



Technical Publications

Direction 5129118-100

Revision 4

Advantage 4D 1.4_17 / 4DCT Review 1.0.27 Conformance Statement for DICOM V3.0

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CONFORMANCE STATEMENT OVERVIEW

Advantage 4D and 4DCT Review are used in the preparation of a 4D CT-scanned patient for treatment by radiotherapy. Advantage 4D uses CT Images (multiple phases), RT Structure Set, or CT images along with an RT Structure Set and produces Secondary Capture Image Storage for further processing. Advantage 4D and 4DCT Review do not provide intrinsic implementation of DICOM Network instead uses application interface of its platform called Advantage Workstation.

Table 0.1 provides an overview of the network services supported by Advantage 4D and 4DCT Review.

Table 0.1 – NETWORK SERVICES

| SOP Classes | User of Service (SCU) | Provider of Service (SCP) |
|---------------------------------|-----------------------|---------------------------|
| Transfer | | |
| CT Image Storage | No | Yes |
| Secondary Capture Image Storage | Yes | No |
| RT Structure Set Storage | No | Yes |

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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 GEHC Conformance Statements is shown in ILLUSTRATION 1 DOCUMENTATION STRUCTURE.

GEHC DICOM Conformance Statements

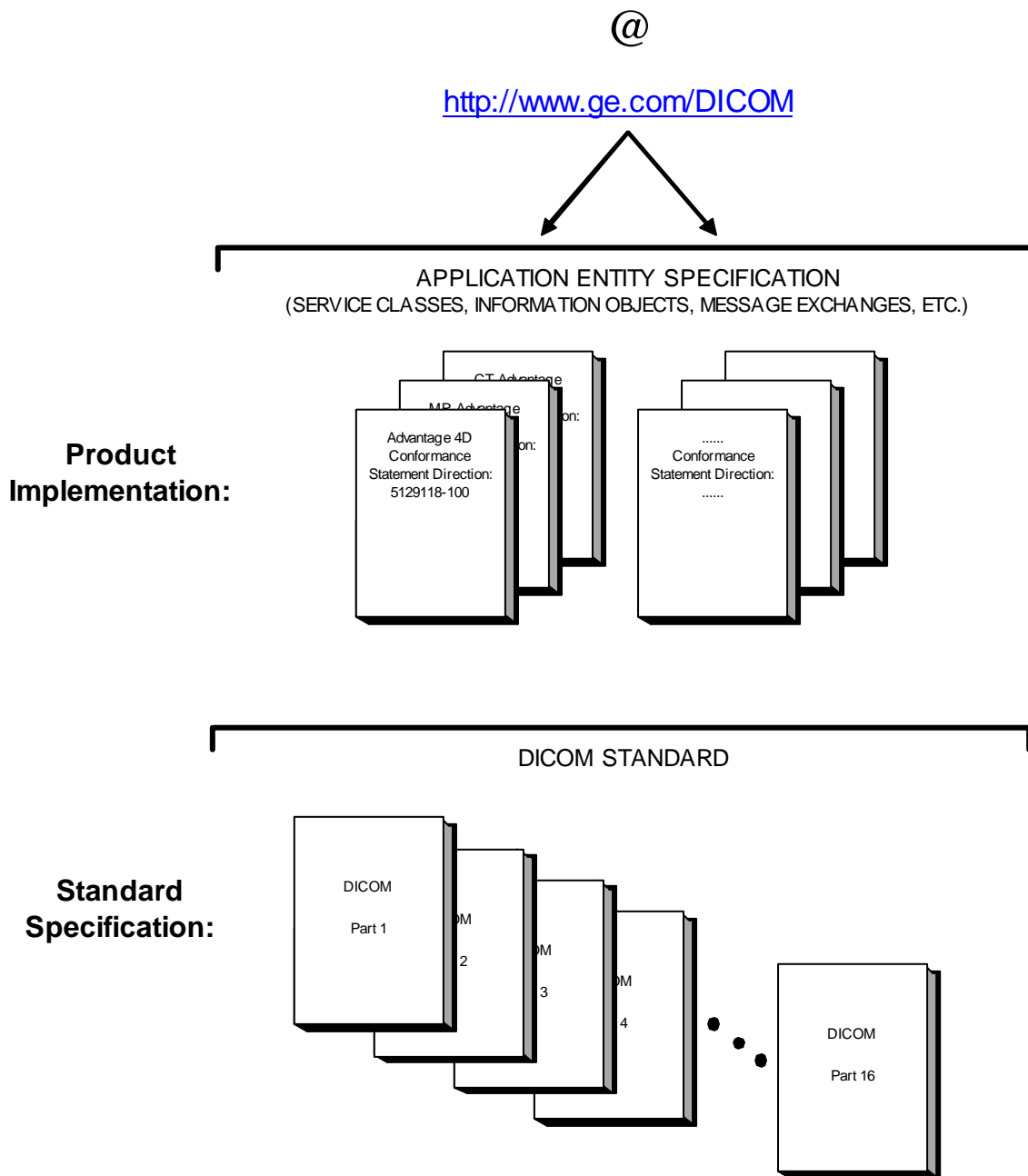


ILLUSTRATION 1 DOCUMENTATION STRUCTURE

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

*4DCT Review
Conformance Statement
Direction# 5129118-100.*

This DICOM Conformance Statement documents the DICOM Conformance Statement and Technical Specification required to interoperate with the GEHC network interface.

The GEHC 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 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 1752
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 Standard and with the terminology and concepts which are used in that Standard..

1.4 SCOPE AND FIELD OF APPLICATION

It is the intent of this document to provide an unambiguous specification for GEHC implementations. This specification, called a Conformance Statement, includes a DICOM Conformance Statement and is necessary to ensure proper processing and interpretation of GEHC medical data exchanged using DICOM. The GEHC Conformance Statements are available to the public.

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

Included in this DICOM Conformance Statement are the Module Definitions which define all data elements used by this GEHC implementation. If the user encounters unspecified private data elements while parsing a GEHC Data Set, the user is well advised to ignore those data elements (per the DICOM 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 re-transmit all of the private data elements which are sent by GEHC devices.

1.5 IMPORTANT REMARKS

The use of these DICOM Conformance Statements, in conjunction with the DICOM 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 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 data once it has crossed the interface between the GE imaging equipment and the non-GE device and the stability of the image data for the intended applications.

Such a validation is required before any clinical use (diagnosis and/or treatment) is performed. It applies when images acquired on GE imaging equipment are processed/displayed on a non-GE device, as well as when images 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 Standard. DICOM will incorporate new features and technologies and GE may follow the evolution of the Standard. The GEHC protocol is based on DICOM as specified in each DICOM Conformance Statement. Evolution of the Standard may require changes to devices which have implemented DICOM. **In addition, GE reserves the right to discontinue or make changes to the support of communications features (on its products) described 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. Failure 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 equipment performance and/or function.

1.6 REFERENCES

NEMA PS3 Digital Imaging and Communications in Medicine (DICOM) Standard, available free at <http://medical.nema.org/>

The different supported Advantage Windows platform DICOM conformance statements are described in the following documents:

| Document title | Direction |
|--|-------------|
| <i>ADVANTAGE WORKSTATION 4.2p Conformance Statement for DICOM V3.0</i> | 2381100-100 |
| <i>ADVANTAGE WORKSTATION 4.3 Conformance Statement for DICOM V3.0</i> | 5138820-100 |
| <i>ADVANTAGE WORKSTATION 4.4 Conformance Statement for DICOM V3.0</i> | 5181424-100 |
| <i>ADVANTAGE WORKSTATION 4.5 Conformance Statement for DICOM V3.0</i> | 5324648-100 |

| | |
|---|-------------|
| ADVANTAGE WORKSTATION 4.6 Conformance Statement for DICOM V3.0 | 5404296-100 |
|---|-------------|

1.7 DEFINITIONS

Informal definitions are provided for the following terms used in this Conformance Statement. The DICOM Standard is the authoritative source for formal definitions of these terms.

Abstract Syntax – the information agreed to be exchanged between applications, generally equivalent to a Service/Object Pair (SOP) Class. Examples : Verification SOP Class, Modality Worklist Information Model Find SOP Class, Computed Radiography Image Storage SOP Class.

Application Entity (AE) – an end point of a DICOM information exchange, including the DICOM network or media interface software; i.e., the software that sends or receives DICOM information objects or messages. A single device may have multiple Application Entities.

Application Entity Title – the externally known name of an *Application Entity*, used to identify a DICOM application to other DICOM applications on the network.

Application Context – the specification of the type of communication used between *Application Entities*. Example: DICOM network protocol.

Association – a network communication channel set up between *Application Entities*.

Attribute – a unit of information in an object definition; a data element identified by a *tag*. The information may be a complex data structure (Sequence), itself composed of lower level data elements. Examples: Patient ID (0010,0020), Accession Number (0008,0050), Photometric Interpretation (0028,0004), Procedure Code Sequence (0008,1032).

Information Object Definition (IOD) – the specified set of *Attributes* that comprise a type of data object; does not represent a specific instance of the data object, but rather a class of similar data objects that have the same properties. The *Attributes* may be specified as Mandatory (Type 1), Required but possibly unknown (Type 2), or Optional (Type 3), and there may be conditions associated with the use of an Attribute (Types 1C and 2C). Examples: MR Image IOD, CT Image IOD, Print Job IOD.

Joint Photographic Experts Group (JPEG) – a set of standardized image compression techniques, available for use by DICOM applications.

Media Application Profile – the specification of DICOM information objects and encoding exchanged on removable media (e.g., CDs)

Module – a set of *Attributes* within an *Information Object Definition* that are logically related to each other. Example: Patient Module includes Patient Name, Patient ID, Patient Birth Date, and Patient Sex.

Negotiation – first phase of *Association* establishment that allows *Application Entities* to agree on the types of data to be exchanged and how that data will be encoded.

Presentation Context – the set of DICOM network services used over an *Association*, as negotiated between *Application Entities*; includes *Abstract Syntaxes* and *Transfer Syntaxes*.

Protocol Data Unit (PDU) – a packet (piece) of a DICOM message sent across the network. Devices must specify the maximum size packet they can receive for DICOM messages.

Security Profile – a set of mechanisms, such as encryption, user authentication, or digital signatures, used by an *Application Entity* to ensure confidentiality, integrity, and/or availability of exchanged DICOM data

Service Class Provider (SCP) – role of an *Application Entity* that provides a DICOM network service; typically, a server that performs operations requested by another *Application Entity* (*Service Class User*). Examples: Picture Archiving and Communication System (image storage SCP, and image query/retrieve SCP), Radiology Information System (modality worklist SCP).

Service Class User (SCU) – role of an *Application Entity* that uses a DICOM network service; typically, a client. Examples: imaging modality (image storage SCU, and modality worklist SCU), imaging workstation (image query/retrieve SCU)

Service/Object Pair (SOP) Class – the specification of the network or media transfer (service) of a particular type of data (object); the fundamental unit of DICOM interoperability specification. Examples: Ultrasound Image Storage Service, Basic Grayscale Print Management.

Service/Object Pair (SOP) Instance – an information object; a specific occurrence of information exchanged in a *SOP Class*. Examples: a specific x-ray image.

Tag – a 32-bit identifier for a data element, represented as a pair of four digit hexadecimal numbers, the “group” and the “element”. If the “group” number is odd, the tag is for a private (manufacturer-specific) data element. Examples: (0010,0020) [Patient ID], (07FE,0010) [Pixel Data], (0019,0210) [private data element]

Transfer Syntax – the encoding used for exchange of DICOM information objects and messages. Examples: *JPEG* compressed (images), little endian explicit value representation.

Unique Identifier (UID) – a globally unique “dotted decimal” string that identifies a specific object or a class of objects; an ISO-8824 Object Identifier. Examples: Study Instance UID, SOP Class UID, SOP Instance UID.

Value Representation (VR) – the format type of an individual DICOM data element, such as text, an integer, a person’s name, or a code. DICOM information objects can be transmitted with either explicit identification of the type of each data element (Explicit VR), or without explicit identification (Implicit VR); with Implicit VR, the receiving application must use a DICOM data dictionary to look up the format of each data element.

1.8 SYMBOLS AND ABBREVIATIONS

| | |
|-------|--|
| AE | Application Entity |
| CT | Computed Tomography |
| CS | Conformance Statement |
| DICOM | Digital Imaging and Communications in Medicine |
| IHE | Integrating the Healthcare Enterprise |
| IOD | Information Object Definition |
| ISO | International Organization for Standards |
| LUT | Look-up Table |
| MR | Magnetic Resonance Imaging |
| NM | Nuclear Medicine |
| O | Optional (Key Attribute) |
| OP | Ophthalmic Photography |
| OSI | Open Systems Interconnection |
| PACS | Picture Archiving and Communication System |
| PET | Positron Emission Tomography |
| PDU | Protocol Data Unit |
| R | Required (Key Attribute) |
| RT | Radiotherapy |
| SC | Secondary Capture |
| SCP | Service Class Provider |
| SCU | Service Class User |
| SOP | Service-Object Pair |
| SR | Structured Reporting |
| U | Unique (Key Attribute) |
| VR | Value Representation |

SECTION 2 NETWORK CONFORMANCE STATEMENT

2.1 INTRODUCTION

This section of the DICOM Conformance Statement (DCS) specifies the 4DCT Review compliance to DICOM requirements for Networking features.

4DCT Review is a diagnostic application used in the preparation of a 4D CT-scanned patient for treatment by radiotherapy that is installed on the same hardware platform as the base application, **Advantage Workstation**. 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 - *Advantage Workstation where 4DCT Review application is running* (See 1.6 References).

The application parses the following DICOM objects:

| SOP Class Name | SOP Class UID |
|--------------------------|-------------------------------|
| CT Image Storage | 1.2.840.10008.5.1.4.1.1.2 |
| RT Structure Set Storage | 1.2.840.10008.5.1.4.1.1.481.3 |

The application creates the following DICOM objects:

| SOP Class Name | SOP Class UID |
|---------------------------------|---------------------------|
| Secondary Capture Image Storage | 1.2.840.10008.5.1.4.1.1.7 |

2.2 IMPLEMENTATION MODEL

2.2.1 Application Data Flow Diagram

Refer to the respective Conformance Statement - *Advantage Workstation where 4DCT Review application is running* (See 1.6 References).

2.2.2 Presentation Context Table

Refer to the respective Conformance Statement - *Advantage Workstation where 4DCT Review application is running* (See 1.6 References).

2.2.3 Real-World Activities

The user can select CT Images (multiple phases), RT Structure Set, or CT images along with an RT Structure Set, and then start application from AW. Perform the review, and 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.

2.2.4 Implementation Identifying Information

The Implementation UID for this DICOM Implementation is:

| | |
|--|----------------------|
| Advantage 4D Implementation UID | 1.2.840.113619.6.160 |
| Advantage 4D Implementation Version Name | 4DCT Review |

2.3 SUPPORT OF EXTENDED CHARACTER SETS

The Advantage 4D accepts the ISO_IR 6 (ASCII) and the ISO_IR 100 (Latin alphabet Number 1 supplementary set) character set as SCU and uses ISO_IR 100 as SCP. Multiple character set is not supported.

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.

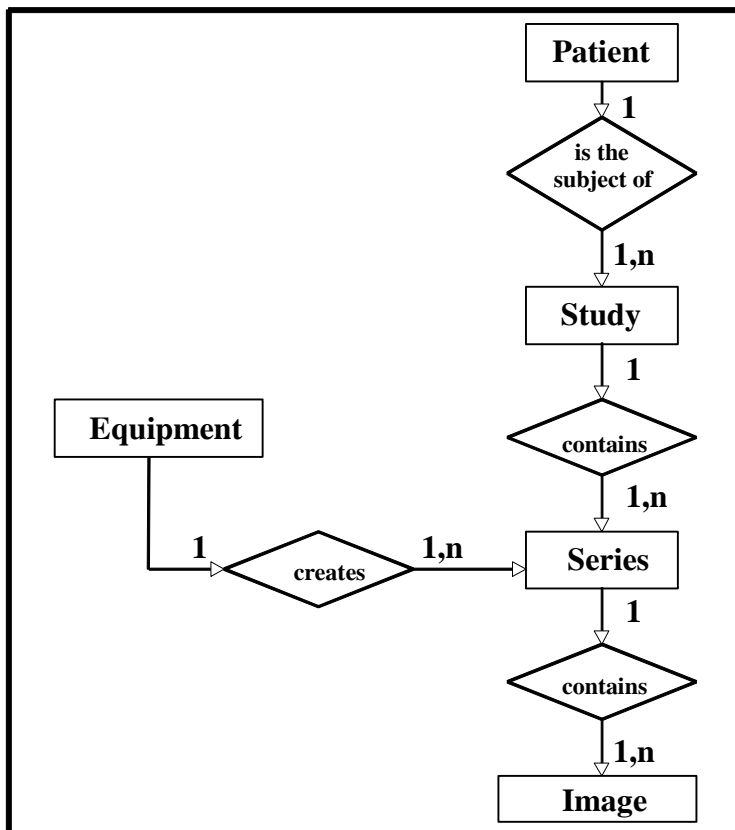
Note that the implementation described in this section relates to generation of SC Images by the 4DCT Review product only. The 4DCT Review application does not display SC Images directly, but relies on the Advantage Workstation product for this function. SC Image conformance for Advantage Workstation is described in a related document entitled *Advantage Workstation Conformance Statement for DICOM, Directions: 2381100-100(AW4.2p), 5138820-100(AW4.3), 5181424-100(AW4.4), 5324648-100 (AW4.5) and 5404296-100 (AW4.6).*

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.

Note: The elements that are not listed in tables will not be present in generated images.

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 |
| Image | SC Equipment | M | 3-5-4-2 |
| | 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 input instances if present in those images, otherwise zero-length |
| Patient ID | (0010,0020) | 2 | Duplicated from input instances if present in those images, otherwise zero-length |
| Patient's Birth Date | (0010,0030) | 2 | Duplicated from input instances if present in those images, otherwise zero-length |
| Patient's Sex | (0010,0040) | 2 | Duplicated from input instances if present in those images, otherwise zero-length |
| Issuer of Patient ID Qualifiers Sequence | (0010,0024) | 3 | Not Used |
| Other Patient IDs | (0010,1000) | 3 | Not Used |
| Other Patient ID Sequence | (0010,1002) | 3 | Not Used |

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 input instances |
| Study Date | (0008,0020) | 2 | Duplicated from input instances if present in those images, otherwise zero-length |
| Study Time | (0008,0030) | 2 | Duplicated from input instances if present in those images, otherwise zero-length |
| Referring Physicians' Name | (0008,0090) | 2 | Zero-length |
| Study ID | (0020,0010) | 2 | Duplicated from input instances (must be present in those images - see Section 5) |
| Accession number | (0008,0050) | 2 | Duplicated from input instances 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 running 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.

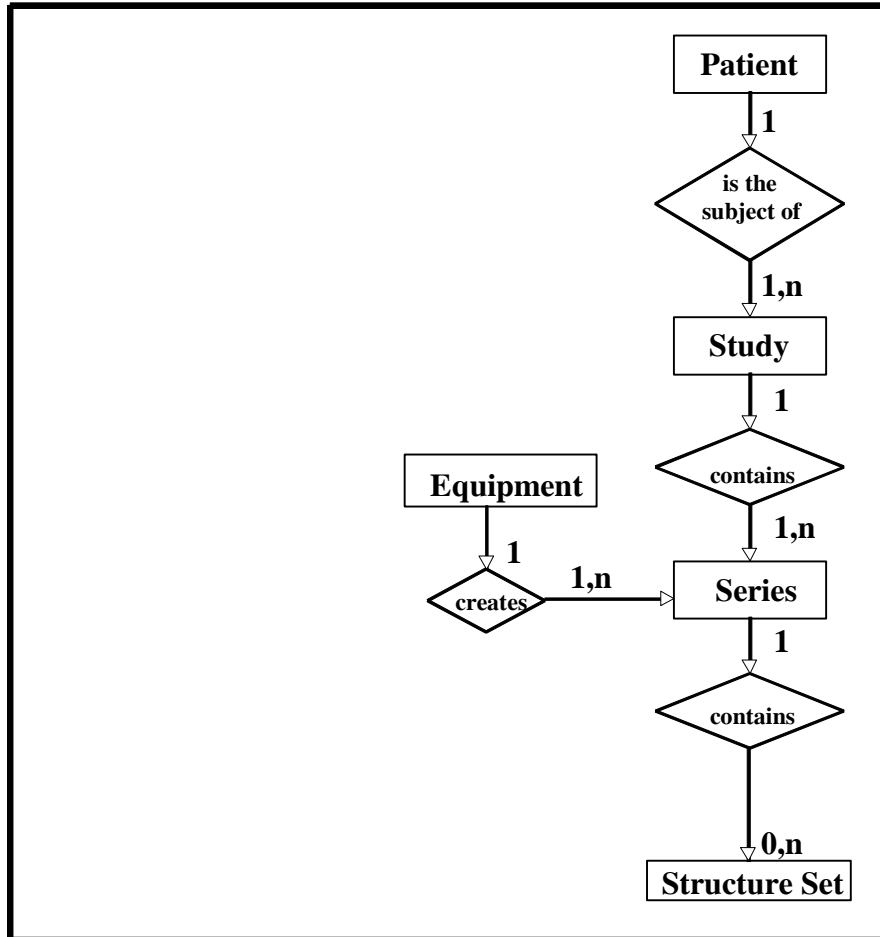
4.2 RT STRUCTURE SET IOD IMPLEMENTATION

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

In the following tables, notes are provided for when 4DCT Review is acting as a consumer of objects. Notes in UPPER CASE LETTERS represent restrictions on object contents imposed by 4DCT Review when loading instances (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 Part 3 (Information Object Definitions) 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 |
|-------|-------------|
|-------|-------------|

| 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 within the entities, which comprise the DICOM RT Structure Set Information Object Definition. Modules are identified by Module Name.

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

Note: The elements that are not listed in tables are not used and will be ignored.

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 |
| Issuer of Patient ID Qualifiers Sequence | (0010,0024) | 3 | Not Used |
| Other Patient IDs | (0010,1000) | 3 | Not Used |
| Other Patient ID Sequence | (0010,1002) | 3 | Not Used |

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 |

| Attribute Name | Element Tag | TP | Notes |
|------------------------------------|-------------|----|--|
| >>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) |

| Attribute Name | Element Tag | TP | Notes |
|--------------------------------|-------------|----|--|
| >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, and 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 | Not used |
| 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

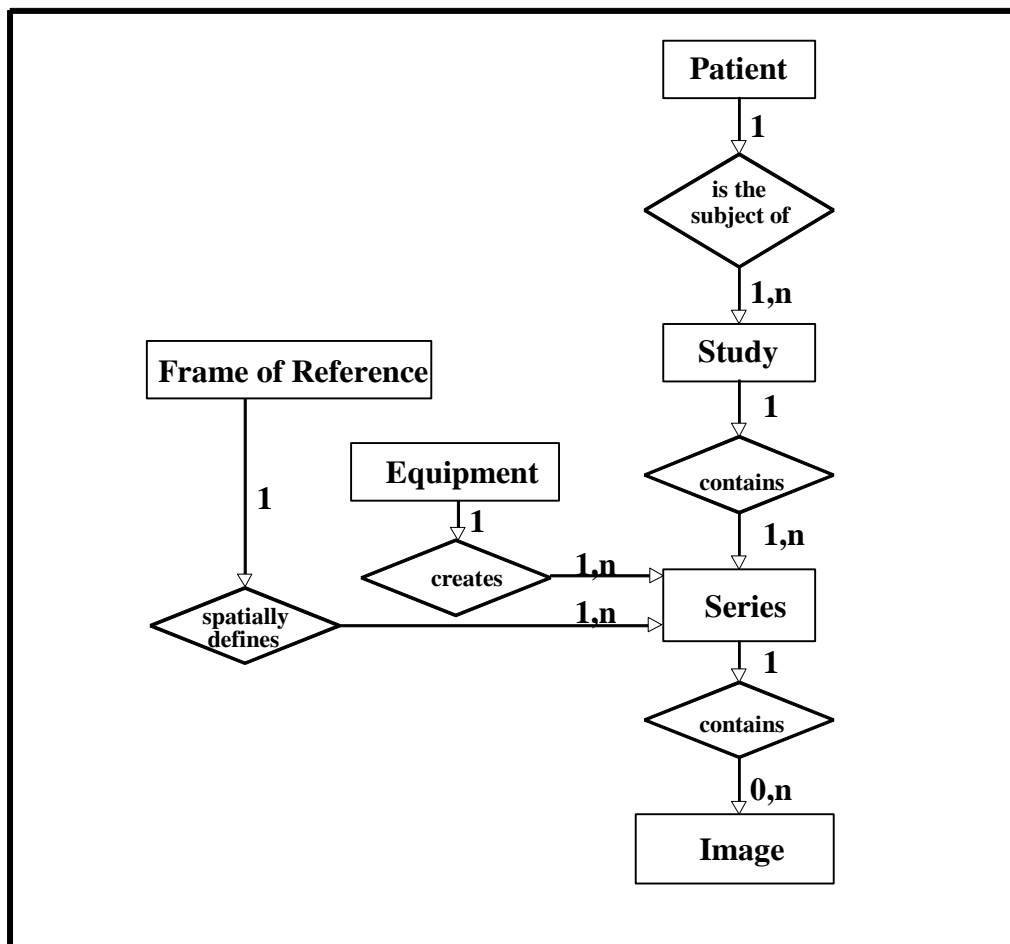
This section specifies the requirements for the DICOM CT Image IOD when being used as input to 4DCT Review.

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 interoperability 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 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.

5.3.1 Entities Description

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 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) |
| 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.

Note: The elements that are not listed in tables are not used and will be ignored.

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 |

| Entity Name | Module Name | Usage | Reference |
|-------------|----------------|-------|-----------|
| | Image Pixel | M | 5-5-6-3 |
| | Contrast/Bolus | C | 5-5-6-4 |
| | CT Image | M | 5-5-6-5 |
| | Overlay Plane | U | Not used |
| | VOI LUT | U | Not used |
| | SOP Common | M | 5-5-6-6 |

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.

Note: The elements that are not listed in tables are not used and will be ignored.

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. |
| Issuer of Patient ID Qualifiers Sequence | (0010,0024) | 3 | Not Used |
| Other Patient IDs | (0010,1000) | 3 | Not Used |
| Other Patient ID Sequence | (0010,1002) | 3 | Not Used |

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. |

| Attribute Name | Element Tag | TP | Notes |
|------------------------------------|-------------|----|---|
| 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 | Used for display. Used by AW if provided. |
| Series Instance UID | (0020,000E) | 1 | Used for series identification. Used by AW if provided. |
| 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) | 2C | 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 | Used for data integrity checks. |
| 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). |

| Attribute Name | Element Tag | TP | Notes |
|--------------------------|-------------|----|---|
| 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 | Shall be 16. |
| Bits Stored | (0028,0101) | 1 | Ignored (expect 16) |
| High Bit | (0028,0102) | 1 | Ignored (expect 15) |
| Rescale Intercept | (0028,1052) | 1 | Used for patient model reconstruction. |
| Rescale Slope | (0028,1053) | 1 | Used for patient model reconstruction. |

| Attribute Name | Element Tag | TP | Notes |
|--------------------------|-------------|----|--|
| 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 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. |