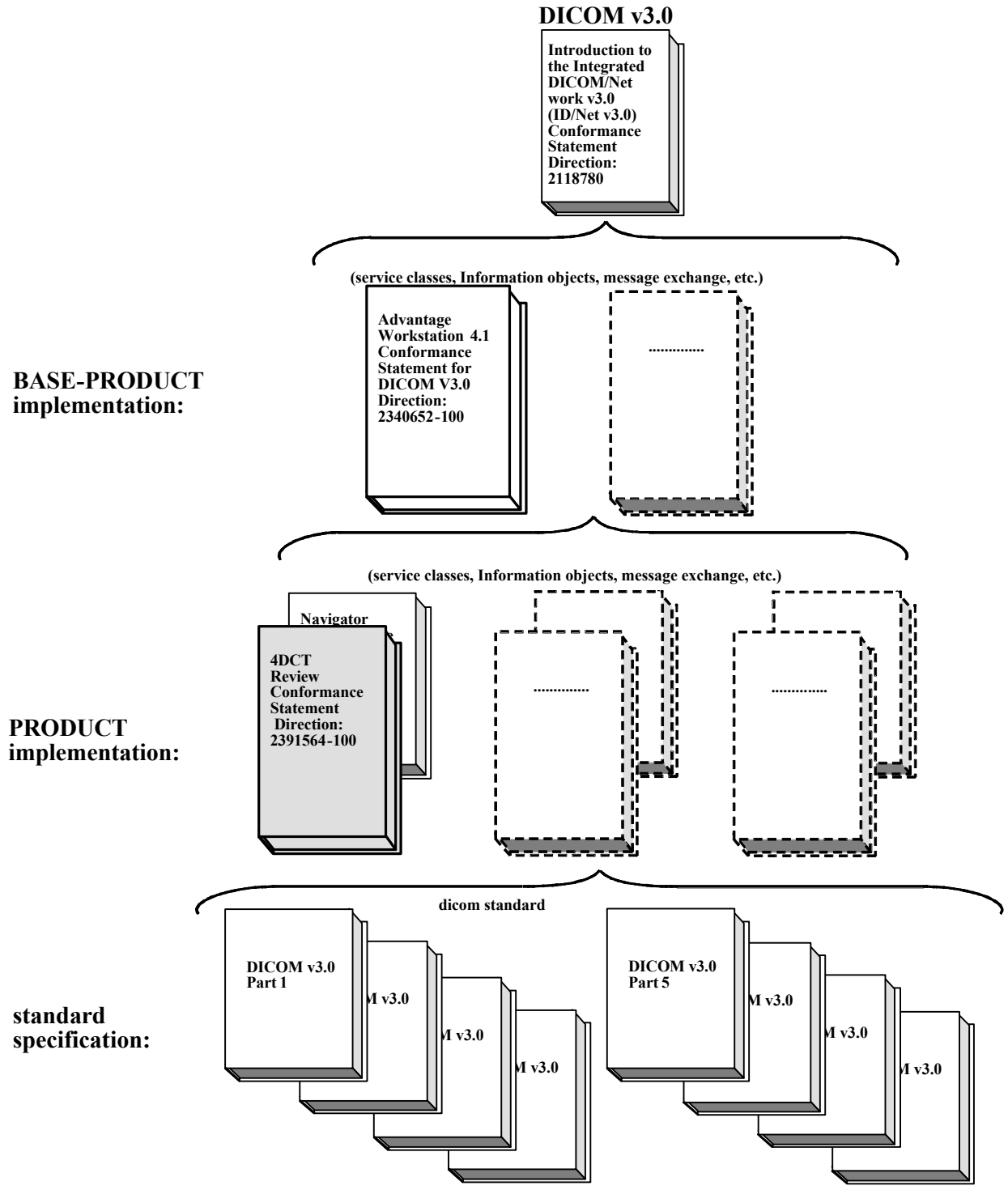
4DCT Review
Conformance Statement
Direction .....# 2391564-100.

This DICOM Conformance Statement documents the DICOM compatibility of the 4DCT Review application, which is not already provided by the base platform application, Advantage Workstation. The DICOM compatibility of this base application is in turn described in the document:

ADVANTAGE WORKSTATION 4.1
Conformance Statement for DICOM V3.0
Direction .....# 2340652-100.

Those sections of the 4DCT Review Conformance Statement, which have been modified with respect to the Workstation Conformance Statement, are included in the current document. The reader should refer to the Advantage Workstation Conformance Statement for all sections not found in the current document.

ILLUSTRATION **1-1**
DOCUMENTATION STRUCTURE



The above DICOM Conformance Statements document the DICOM Conformance Statement and Technical Specification required to interoperate with the GEMS DICOM v3.0 network interface. Introductory information, which is applicable to all GEMS DICOM v3.0 Conformance Statements, is described in the document:

Introduction to the Integrated DICOM/Network v3.0 (ID/Net v3.0)
Conformance Statement
Direction .....# 2118780.

This Introduction familiarizes the reader with DICOM terminology and general concepts. It should be read prior to reading the individual products' GEMS Conformance Statements.

The GEMS Conformance Statement, contained in this document, also specifies the Lower Layer communications, which it supports (e.g. TCP/IP). However, the Technical Specifications are defined in the DICOM v3.0 Part 8 Standard.

For more information regarding DICOM, copies of the Standard may be obtained on the Internet at <http://medical.nema.org>. Comments on the Standard may be addressed to:

DICOM Secretariat

NEMA

1300 N. 17th Street, Suite 1847

Rosslyn, VA 22209

USA

Phone: +1.703.841.3200

1-3 Intended Audience

The reader of this document is concerned with software design and/or system integration issues. It is assumed that the reader of this document is familiar with the DICOM Standards and with the terminology and concepts, which are used in those Standards.

If readers are unfamiliar with DICOM terminology they should first refer to the document listed below, then read the DICOM Standard itself, prior to reading this Conformance Statement document.

Introduction to the Integrated DICOM/Network v3.0 (ID/Net v3.0)
Conformance Statement
Direction .....# 2118780.

1-4 Scope and Field of Application

It is the intent of this document, in conjunction with the *Introduction to the Integrated DICOM/Network v3.0 (ID/Net v3.0) Conformance Statement, Direction: 2118780* , and the *Advantage Workstation 4.1 Conformance Statement for DICOM V3.0, Direction: 2340652-100* to provide an unambiguous specification for GEMS implementations. This specification, called a Conformance Statement, includes a DICOM v3.0 Conformance Statement and is necessary to ensure proper processing and interpretation of GEMS medical data exchanged using DICOM. The GEMS Conformance Statements are available to the public.

The reader of this Conformance Statement should be aware that different GEMS devices are capable of using different Information Object Definitions. For example, a GEMS CT Scanner may send images using the CT Information Object, MR Information Object, Secondary Capture Object, etc.

Included in this Conformance Statement are the Module Definitions, which define all data elements, used by this GEMS implementation. If the user encounters unspecified private data elements while parsing a GEMS Data Set, the user is well advised to ignore those data elements (per the DICOM v3.0 standard). Unspecified private data element information is subject to change without notice. If, however, the device is acting as a "full fidelity storage device", it should retain and retransmit all of the private data elements, which are sent by GEMS devices.

1-5 Important Remarks

The use of these DICOM Conformance Statements, in conjunction with the DICOM v3.0 Standards, is intended to facilitate communication with GE imaging equipment. However, **by itself, it is not sufficient to ensure that inter-operation will be successful.** The **user (or user's agent)** needs to proceed with caution and address at least four issues:

- **Integration** – The integration of any device into an overall system of interconnected devices goes beyond the scope of standards (DICOM v3.0), and of this introduction and associated DICOM Conformance Statements when interoperability with non-GE equipment is desired. The responsibility to analyze the applications requirements and to design a solution that integrates GE imaging and radiotherapy equipment with non–GE systems is the **user's** responsibility and should not be underestimated. The **user** is strongly advised to ensure that such an integration analysis is correctly performed.
- **Validation** – Testing the complete range of possible interactions between any GE device and non–GE devices, before the connection is declared operational, should not be overlooked. Therefore, the **user** should ensure that any non–GE provider accepts full responsibility for all validation required for their connection with GE devices. This includes the accuracy of the image or therapy data once it has crossed the interface between the GE imaging or radiotherapy equipment and the non–GE device and the stability of the image or radiotherapy data for the intended applications.
  Such a validation is required before any clinical use (diagnosis and/or treatment) is performed. It applies when images and radiotherapy data acquired on GE imaging equipment are processed/displayed on a non-GE device, as well as when images and radiotherapy data acquired on non-GE equipment is processed/displayed on a GE console or workstation.
- **Future Evolution** – GE understands that the DICOM Standard will evolve to meet the user's growing requirements. GE is actively involved in the development of the DICOM v3.0 Standard. DICOM v3.0 will incorporate new features and technologies and GE may follow the evolution of the Standard. The GEMS protocol is based on DICOM v3.0 as specified in each Conformance Statement. Evolution of the Standard may require changes to devices, which have implemented DICOM v3.0. **In addition, GE reserves the right to discontinue or make changes to the support of communications features (on its products) reflected on by these DICOM Conformance Statements.** The **user** should ensure that any non–GE provider, which connects with GE devices, also plans for the future evolution of the DICOM Standard. Failures to do so will likely result in the loss of function and/or connectivity as the DICOM Standard changes and GE Products are enhanced to support these changes.
- **Interaction** – It is the sole responsibility of the **non–GE provider** to ensure that communication with the interfaced equipment does not cause degradation of GE imaging or radiotherapy equipment performance and/or function.

1-6 References

A list of references which is applicable to all DICOM v3.0 Conformance Statements is included in the *Introduction to the Integrated DICOM/Network v3.0 (ID/Net v3.0) Conformance Statement, Direction: 2118780.*

The information object implementation refers to DICOM PS3.3 -1998 (Information Object Definitions).

1-7 Definitions

A set of definitions which is applicable to all DICOM v3.0 Conformance Statements is included in the *Introduction to the Integrated DICOM/Network v3.0 (ID/Net v3.0) Conformance Statement, Direction: 2118780.*

A set of definitions, which is applicable to radiotherapy, is included in DICOM PS3.3 - 1998 (Information Object Definitions).

1-8 Symbols and Abbreviations

A list of symbols and abbreviations which is applicable to all DICOM v3.0 Conformance Statements is included in the *Introduction to the Integrat ed DICOM/Network v3.0 (ID/Net v3.0) Conformance Statement, Direction: 2118780.*

A set of symbols and abbreviations, whi ch is applicable to radiotherapy, is available in CEI/IEC 1217: 1996 (Radiotherapy equipment – Coordinates, movements and scales).

SECTION 2 NETWORK CONFORMANCE STATEMENT

2-1 Introduction

This section of the conformance statement (CS) specifies the 4DCT Review compliance to DICOM Media Interchange.

4DCT Review is a diagnostic application used in the preparation of a 4DCT-scanned patient for treatment by radiotherapy that is installed on the same hardware platform as the base application, Advantage Workstation (Conformance Statement for DICOM V3.0 Direction: 2261302-100.). This base application is a Networked Medical Imaging Console dedicated to Examination Review and Diagnosis. The workstation uses DICOM services to import acquisition images for possible further analysis or processing, and to export images and radiotherapy data to other vendors. Additionally, radiotherapy data may be imported for further processing by Advantage Workstation or 4DCT Review.

4DCT Review does not have an intrinsic DICOM Network feature. It does not directly invoke the DICOM Server AE. For some detailed information on DICOM features of Advantage Windows, refer to the respective Conformance Statement

The application creates Secondary capture SOP Instances (Secondary Capture Image Storage 1.2.840.10008.5.1.4.1.1.7), use CT Images (CT Image Storage 1.2.840.10008.5.1.4.1.1.2) and RT Structure Sets (RT Structure Set Storage 1.2.840.10008.5.1.4.1.1.481.3).

2-2 Implementation model

2-2-1 Application Data Flow Diagram

Refer to the respective Conformance Statement - ***Advantage Workstation 4.1*** *Conformance Statement for DICOM, Direction 2340652-100, Revision 1.*

2-2-2 Presentation Context Table

Presentation Context Table					
Abstract Syntax		**Transfer Syntax**		**Role**	**Extended Negotiation**
Name	**UID**	**Name**	**UID**		
SC Image Storage (4DCT Review implementation)	1.2.840.10008.5.1.4.1.1.7	Implicit VR Little Endian	1.2.840.10008.1.2	SCU	NONE
CT Image Storage	1.2.840.10008.5.1.4.1.1.2	Explicit VR Little Endian Implicit VR Little Endian	1.2.840.10008.1.2.1 1.2.840.10008.1.2	SCP	NONE
RT Structure Set Storage	1.2.840.10008.5.1.4.1.1.481.3	Explicit VR Little Endian Implicit VR Little Endian	1.2.840.10008.1.2.1 1.2.840.10008.1.2	SCP	NONE

2-2-3 Real-World Activities

The user can select CT Images(multiple phases), R T Structure Set, or CT images al ong with an RT Structure Set, then start application from AW. Perform the review, then user action needs to indicate saving SC. Also the 4DCT Review application can be started from the Advantage 4DCT application, with the CT Images just created. After user request the Secondary Capture is created and saved into Advantage Windows database.

The **goal of this document** is to give a detailed description of:

- the CT IMAGE DICOM IOD (1.2. 840.10008.5.1.4.1.1.2) read by the application, required to reconstruct a 3-dimensional volume

- the SC IMAGE IOD (1.2.840.10008.5.1.4.1.1.7) generated by the application

- the RT STRUCTURE SET IOD (1.2.840.10008.5.1.4.1.1. 481.3) read by the application.

Note that the format of this section strictly follows the format defi ned in DICOM Standard PS 3.2 (Conformance). Please refer to that part of the standard while reading this section.

SECTION 3 SECONDARY CAPTURE INFORMATION OBJECT IMPLEMENTATION

3-1 Introduction

This section specifies the use of the DICOM Secondary Capture Image IOD to represent the information included in Secondary Capture images produced by this implementation. Corresponding attributes are conveyed using the module construct.

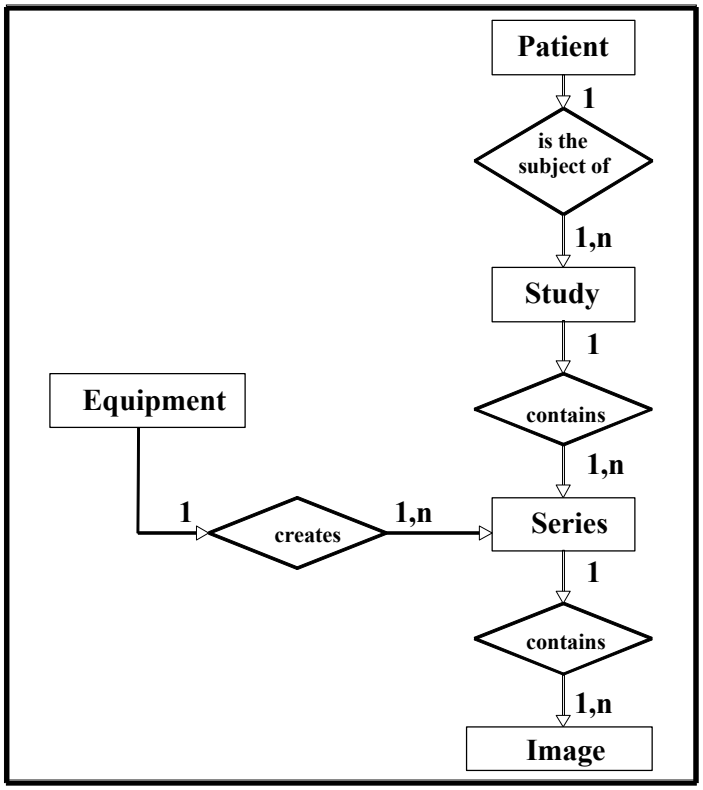
Note that the implementation described in this section relates to generation of SC Images by the 4DCT Review product only. The 4DCT Review application does not display SC Images directly, but relies on the Advantage Workstation product for this function. SC Image conformance for Advantage Workstation is described in a related document entitled ***Advantage Workstation 4.1*** *Conformance Statement for DICOM V3.0, Direction 2340652-100*.

3-2 SC Image IOD Implementation

This section defines the implementation of the SC Image information object in the 4DCT Review application. It refers to the DICOM Standard, Part 3 (Information Object Definition).

3-3 SC Image IOD Entity-Relationship Model

ILLUSTRATION **3-2**
SC IMAGE ENTITY RELATIONSHIP DIAGRAM



The Entity-Relationship diagram for the SC Image interoperability schema is shown in **ILLUSTRATION** 3-2. In this figure, the following diagrammatic convention is established to represent the information organization:

- each entity is represented by a rectangular box
- each relationship is represented by a diamond shaped box.
- the fact that a relationship exists between two entities is depicted by lines connecting the corresponding entity boxes to the relationship boxes.

The relationships are fully defined with the maximum number of possible entities in the relationship shown. See DICOM Part 3 Section 5.1.2 for an explanation of the entity-relationship notation.

3-3-1 Entities Description

Refer to DICOM Standard Part 3 (Information Object Definitions) for a description of each of the entities contained within the Secondary Capture Image information object.

3-3-2 4DCT Review Mapping of DICOM entities

DICOM entities map to the 4DCT Review entities in the following manner:

DICOM	4DCT Review
Patient Entity	Patient Entity (Advantage Workstation)
Study Entity	Examination Entity (Advantage Workstation)
Series Entity	Series Entity (Advantage Workstation)
Equipment Entity	Workstation on which 4DCT Review application is running
Image Entity	Screen save of any 4DCT Review image (generated from within application using 4DCT Review menu option in main panel). 4DCT Review does not directly display SC Images.

3-4 SC Image IOD Module Table

Within an entity of the DICOM SC Image Information Object Definition, attributes are grouped into related set of attributes. A set of related attributes is termed a module. A module facilitates the understanding of the semantics concerning the attributes and how the attributes are related with each other. A module grouping does not infer any encoding of information into datasets.

TABLE 3-1 identifies the defined modules within the entities, which comprise the DICOM SC Image Information Object Definition. Modules are identified by Module Name.

See DICOM Part 3 for a complete definition of the entities, modules, and attributes.

TABLE 3-1
SC Image Information Object Definition (IOD) Module Table

Entity Name	Module Name	Usage	Reference
Patient	Patient	M	3-5-1-1
Study	General Study	M	3-5-2-1
	Patient Study	U	not used
Series	General Series	M	3-5-3-1
Equipment	General Equipment	U	3-5-4-1
	SC Equipment	M	3-5-4-2
Image	General Image	M	3-5-5-1
	Image Pixel	M	3-5-5-2
	SC Image	M	3-5-5-3
	Overlay Plane	U	not used
	Modality LUT	U	not used
	VOI LUT	U	not used
	SOP Common	M	3-5-5-4

3-5 Information Module Definitions

Please refer to DICOM Standard Part 3 (Information Object Definition) for a description of each of the entities and modules contained within the SC Information Object.

3-5-1 Patient Entity Modules

3-5-1-1 Patient Module

Attribute Name	Element Tag	TP	Notes
Patient's Name	(0010,0010)	2	Duplicated from patient model images if present in those images, otherwise zero-length
Patient ID	(0010,0020)	2	Duplicated from patient model images if present in those images, otherwise zero-length
Patient's Birth Date	(0010,0030)	2	Duplicated from patient model images if present in those images, otherwise zero-length

Patient's Sex	(0010,0040)	2	Duplicated from patient model images if present in those images, otherwise zero-length

3-5-2 Study Entity Modules

3-5-2-1 General Study

Attribute Name	Element Tag	TP	Notes
Study Instance UID	(0020,000D)	1	Duplicated from patient model images
Study Date	(0008,0020)	2	Duplicated from patient model images if present in those images, otherwise zero-length
Study Time	(0008,0030)	2	Duplicated from patient model images if present in those images, otherwise zero-length
Referring Physicians' Name	(0008,0090)	2	Zero-length
Study ID	(0020,0010)	2	Duplicated from patient model images (must be present in those images - see Section 5)
Accession number	(0008,0050)	2	Duplicated from patient model images if present in those images, otherwise zero-length

3-5-3 Series Entity Modules

3-5-3-1 General Series

Attribute Name	Element Tag	TP	Notes
Modality	(0008,0060)	1	'OT'
Series Instance UID	(0020,000E)	1	Created for first image in series, otherwise copied from existing images in series
Series Number	(0020,0011)	2	'100' by default, if it already exists for other type of objects then '1100'
Series Description	(0008,103E)	3	'SC Image (4DCT Review)'

3-5-4 Equipment Entity Modules

3-5-4-1 General Equipment

Attribute Name	Element Tag	TP	Notes
Manufacturer	(0008,0070)	2	'GE MEDICAL SYSTEMS'
Station Name	(0008,1010)	3	<station hostname>
Manufacturer's Model Name	(0008,1090)	3	'4DCT Review'
Device Serial Number	(0018,1000)	3	<station host ID>
Software Versions	(0018,1020)	3	'1.x.x' (single-valued)

3-5-4-2 SC Equipment

Attribute Name	Element Tag	TP	Notes
Conversion Type	(0008,0064)	1	'WSD'
Modality	(0008,0060)	3	'OT'
Secondary Capture Device ID	(0018,1010)	3	<station host ID>
Secondary Capture Device Manufacturer	(0018,1016)	3	'GE MEDICAL SYSTEMS'
Secondary Capture Device Manufacturer's Model Name	(0018,1018)	3	'4DCT Review'
Secondary Capture Device Software Version	(0018,1019)	3	'1.x.x'

3-5-5 Image Entity Modules

3-5-5-1 General Image

Attribute Name	Element Tag	TP	Notes
Image (Instance) Number	(0020,0013)	2	Unique Number within current runnin g of 4DCT Review.
Patient Orientation	(0020,0020)	2C	Zero-length
Image Date	(0008,0023)	2C	Date when Secondary Capture Image was created.
Image Time	(0008,0033)	2C	Time when Secondary Capture Image was created.
Image Type	(0008,0008)	3	'DERIVED\SECONDARY' (Value 3 and Value 4 not supplied)
Image Comments	(0020,4000)	3	If RTSS was loaded, 'rtss_*name* (rtss_*date_time*)' where rtss_*name* is the RTSS Label of the referenced RTSS, and *rtss_date_time* is the save date/ time of referenced RTSS, if no RTSS was loaded, the date and time of the CT data default empty.
Burned In Annotation	(0028,0301)	3	'YES'
Lossy Image Compression	(0028,2110)	3	'00'

3-5-5-2 Image Pixel

Attribute Name	Element Tag	TP	Notes
Samples per Pixel	(0028,0002)	1	1
Photometric Interpretation	(0028,0004)	1	'MONOCHROME2'
Rows	(0028,0010)	1	512 (quarter-screen image) or 1024 (full-screen image)
Columns	(0028,0011)	1	512 (quarter-screen image) or 1024 (full-screen image)
Bits Allocated	(0028,0100)	1	8
Bits Stored	(0028,0101)	1	8
High Bit	(0028,0102)	1	7
Pixel Representation	(0028,0103)	1	0000H
Pixel Data	(7FE0,0010)	1	Overlaid data in 4DCT Review image display (e.g. on-screen annotations, geometrical structures and beam edges) are converted into monochrome, 'burned in' to the image (i.e. obscure the image pixels) and transmitted as part of Pixel Data

3-5-5-3 SC Image

Attribute Name	Element Tag	TP	Notes
Date of Secondary Capture	(0018,1012)	3	Date when Secondary Capture Image was created.
Time of Secondary Capture	(0018,1014)	3	Time when Secondary Capture Image was created.

3-5-5-4 SOP Common

Attribute Name	Element Tag	TP	Notes
SOP Class UID	(0008,0016)	1	'1.2.840.10008.5.1.4.1.1.7'
SOP Instance UID	(0008,0018)	1	UID root will be '1.2.840.113619.2.160'
Specific Character Set	(0008,0005)	1C	'ISO_IR 100'
Instance Creation Date	(0008,0012)	3	Date when Secondary Capture Image was created.
Instance Creation Time	(0008,0013)	3	Time when Secondary Capture Image was created.
Instance Creator UID	(0008,0014)	3	'1.2.840.113619.6.160'

SECTION 4 RT STRUCTURE SET INFORMATION OBJECT REQUIREMENTS (AS SCP)

4-1 Introduction

This section specifies the requirements of the DICOM RT Structure Set IOD when being used as input to 4DCT Review.

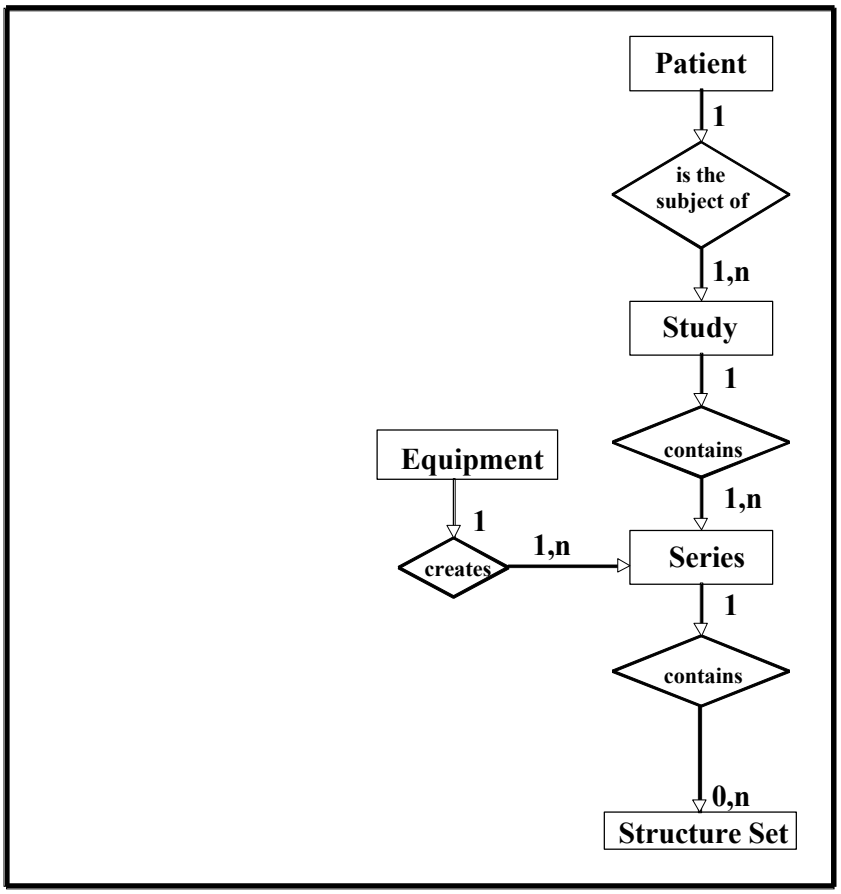
4-2 RT Structure Set IOD Implementation

This section defines the implementation of the RT Structure Set information object in the 4DCT Review application. It refers to the DICOM Standard 2000 Part 3 (Information Object Definitions).

In the following tables, notes are provided for when 4DCT Review is acting as a consumer of objects (SCP). Notes in UPPER CASE LETTERS represent restrictions on object contents imposed by 4DCT Review when acting as an SCP (object consumer).

4-3 RT Structure Set IOD Entity-Relationship Model

ILLUSTRATION **4-3**
RT STRUCTURE SET ENTITY RELATIONSHIP DIAGRAM



The Entity-Relationship diagram for the RT Structure Set interoperability schema is shown in **ILLUSTRATION** 4-3. In this figure, the following diagrammatic convention is established to represent the information organization:

- each entity is represented by a rectangular box.
- each relationship is represented by a diamond shaped box.
- the fact that a relationship exists between two entities is depicted by lines connecting the corresponding entity boxes to the relationship boxes.

The relationships are fully defined with the maximum number of possible entities in the relationship shown. See DICOM Part 3 Section 5.1.2 for an explanation of the entity-relationship notation.

4-3-1 Entities Description

Refer to DICOM Standard 2000 Part 3 (Information Object Defin itions) for a description of each of the entities contained within the RT Structure Set information object.

4-3-2 4DCT Review Mapping of DICOM entities

DICOM entities map to the 4DCT Review entities in the following manner:

DICOM	4DCT Review
Patient Entity	Patient Entity (Advantage Workstation)
Study Entity	Examination Entity (Advantage Workstation)
Series Entity	Series Entity (Advantage Workstation)
Equipment Entity	Workstation on which 4DCT Review application is running
Structure Set	4DCT Review geometric information relating to defined structures and markers

4-4 RT Structure Set IOD Module Table

Within an entity of the DICOM RT Structure Set Information Object Definition, attributes are grouped into related set of attributes. A set of related attributes is termed a module. A module facilitates the understanding of the semantics concerning the attributes and how the attributes are related with each other. A module grouping does not infer any encoding of information into datasets.

TABLE 4-2 identifies the defined modules withi n the entities, which comprise the DICOM RT Structure Set Information Object Definition. Modules are identified by Module Name.

See DICOM Standard 2000 Part 3 for a complete definition of the entities, modules, and attributes.

TABLE 4-2
RT STRUCTURE SET INFORMATION OBJECT DEFINITION (IOD) MODULE TABLE

Entity Name	Module Name	Usage	Reference
Patient	Patient	M	4-5-1-1
Study	General Study	M	4-5-2-1
	Patient Study	U	not used
Series	RT Series	M	4-5-3-1
Equipment	General Equipment	M	4-5-4-1
Structure Set	Structure Set	M	4-5-5-1
	ROI Contour	M	4-5-5-2
	RT ROI Observations	M	4-5-5-3
	Approval	U	not used
	Audio	U	not used
	SOP Common	M	4-5-5-4

4-5 Information Module Definitions

Please refer to DICOM Standard 2000 Part 3 (Information Object Definitions) for a description of each of the entities and modules contained within the RT Structure Set Information Object.

4-5-1 Patient Entity Modules

4-5-1-1 Patient Module

Attribute Name	Element Tag	TP	Notes
Patient's Name	(0010,0010)	2	Used for display and database key. NON-NULL VALUE REQUIRED BY 4DCT REVIEW FOR SAFE PATIENT IDENTIFICATION
Patient ID	(0010,0020)	2	Used for display and database key. NON-NULL VALUE STRONGLY RECOMMENDED FOR SAFE PATIENT IDENTIFICATION
Patient's Birth Date	(0010,0030)	2	Used for database key if non-null. Use of identical value to that found in acquisition images is recommended
Patient's Sex	(0010,0040)	2	Used for database key if non-null. Use of identical value to that found in acquisition images is recommended

4-5-2 Study Entity Modules

4-5-2-1 General Study

Attribute Name	Element Tag	TP	Notes
Study Instance UID	(0020,000D)	1	Not used
Study Date	(0008,0020)	2	Not used
Study Time	(0008,0030)	2	Not used
Referring Physicians' Name	(0008,0090)	2	Not used
Study ID	(0020,0010)	2	Not used
Accession number	(0008,0050)	2	Not used

4-5-3 Series Entity Modules

4-5-3-1 RT Series

Attribute Name	Element Tag	TP	Notes
Modality	(0008,0060)	1	Must be 'RTSTRUCT' (DICOM requirement)
Series Instance UID	(0020,000E)	1	Not used
Series Number	(0020,0011)	2	Used for display if non-null
Series Description	(0008,103E)	3	Used for display if provided

4-5-4 Equipment Entity Modules

4-5-4-1 General Equipment

Attribute Name	Element Tag	TP	Notes
Manufacturer	(0008,0070)	2	Used to determine system creating object and for display, if non-null (recommended for clear identification of creating system)
Station Name	(0008,1010)	3	Not used
Manufacturer's Model Name	(0008,1090)	3	Used to determine system creating object and for display, if provided (recommended for clear identification of creating system)
Device Serial Number	(0018,1000)	3	Not used
Software Versions	(0018,1020)	3	Used to determine system creating object and for display, if provided (recommended for clear identification of creating system)

4-5-5 Structure Set Entity Modules

4-5-5-1 Structure Set

Attribute Name	Element Tag	TP	Notes
Structure Set Label	(3006,0002)	1	Used for display and object identification
Structure Set Name	(3006,0004)	3	Used for display and object identification
Instance Number	(0020,0013)	3	Used for display if provided
Structure Set Date	(3006,0008)	2	Used for display if non-null
Structure Set Time	(3006,0009)	2	Used for display if non-null
Build Resolution (GE private attribute)	(0249,xx1C)	3	Used for building 3D model if provided. If not provided, user is prompted for desired build resolution.
View Layout (GE private attribute)	(0249,xxE1)	3	Used to initialize view layout. Not required by 4DCT Review (if absent, default 4DCT Review view layout will be used).
Planar View Windowing (GE private attribute)	(0249,xxE2)	3	Used to set initial W/L after loading RT Structure Set. Not required by 4DCT Review (if absent, default 4DCT Review W/L will be used).
Referenced Frame of Reference Sequence	(3006,0010)	3	MUST CONTAIN ONE OR MORE ITEMS, EXACTLY ONE OF WHICH MUST BE REFERENCED BY ALL ROIS
>Frame of Reference UID	(0020,0052)	1C	FOR THE ITEM REFERENCED BY ROIS, MUST CORRESPOND TO FRAME OF REFERENCE UID (0020,0052) OF ACQUISITION IMAGES
>RT Referenced Study Sequence	(3006,0012)	3	MUST CONTAIN ONE OR MORE ITEMS, EXACTLY ONE OF WHICH MUST BE REFERENCED BY ROIS
>>Referenced SOP Class UID	(0008,1150)	1C	Not used
>>Referenced SOP Instance UID	(0008,1155)	1C	Not used

>>RT Referenced Series Sequence	(3006,0014)	1C	FOR THE ITEM REFERENCED BY ROIS, MUST CORRESPOND TO CT IMAGE SERIES
>>>Series Instance UID	(0020,000E)	1C	Not used
>>>Contour Image Sequence	(3006,0016)	1C	If specific CT images were not selected(only RTSS), the RT Referenced Series Sequence item referenced by ROIs, all images will be used to construct 3D model, even if they do not contain a contour. AT LEAST FIVE IMAGE ITEMS MUST BE PROVIDED. SPACING BETWEEN IMAGES IS STRONGLY RECOMMENDED TO BE LESS THAN 10 MM FOR ADEQUATE 3D MODEL RECONSTRUCTION
>>>>Referenced SOP Class UID	(0008,1150)	1C	Must be equal to CT Image SOP Class
>>>>Referenced SOP Instance UID	(0008,1155)	1C	Required by 4DCT Review to locate referenced images in AW database
Structure Set ROI Sequence	(3006,0020)	3	There is no practical limit to the number of structures in 4DCT Review. This sequence may also be empty (no structures defined).
>ROI Number	(3006,0022)	1C	Used to uniquely identify ROI when referenced by ROI Contour and RT ROI Observations Modules (DICOM requirement). Used to uniquely identify 4DCT Review structures and markers if ROI Name is invalid or not supplied
>Referenced Frame of Reference UID	(3006,0024)	1C	MUST BE EQUAL TO EXACTLY ONE FRAME OF REFERENCE UID (0020,0052) IN REFERENCED FRAME OF REFERENCE SEQUENCE (3006,0010). ALL ROIS MUST REFERENCE THE SAME FRAME OF REFERENCE
>ROI Name	(3006,0026)	2C	Used for 4DCT Review structure name if a valid non-duplicate name, otherwise ROI Number is used to uniquely identify ROI in 4DCT Review
>ROI Generation Algorithm	(3006,0036)	2C	Not used

4-5-5-2 ROI Contour

Attribute Name	Element Tag	TP	Notes
ROI Contour Sequence	(3006,0039)	1	Multiple contours on slices (bifurcation or multi-part structures), and slices without contours are permitted. Each item corresponds to an ROI defined in the Structure Set ROI Sequence (3006,0020). If none of the structures in the RT Structure Set have defined contours, then ROI Contour Sequence (3006,0039) is zero-length
>Referenced ROI Number	(3006,0084)	1	Must correspond to exactly one ROI Number (3006,0022) in Structure Set ROI Sequence (3006,0020) (DICOM requirement)
>ROI Display Color	(3006,002A)	3	If RGB values correspond to 4DCT Review color, 4DCT Review color is used. 4DCT Review color

			triplet RGB values are: Red: 255 0 0 Blue: 0 0 255 Green: 0 255 0 Yellow: 255 255 0 Violet: 155 48 255 Pink: 255 192 203 Lavender: 230 230 250 Orange: 255 165 0 Forest: 34 139 34 Yellow green: 154 205 50 Khaki: 240 230 140 Aquamarine: 127 255 212 Brown: 165 42 42 SkyBlue: 135 206 235 SlateBlue: 106 90 205 Grey 190: 190 190 SteelBlue: 70 130 180 Olive: 192 255 62 Tomato: 255 99 71 Otherwise, "nearest" 4DCT Review color is used.
>Contour Sequence	(3006,0040)	3	Sequence may be absent if no contours have been defined
>>Contour Number	(3006,0048)	3	IF CONTOUR NUMBER IS PRESENT, MUST BE > 0, OTHERWISE THE STRUCTURE CONTAINING THIS CONTOUR WILL BE REJECTED.
>>Attached Contours	(3006,0049)	3	Not used.
>>Contour Image Sequence	(3006,0016)	3	Contours without a Contour Image Sequence (3006,0016) (i.e. not attached to an acquisition slice) are not used by 4DCT Review
>>>Referenced SOP Class UID	(0008,1150)	1C	Not used
>>>Referenced SOP Instance UID	(0008,1155)	1C	Used to locate acquisition image in order to verify consistency of contour z coordinates.
>>Contour Geometric Type	(3006,0042)	1C	Structures with contours other than 'CLOSED_PLANAR' will not be used by 4DCT Review
>>Contour Slab Thickness	(3006,0044)	3	Not used (slab thickness calculated from acquisition slice)
>>Number of Contour Points	(3006,0046)	1C	'CLOSED_PLANAR' CONTOURS MUST HAVE THREE OR MORE POINTS
>>Contour Data	(3006,0050)	1C	Contour is projected onto voxel plane of 4DCT Review 3D model, which is closest to the Contour Data Z coordinates. THESE Z COORDINATES MUST LIE WITHIN THE SLICE THICKNESS OF THE ACQUISITION SLICE REFERENCED IN THE CONTOUR IMAGE SEQUENCE (3006,0016)

4-5-5-3 RT ROI Observations

Attribute Name	Element Tag	TP	Notes
RT ROI Observations Sequence	(3006,0080)	1	Each item corresponds to a ROI defined in the Structure Set ROI Sequence (3006,0020). If none of the structures in the RT Structure Set have defined contours, then RT ROI Observations Sequence (3006,0080) is zero-length
>Observation Number	(3006,0082)	1	Not used
>Referenced ROI Number	(3006,0084)	1	Must correspond to exactly one ROI Number (3006,0022) in Structure Set ROI Sequence (3006,0020) (DICOM requirement)
>ROI Observation Label	(3006,0085)	3	Not used
>RT ROI Interpreted Type	(3006,00A4)	2	Supported types are EXTERNAL, PTV, CTV, GTV, AVOIDANCE, ORGAN, CONTRAST_AGENT, CAVITY. ROIs with an Interpreted Type other than those in the above list will be converted to UNKNOWN
>ROI Interpreter	(3006, 00A6)	2	Not used

4-5-5-4 SOP Common

Attribute Name	Element Tag	TP	Notes
SOP Class UID	(0008,0016)	1	Must be equal to '1.2.840.10008.5.1.4.1.1.481.3' (DICOM requirement)
SOP Instance UID	(0008,0018)	1	Used to verify association with RT Plans
Specific Character Set	(0008,0005)	1C	Specific Character Sets other than 'ISO_IR 100' are not handled explicitly by 4DCT Review
Instance Creation Date	(0008,0012)	3	Not used
Instance Creation Time	(0008,0013)	3	Not used
Instance Creator UID	(0008,0014)	3	If Instance Creator UID corresponds to a version of Advantage Sim, then it is used to prevent loading of old-format RT Structure Sets, otherwise not used

4-6 Private Data Dictionary for RT Structure Set

Private Creator Identification GEMS_RTEN_01

Attribute Name	Element Tag	VR	VM
Build Resolution	(0249,xx1C)	CS	1
View Layout	(0249,xxE1)	CS	4
Planar View Windowing	(0249,xxE2)	IS	2

SECTION 5 CT IMAGE INFORMATION OBJECT REQUIREMENTS

5-1 Introduction

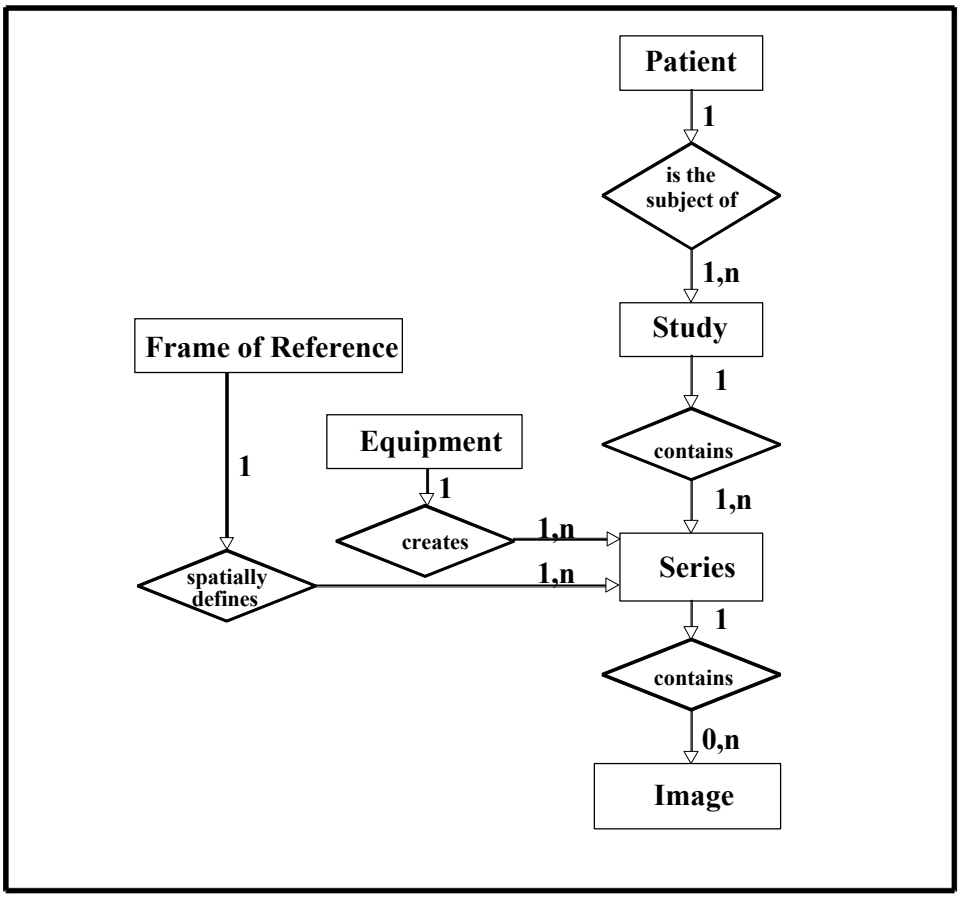
This section specifies the requirements for the DICOM CT Image IOD when being used as input to 4DCT Review.

5-2 CT Image IOD Implementation

This section defines how CT Image attributes are used within the 4DCT Review implementation, and whether these attributes are mandatory or optional for the correct operation of 4DCT Review.

5-3 CT Image IOD Entity-Relationship Model

ILLUSTRATION **5-4**
CT IMAGE ENTITY RELATIONSHIP DIAGRAM



The Entity-Relationship diagram for the CT Image interoperabilit y schema is shown in **ILLUSTRATION** 5-4. In this figure, the following diagrammatic convention is established to represent the information organization:

- each entity is represented by a rectangular box
- each relationship is represented by a diamond shaped box.
- the fact that a relationship exists between two entities is depicted by lines connecting the correspon ding entity boxes to the relationsh ip boxes.

The relationships are fully defined with the maximum number of possible entities in the relationship shown. See DICOM Part 3 Section 5.1.2 for an explanation of the entity - relationship notation.

5-3-1 Entities Descrip tion

Refer to DICOM Standard Part 3 (Information Object Definitions) for a description of each of the entities contained within the CT Image information object.

5-3-2 4DCT Review Mapping of DICOM entities

DICOM entities map to the 4DCT Review entiti es in the following manner:

DICOM	4DCT Review
Patient Entity	Patient Entity (Advantage Workstation)
Study Entity	Examination Entity (Advantage Workstation)
Series Entity	Series Entity (Advantage Workstation)
Frame of Reference Entity	None
Equipment Entity	None
Image Entity	Patient model reconstruction on 3D server

5-4 CT Image IOD Module Table

Within an entity of the DICOM CT Image Information Object Definition, attributes are grouped into a related set of attributes. A set of related attributes is termed a module. A module facilitates the understanding of the semantics concerning the attributes and how the attributes are related with each other. A module grouping does not infer any encoding of information into datasets.

TABLE 5-3 identifies the defined modules within the entities, which comprise the DICOM CT Image Information Object Definition. Modules are identified by Module Name.

See DICOM Part 3 for a complete definition of the entities, modules, and attributes.

TABLE 5-3
CT IMAGE INFORMATION OBJECT DEFINITION (IOD) MODULE TABLE

Entity Name	Module Name	Usage	Reference
Patient	Patient	M	5-5-1-1
Study	General Study	M	5-5-2-1
	Patient Study	U	5-5-2-2
Series	General Series	M	5-5-3-1
Frame of Reference	Frame of Reference	M	5-5-4-1
Equipment	General Equipment	M	5-5-5-1
Image	General Image	M	5-5-6-1
	Image Plane	M	5-5-6-2
	Image Pixel	M	5-5-6-3
	Contrast/Bolus	C	5-5-6-4
	CT Image	M	5-5-6-5
	Overlay Plane	U	5-5-6-6
	VOI LUT	U	not used
	SOP Common	M	5-5-6-7

5-5 Information Module Definitions

Please refer to DICOM Standard Part 3 (Information Object Definition) for a description of each of the entities and modules contained within the SC Information Object.

5-5-1 Patient Entity Modules

5-5-1-1 Patient Module

Attribute Name	Element Tag	TP	Notes
Patient's Name	(0010,0010)	2	Used for display if provided. REQUIRED FOR SAFE PATIENT IDENTIFICATION.
Patient ID	(0010,0020)	2	Used for display if provided. STRONGLY RECOMMENDED FOR SAFE PATIENT IDENTIFICATION.

Patient's Birth Date	(0010,0030)	2	Used for display if provided.
Patient's Sex	(0010,0040)	2	Used for display if provided.

5-5-2 Study Entity Modules

5-5-2-1 General Study

Attribute Name	Element Tag	TP	Notes
Study Instance UID	(0020,000D)	1	Used by 4DCT Review for SC Image creation.
Study Date	(0008,0020)	2	Used for display if provided.
Study Time	(0008,0030)	2	Used for display if provided.
Referring Physicians' Name	(0008,0090)	2	Used for display if provided.
Study ID	(0020,0010)	2	REQUIRED BY 4DCT REVIEW FOR IMAGE IDENTIFICATION (MUST NOT BE ZERO-LENGTH). The values of (Study ID, Series Number) pair must uniquely identify series in Advantage Workstation database.
Accession number	(0008,0050)	2	Used if provided.
Study Description	(0008,1030)	3	Used if provided.
Name of Physician(s) Reading Study	(0008,1060)	3	Used if provided.

5-5-2-2 Patient Study

Attribute Name	Element Tag	TP	Notes
Admitting Diagnoses Description	(0008,1080)	3	Used by AW if provided.
Patient's Age	(0010,1010)	3	Used by AW if provided.
Patient's Weight	(0010,1030)	3	Used by AW if provided.
Additional Patient's History	(0010,21B0)	3	Used by AW if provided.

5-5-3 Series Entity Modules

5-5-3-1 General Series

Attribute Name	Element Tag	TP	Notes
Modality	(0008,0060)	1	Not used.
Series Instance UID	(0020,000E)	1	Not used
Series Number	(0020,0011)	2	Used for image identification if provided. REQUIRED IF MULTIPLE CT SERIES ARE TO BE REFERENCED FOR THE SAME STUDY. The values of (Study ID, Series Number) pair must uniquely identify series in Advantage Workstation database.
Series Date	(0020,0021)	3	Used by AW if provided.
Series Time	(0020,0031)	3	Used by AW if provided.

Performing Physician's Name	(0008,1050)	3	Used by AW if provided.
Series Description	(0008,103E)	3	Used by AW if provided.
Operators' Name	(0008,1070)	3	Used by AW if provided.
Body Part Examined	(0018,0015)	3	Used by AW if provided.
Patient Position	(0018,5100)	3	Used by 4DCT Review for patient model reconstruction. If absent, 4DCT Review defaults to "HFS" after user confirmation. GE STRONGLY RECOMMENDS THAT THIS ATTRIBUTE BE SYSTEMATICALLY PROVIDED.

5-5-4 Common Frame Of Reference Entity Modules

5-5-4-1 Frame Of Reference

Attribute Name	Element Tag	TP	Notes
Frame of Reference UID	(0020,0052)	1	Not used.
Position Reference Indicator	(0020,1040)	2	Used by AW if provided.

5-5-5 Equipment Entity Modules

5-5-5-1 General Equipment

Attribute Name	Element Tag	TP	Notes
Manufacturer	(0008,0070)	2	Used by AW if provided.
Institution Name	(0008,0080)	3	Used by AW if provided.
Station Name	(0008,1010)	3	Used by AW if provided.
Manufacturer's Model Name	(0008,1090)	3	Used by AW if provided.
Pixel Padding Value	(0028,0120)	3	Used by AW if provided, defaults to 0 otherwise.

5-5-6 Image Entity Modules

5-5-6-1 General Image

Attribute Name	Element Tag	TP	Notes
Image Number	(0020,0013)	2	REQUIRED BY 4DCT REVIEW FOR IMAGE IDENTIFICATION. MUST NOT BE ZERO LENGTH.
Image Date	(0008,0023)	2C	Used by 4DCT Review if provided (image time stamp).
Image Time	(0008,0033)	2C	Used by 4DCT Review if provided (image time stamp).
Image Type	(0008,0008)	3	See CT Image Module.
Acquisition Number	(0020,0012)	3	See CT Image Module.
Acquisition Date	(0008,0022)	3	Used by AW if provided.
Acquisition Time	(0008,0032)	3	Used by AW if provided.

5-5-6-2 Image Plane

Attribute Name	Element Tag	TP	Notes
Pixel Spacing	(0028,0030)	1	Used for patient model reconstruction. PIXELS MUST BE SQUARE (i. e. X and Y values must be equal).
Image Orientation (Patient)	(0020,0037)	1	Used for patient model reconstruction. IMAGES MUST NOT HAVE GANTRY TILT OR SWIVEL (i.e. only one of each (x,y,z) cosine triplet can be non-zero).
Image Position (Patient)	(0020,0032)	1	Used for patient model reconstruction.
Slice Thickness	(0018,0050)	2	Used by AW if provided.
Slice Location	(0020,1041)	3	Used by AW if provided. 4DCT REVIEW USES IMAGE POSITION (PATIENT) TO IDENTIFY Z COORDINATE.

5-5-6-3 Image Pixel

Attribute Name	Element Tag	TP	Notes
Samples per Pixel	(0028,0002)	1	See CT Image Module.
Photometric Interpretation	(0028,0004)	1	See CT Image Module.
Rows	(0028,0010)	1	Used for patient model reconstruction. ROWS AND COLUMNS MUST BE EQUAL.
Columns	(0028,0011)	1	Used for patient model reconstruction. ROWS AND COLUMNS MUST BE EQUAL.
Bits Allocated	(0028,0100)	1	See CT Image Module.
Bits Stored	(0028,0101)	1	See CT Image Module.
High Bit	(0028,0102)	1	See CT Image Module.
Pixel Representation	(0028,0103)	1	Not Used.
Pixel Data	(7FE0,0010)	1	Used for patient model reconstruction.
Smallest Image Pixel Value	(0028,0106)	3	Used by AW, defaults to 0 if absent.
Largest Image Pixel Value	(0028,0107)	3	Used by AW, default to 4095 if absent.

5-5-6-4 Contrast/Bolus (not mandatory)

Attribute Name	Element Tag	TP	Notes
Contrast/Bolus Agent	(0018,0020)	1	Used by AW if Contrast/Bolus Module present.
Contrast/Bolus Route	(0018,1040)	1	Used by AW if Contrast/Bolus Module present.

5-5-6-5 CT Image

Attribute Name	Element Tag	TP	Notes
Image Type	(0008,0008)	1	Not Used.
Samples per Pixel	(0028,0002)	1	Used by AW.
Photometric Interpretation	(0028,0004)	1	Only MONOCHROME2 images are handled by 4DCT Review.
Bits Allocated	(0028,0100)	1	Not Used, shall be 16.
Bits Stored	(0028,0101)	1	Not Used.
High Bit	(0028,0102)	1	Not Used.
Rescale Intercept	(0028,1052)	1	Used for patient model reconstruction.
Rescale Slope	(0028,1053)	1	Used for patient model reconstruction.
KVP	(0018,0060)	2	Used by AW if provided.
Acquisition Number	(0020,0012)	2	Not used.
Scan Options	(0018,0022)	3	Used by AW if provided.
Data Collection Diameter	(0018,0090)	3	Used by AW if provided.
Reconstruction Diameter	(0018,1100)	3	Used by AW if provided.
Gantry/Detector Tilt	(0018,1120)	3	Used by AW if provided. Images with Gantry Tilt are rejected by 4DCT Review - see Image Orientation (Patient) attribute.
Exposure Time	(0018,1150)	3	Used by AW if provided.
X-ray Tube Current	(0018,1151)	3	Used by AW if provided.
Convolution Kernel	(0018,1210)	3	Used by AW if provided.

5-5-6-6 Overlay Plane (not mandatory)

Attribute Name	Element Tag	TP	Notes
Rows	(60xx,0010)	1	Used by AW if Overlay Plane Module present.
Columns	(60xx,0011)	1	Used by AW if Overlay Plane Module present.
Overlay Type	(60xx,0040)	1	Used by AW if Overlay Plane Module present.
Origin	(60xx,0050)	1	Used by AW if Overlay Plane Module present.
Bits Allocated	(60xx,0100)	1	Used by AW if Overlay Plane Module present.
Bits Position	(60xx,0102)	1	Used by AW if Overlay Plane Module present.
Overlay Data	(60xx,3000)	1C	Used by AW if provided. **Overlays are burned into the pixel data of the image before storage in the AW database.**

5-5-6-7 SOP Common

Attribute Name	Element Tag	TP	Notes
SOP Class UID	(0008,0016)	1	Used by 4DCT Review to confirm image is CT Image.

SOP Instance UID	(0008,0018)	1	Used by 4DCT Review for image identification.
Specific Character Set	(0008,0005)	1C	Only the ISO_IR 100 extended character set is supported by 4DCT Review.