GE Medical Systems

# Technical Publications

**2192581–100**

**Revision 1**

# ADVANTAGE SIM 3.0

# Conformance Statement

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# TABLE OF CONTENTS

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# REVISION HISTORY

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## LIST OF EFFECTIVE PAGES

| PAGE NUMBER | REVISION NUMBER | PAGE NUMBER | REVISION NUMBER | PAGE NUMBER | REVISION NUMBER |
|---|---|---|---|---|---|
| Title page | 1 | | | | |
| i thru iv | 1 | | | | |
| Direction 2118780 | 0 | | | | |
| 2184231–100 | 3 | | | | |

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GE Medical Systems

# Technical Publications

**Direction 2118780**

**Revision 0**

# Introduction to the Integrated Dicom/Network V3.0 (ID/NET V3.0)

# Conformance Statement

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# TABLE OF CONTENTS

# TABLE OF CONTENTS (CONT.)

# REVISION HISTORY

| REV | DATE | REASON FOR CHANGE |
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| 0 | August 31, 1994 | Initial release to Direction Stock. |

## LIST OF EFFECTIVE PAGES

| PAGE NUMBER | REVISION NUMBER | PAGE NUMBER | REVISION NUMBER | PAGE NUMBER | REVISION NUMBER |
|---|---|---|---|---|---|
| Title page | 0 | | | | |
| i thru iv | 0 | | | | |
| 1–1 thru 1–10 | 0 | | | | |
| 2–1 thru 2–10 | 0 | | | | |
| 3–1 thru 3–10 | 0 | | | | |
| 4–1 thru 4–6 | 0 | | | | |

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# SECTION 1 – INTRODUCTION

## 1–1 OVERVIEW

This document is the *Introduction to the Integrated DICOM/Network v3.0 (ID/Net v3.0)Conformance Statement*. It is applicable to all GE Medical Systems (GE) products which support the ID/Net v3.0 network. More specifically, this document is an introduction to the Conformance Statements related to GE ID/Net products.

**Section 1** provides general information about the GE strategy for Open Connectivity. It includes a brief description of the relationships of GE ID/Net v3.0 and the DICOM V3.0 standards and also includes important remarks which users of ID/Net should address carefully when connecting imaging systems.

**Section 2** is an overview of network architecture concepts, including the ISO seven layer model and the DICOM Applications Layer model.

**Section 3** describes the basic technical concepts and terminology which are used in the DICOM standard and the ID/Net environment.

**Section 4** provides some basic reference material (references, definitions, acronyms) for DICOM and ID/Net which is common to all GE DICOM Conformance Statements.

## 1–2 INTENDED AUDIENCE FOR THIS DOCUMENT

This document is intended for a broad audience in areas of medical imaging, software design, network planning, and/or systems integration. The reader must have a basic understanding of networking. The purpose of this document is to familiarize the reader with some of the ID/Net and DICOM v3.0 terminology and concepts.

If, however, the reader intends to work at the software implementation and/or systems integration levels, this Introduction will be helpful, but insufficient. In this case the reader must also read the DICOM v3.0 standard and the specific product Conformance Statements.

## 1–3 CONNECTIVITY FOR INCREASED EFFICIENCY

Connectivity is desirable for a number of reasons since it may provide clinical benefits and may increase the following departmental efficiencies:

- Rapid availability of images to diagnosticians and clinicians.
- Ease of exchange of images between locations (remotely or locally).
- Ease of image access for filming, reading, archiving (off–loading the tasks from scanners), or advanced analysis (3D, DentaScan).
- Integration of image acquisition and diagnostic information into the hospital information system, a necessary step toward patient record consolidation.

The benefits of shared digital information may include simultaneous access of information by multiple users, post processing of image data, reduction in film loss, reduction in film storage space, etc., which may result in increased productivity, efficiency, cost-effectiveness, and improved patient care. To pursue these potential benefits the concept of “Networked systems” must be incorporated. Fully networked systems are capable of **interoperating** to communicate image and related information. Simply being connected to a network does not mean that two devices can interoperate, that is, send, receive, display, analyze, or archive data, etc. ID/Net provides the interoperability foundation for networked devices, thus allowing customers to begin to choose equipment optimized for a particular application.

## 1–4 THE NEED FOR A STANDARD

True connectivity requires the definition and implementation of a common network communications standard among manufacturers, one that addresses a wide variety of imaging components – image acquisition equipment, display workstations, archiving systems, hard copy devices and information management systems, for example.

DICOM has emerged as the medical information networking standard, currently defining CT, MR, Nuclear Medicine, Ultrasound and Computed Radiography images, as well as Laser Camera and HIS/RIS interfaces. Also, the definition of X–Ray Angiography and Media Interchange is well underway. The development of DICOM has been the result of joint effort between NEMA (Medical Imaging Vendors) and the ACR (American College of Radiology). Other medical specialties have also contributed to this effort, in particular the ACC (American College of Cardiology).

DICOM is also a global standard. In particular, CEN in Europe is actively involved in the definition of DICOM standards and has decided to use DICOM as the basis for a European Standard. An active liaison also exists with the JIRA and IS&C committees in Japan. GE has been a major contributor to the development of this standard, and implementation of these DICOM concepts is realized in the GE ID/Net v3.0.

## 1–5 ID/NET – AN OPEN, INTEGRATED INTERFACE

The GE Integrated DICOM/Network v3.0 allows users to connect among GE DICOM imaging systems, as well as to other manufacturers' DICOM–based products. GE ID/Net v3.0 is a DICOM–based implementation which provides a common, open networking approach for medical imaging equipment. ID/Net is the **interoperability foundation** for a wide range of GE products and for interfacing with third party devices.

ID/Net provides the flexibility to configure, in many cases, network solutions that meet GE customers' diverse communication requirements. ID/Net also inherently provides for the option of purchasing standard network devices, such as cabling, transceivers, modems, routers, bridges, etc., to meet most network needs.

Because ID/Net is based upon networking standards, the size and configuration of health care site networks are flexible. The networking standards allow different technologies to be employed (e.g., wide area networks, local area networks, etc.).

With GE and ID/Net, you have the ability to begin accessing the benefits of connectivity today – and a solid link to the future.

### **1–5–1** ID/Net – An Integrated Network

ID/Net is *integrated*. DICOM standards are an integral part of product design, so investment in costly and complex gateways often needed to network between dissimilar proprietary networks is not likely (some older equipment may be an exception.)

### **1–5–2** ID/Net – An Open Network

ID/Net is *open*. It enables connectivity to other manufacturers' DICOM–compatible equipment. GE ID/Net interfaces are documented in DICOM Conformance Statements. If your current systems have not been built to DICOM standards, third party connections may be used to convert proprietary image format into DICOM standards.

### **1–5–3** ID/Net – Support by GE Products and ID/Net DICOM Conformance Statements

A number of GE systems are already demonstrating the effectiveness of ID/Net v2.0 and/or ID/Net v3.0 connectivity. Among them are our CT 9800, HiLight and HiSpeed Advantage systems, as well as MR Signa 5.X systems, Advantage Independent Consoles, and Advantage Windows workstations. As the DICOM standard evolves, additional modalities and connections are expected to be implemented.

For more specific information regarding current product capabilities and availability, please contact your GE Sales representative.

For the purposes of backward compatibility, the CT Advantage, MR Signa 5.x Advantage, and CT9800 ID/Link II continue to support ID/Net v2.0. This continuum in network connectivity is presented in section 1–5–4.

Any GE equipment which supports ID/Net will have a "DICOM Conformance Statement" available to the public. The Conformance Statement is an implementation profile which lists the DICOM functions (e.g., send a CT image, send an MR image, query for images, etc.) which have been implemented by a particular piece of equipment.

The DICOM standard, and thus ID/Net, is structured such that each device can implement the appropriate functions of the standard for its intended application. In order for two devices to interoperate, both devices must have a complementary set of functions implemented. As part of the standard, two devices negotiate before they begin to communicate to verify that the common function(s) does exist. However, before attempting to interoperate, the existence of a set of common functions should be determined by reviewing the Conformance Statement of each device. For example, a product could implement the "image send" function, but not the "image receive" function.

The exact technical specification of how ID/Net v3.0 implementations conform to DICOM v3.0 is given in each GE product ID/Net DICOM Conformance Statement. It is the intent of this document ("Introduction to the ID/Net v3.0 Conformance Statement") to provide introductory information which is common and applicable to all ID/Net DICOM Conformance Statements.

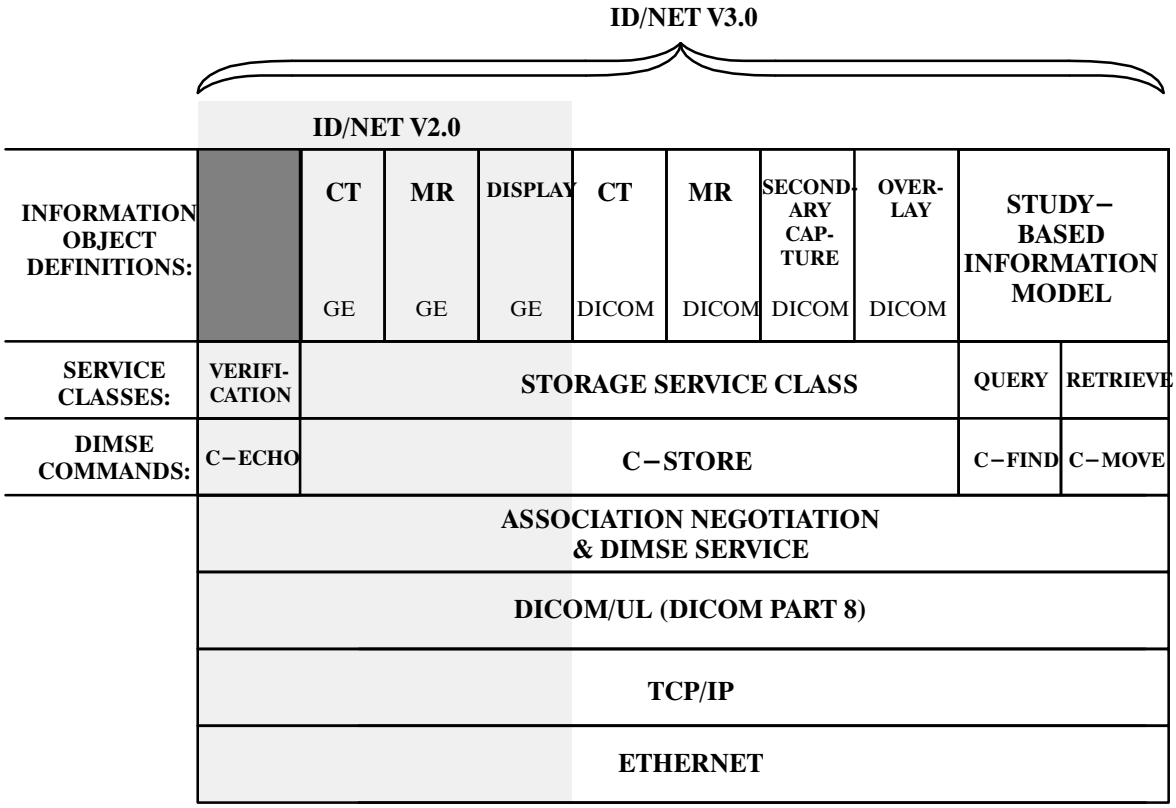
The Conformance Statements may be ordered by specifying the Direction number, as defined in the "Overall ID/Net Documentation Structure", section 1–7.

**1–5–4** ID/Net v3.0 Compatibility with ID/Net v2.0

ID/Net v2.0 products were released before the DICOM Standard was completed. ID/Net v2.0 is a network protocol based on the DICOM Part 8 network communications specification, but with GE specific Information Object Definitions (IOD's). The GE IOD's are publicly available as the "ID/Net v2.0 Implementation Profiles", Direction 46–269546G2, and are based on the April 1993 draft version of DICOM v3.0.

ID/Net v3.0 is fully compliant with the final version of DICOM v3.0, but also backward compatible with ID/Net v2.0 as shown in Illustration 1–1.

ILLUSTRATION **1–1**
**ID/NET V2.0 – ID/NET V3.0 RELATIONSHIP**



## 1–6 IMPORTANT REMARKS

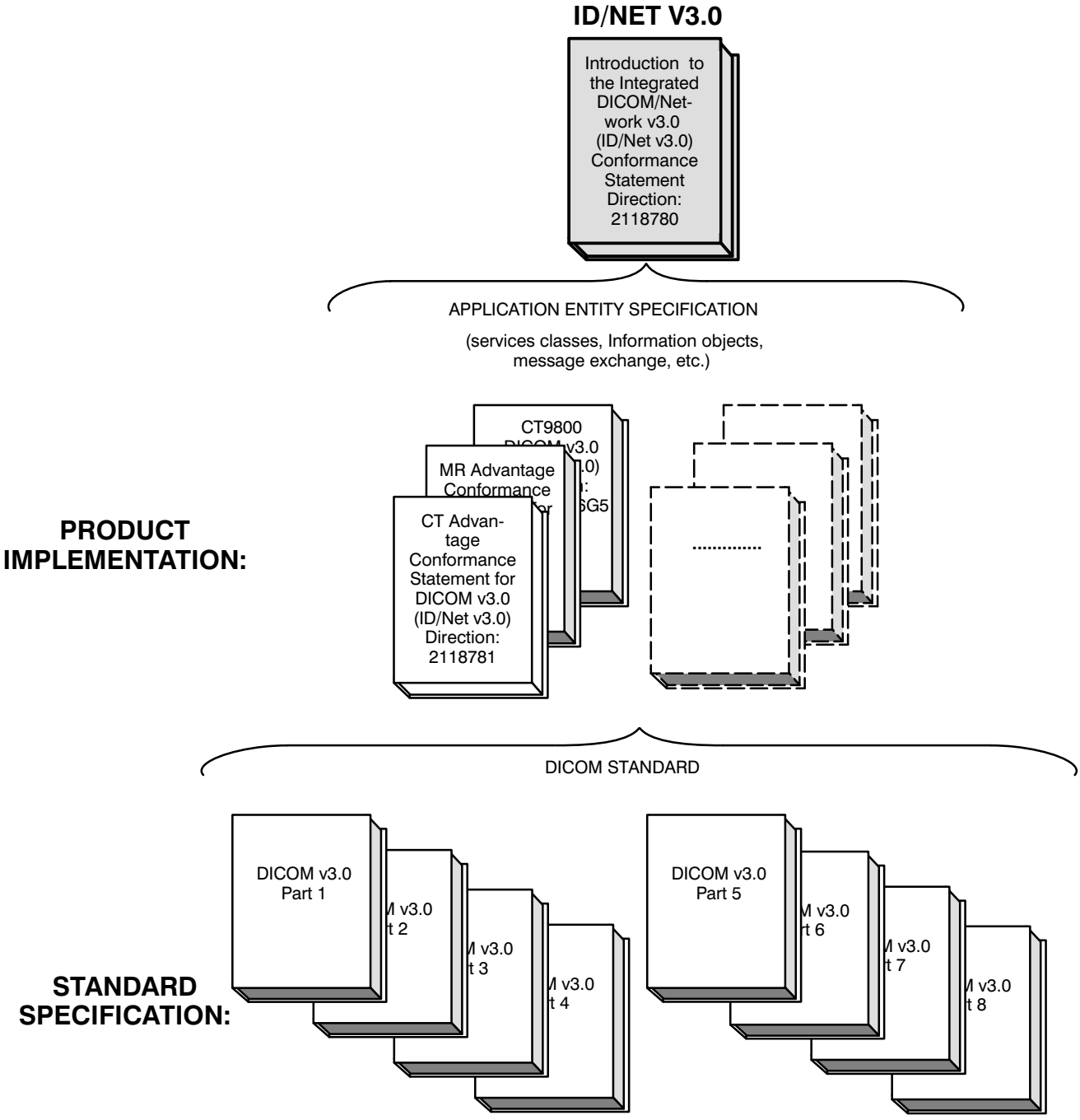
The use of these Conformance Statements, in conjunction with the DICOM v3.0 Standards, is intended to facilitate communication with GE imaging equipment. However, **by itself, it is not sufficient to ensure that inter–operation will be successful.** The **user (or user's agent)** needs to proceed with 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 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 v3.0 Standard. DICOM v3.0 will incorporate new features and technologies and GE may follow the evolution of the Standard. ID/Net v3.0 is based on DICOM v3.0 as specified in each ID/Net DICOM 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 ID/Net 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.

## 1–7 OVERALL ID/NET DOCUMENTATION STRUCTURE

The Documentation Structure presented in Illustration 1–2 (next page) shows the overall organization of the ID/Net documentation.

ILLUSTRATION **1–2**
**DOCUMENTATION STRUCTURE**



**1–7–1** ID/Net v3.0 Documentation

This document focuses upon the ID/Net DICOM v3.0 Conformance Statements and provides references to the ID/Net v2.0 Implementation Profiles. This document is the introductory level document:

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

This Introduction is applicable to all ID/Net v3.0 GE products. It is intended to familiarize the reader with ID/Net v3.0 and DICOM v3.0 terminology and general concepts. This document should be read prior to reading the product specific ID/Net DICOM Conformance Statements.

For the convenience of software developers, this Introduction and all of the currently published ID/Net DICOM Conformance Statements may be ordered under a single reference:

*ID/Net v3.0 Conformance Statements*
*Direction: 2117016*

### **1–7–2** ID/Net v2.0 Documentation

ID/Net v2.0 documentation followed a similar structure. In cases where installed equipment not yet upgraded to ID/Net v3.0 needs to be networked, the ID/Net v2.0 documentation (Implementation Profiles) include complete conformance statements. The following documents may be ordered:

*CT Advantage*
*Implementation Profile for ACR–NEMA v2.0*
*with DICOM v3.0 Extensions (ID/Net v2.0)*
*Direction: 46–269546G3*

*MR Advantage*
*Implementation Profile for ACR–NEMA v2.0*
*with DICOM v3.0 Extensions (ID/Net v2.0)*
*Direction: 46–269546G4*

*CT 9800*
*Implementation Profile for ACR–NEMA v2.0*
*with DICOM v3.0 Extensions (ID/Net v2.0)*
*Direction: 46–269546G5*

For the sake of convenience, the ID/Net v2.0 documentation can be ordered under a single direction number:

*ID/Net v2.0 Implementation Profiles*
*Direction 46–269546G2*

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# SECTION 2 – NETWORK ARCHITECTURE CONCEPTS

## 2–1 OVERVIEW

The second part of this document describes some of the Network Architecture concepts and models which are used in ID/Net v3.0 and DICOM v3.0. ID/Net v3.0 is fully based upon DICOM v3.0.

## 2–2 BASIC NETWORK LEVELS AND PROTOCOLS

A successful network architecture must be layered to facilitate integration of evolving technologies. The Open Systems Interconnection (OSI) Reference Model defined by the International Standards Organization is the accepted seven layer model for the design of modular network architectures.

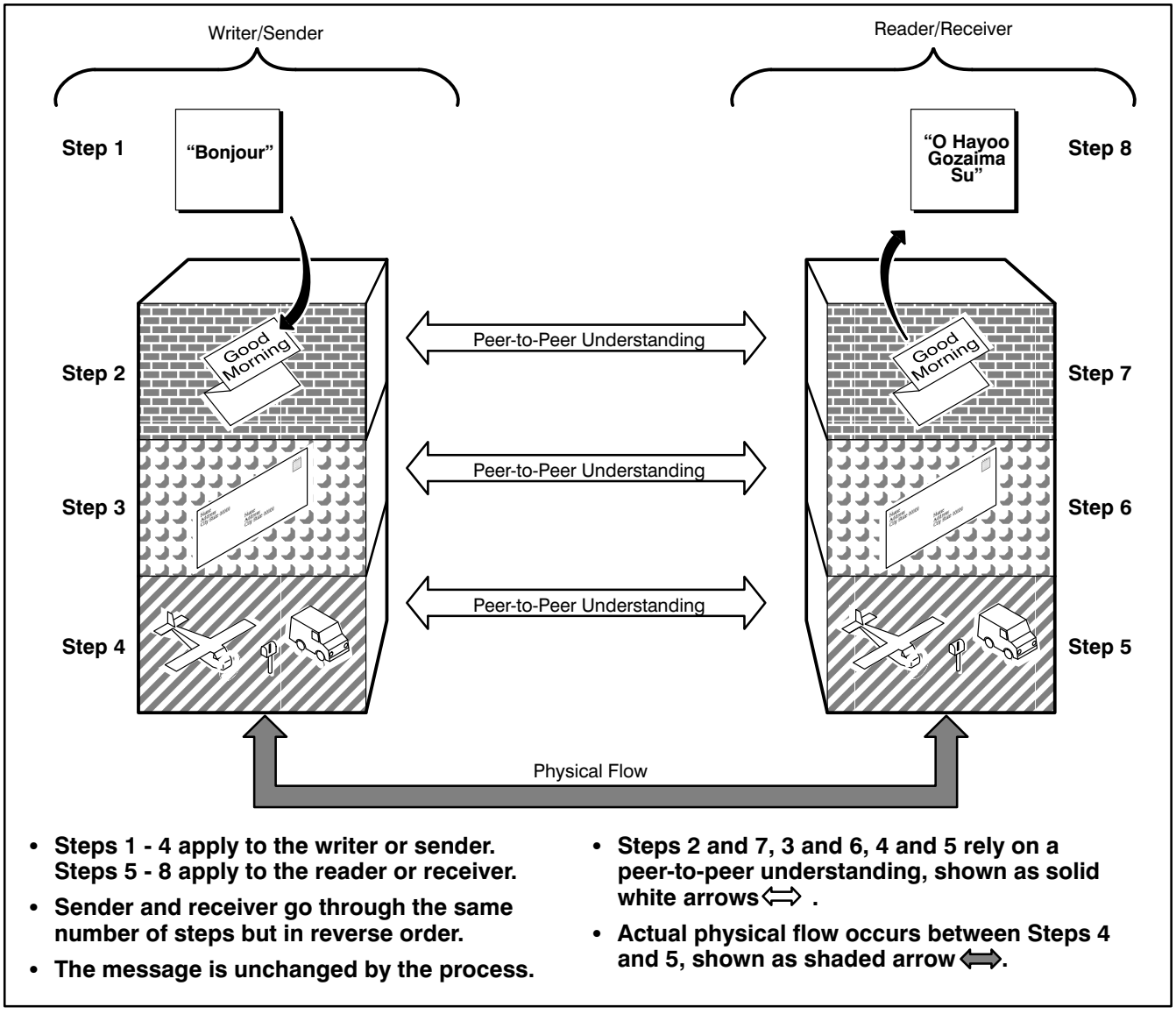
The purpose of this Section is to provide a brief explanation of the OSI networking architecture. Section 2–2–1 provides some analogies to introduce these concepts. Section 2–2–2 illustrates how DICOM is based on the OSI reference model.

### **2–2–1** Network Architecture and the Post Office Analogy

The fundamental choices made by the DICOM v3.0 Standard can be understood by comparing a digital medical image network to a postal system. A postal system is complex, employing computers to track and route mail, and trucks, trains, and airplanes to move mail. But for the end user, the complexity of the system is transparent.

When it comes to the content of the envelope, the two people who want to communicate need a common language for writing the letter. If they do not speak the same language but both know a third language, the third language would be the common language, the language of communication. For example, if a French person and a Japanese person both spoke English and they wanted to write to each other, they would go through this process (refer to Illustration 2–1 as you read the steps below it):

ILLUSTRATION **2–1**
**GETTING THE MESSAGE ACROSS**

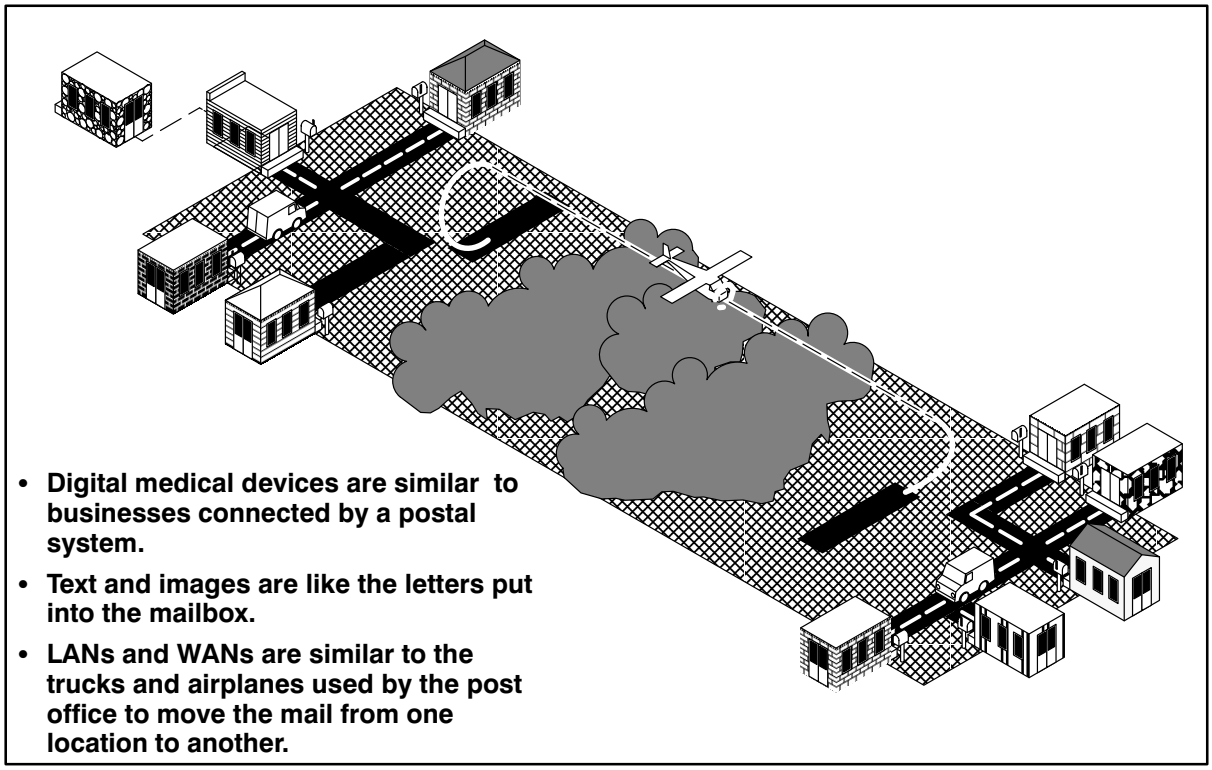



1. The letter is composed in the writer's native language, for example, French.
2. The letter is translated into English.
3. The letter is inserted into an envelope, and the envelope is addressed to meet the postal system's requirements.
4. The letter is put into a mail box, picked up by the writer's post office and sent across town or around the world.
5. The letter is received by the reader's post office.
6. The address on the envelope is read, and the letter is delivered to that address.
7. The letter is opened and read in English.
8. The English is translated into the reader's native language, for example, Japanese.

After packaging and addressing a letter and putting it into a mailbox, the postal system takes over and performs Steps 4 and 5. The letter could travel by truck, train or plane. The method of transportation does not matter as long as the letter is reliably delivered to its destination. Refer to Illustration 2–2 as you read the following:

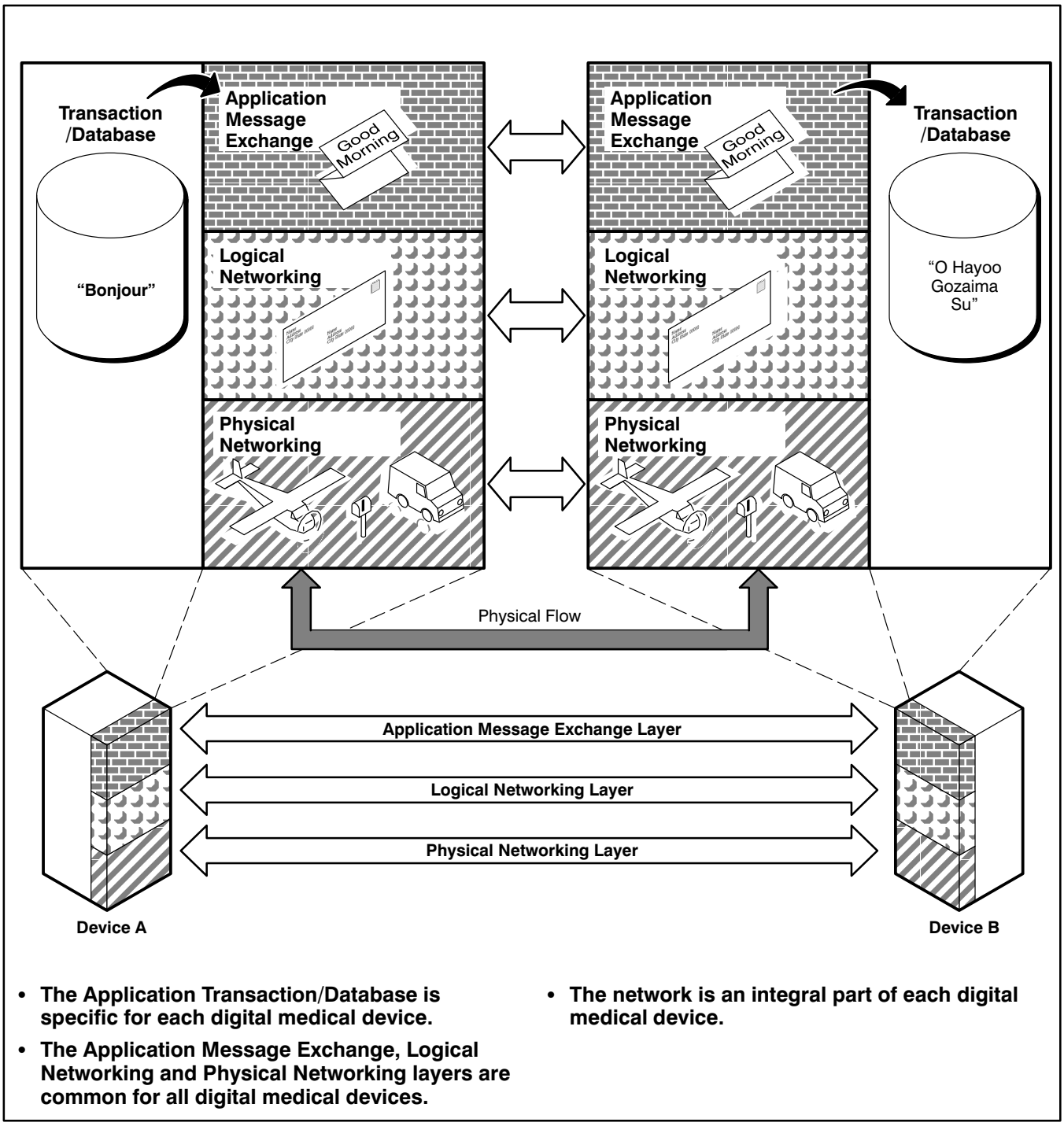
- The devices on a digital medical network are similar to the businesses on a postal system. Just as each business is different, the devices can be different. They include workstations, image acquisition devices, information systems, image storage and distribution control devices, gateways, hard copy printers and other peripherals.
- The imaging and text data being transferred across a digital medical network varies, just as the contents of letters being carried by the postal system varies. The postal system does not care about the contents of the letters it delivers, nor does it alter the contents. In a similar manner, digital medical networks should transfer image and text data without altering the information.
- The postal system delivers both small envelopes and large packages. In the same manner, a digital medical network should reliably transfer a few bytes to megabytes of data.
- The postal system employs different methods of transportation to move the mail in an efficient and cost effective manner, including people, trucks, trains and airplanes. In the same way, digital medical networks should integrate different transmission technologies to get the job done:
  - Within the hospital, digital medical networks may support different types of Local Area Networks (LANs). For example, Ethernet, Fiber Distributed Data Interface (FDDI), Digital Links, Dial–up circuits, etc.
  - When communicating outside a hospital, a digital medical network should integrate Wide Area Networks (WANs) links. These links are in general provided by regional or national telecommunication carriers who use a combination of terrestrial, microwave and satellite technologies. A wide range of service and speeds are available ranging from kilobit per second phone lines to megabit per second leased lines and switched high speed services.

ILLUSTRATION **2–2**
**POSTAL SYSTEM COMPARED TO A DIGITAL MEDICAL NETWORK**




When digital medical devices need to “get the message across”, they communicate using the same steps as the businesses of the postal system. The sending and receiving digital medical devices should match at all levels of networking to guarantee efficient and reliable delivery of data. The three layers of networking and the application they support are defined immediately following Illustration 2–3.

ILLUSTRATION **2–3**
**PARALLEL STRUCTURE OF NETWORKED DEVICES**




- **The Application Transaction/Database is specific for each digital medical device.**
- **The Application Message Exchange, Logical Networking and Physical Networking layers are common for all digital medical devices.**
- **The network is an integral part of each digital medical device.**

- The application **Transactions and Database** are like the contents of a letter written in the native language. They are specific to each device, just as the usage of the contents of a letter is specific to each reader and writer. The DICOM v3.0 Standard only addresses the network communications functions and data necessary to support the applications. It does not specify the internal design of the device.
- The **Application Message Exchange** layer is similar to the translated letter. Using DICOM v3.0, this layer allows non-compatible platforms and applications to communicate by defining common protocols and formats which support such features as image transfer, database queries and retrieval of images/text related information.
- The **Logical Networking** layer is similar to the letter's packaging and labeling. This layer defines how the message will be managed by the network and guarantees reliable delivery within a hospital and remote hospitals. The Logical Networking layer shields the Application Message Exchange layer from physical network technologies.
- The **Physical Networking** layer is similar to the trucks, trains and airplanes which transport the letter. It is the physical medium (i.e. cabling) and its access methods (access hardware and intermediate switches) such as Ethernet, FDDI, etc., which exchanges the bits of data. The Physical Networking layer should support a choice of options in order to address, in a cost effective manner, the various performance requirements of the Logical Networking layer.

The Logical and Physical Networking layers must work together to support the Application Message Exchange layer. To guarantee interoperability between devices, one approach must be specified for each layer. The selection of these choices establishes a network architecture.

Networking support is an integral part of any digital medical device. The Physical Network which externally links the device is a small component of what is required for devices to actually interoperate. The Logical Networking and Application Message Exchange functions which are integrated into the medical devices play a role transparent to the user, but fundamental to information exchange.

GE ID/Net is an open network architecture as it relies on network standards broadly supported by the medical industry (e.g., DICOM) and the computer industry (e.g., TCP/IP, Ethernet, OSI, etc.) for all of the networking layers.

### **2–2–2** DICOM and the OSI Reference Model

As stated earlier, DICOM v3.0 is structured according to the OSI Reference Model. The OSI Reference Model defines seven layers of communication protocol which may be more simply grouped into the three layers previously described:

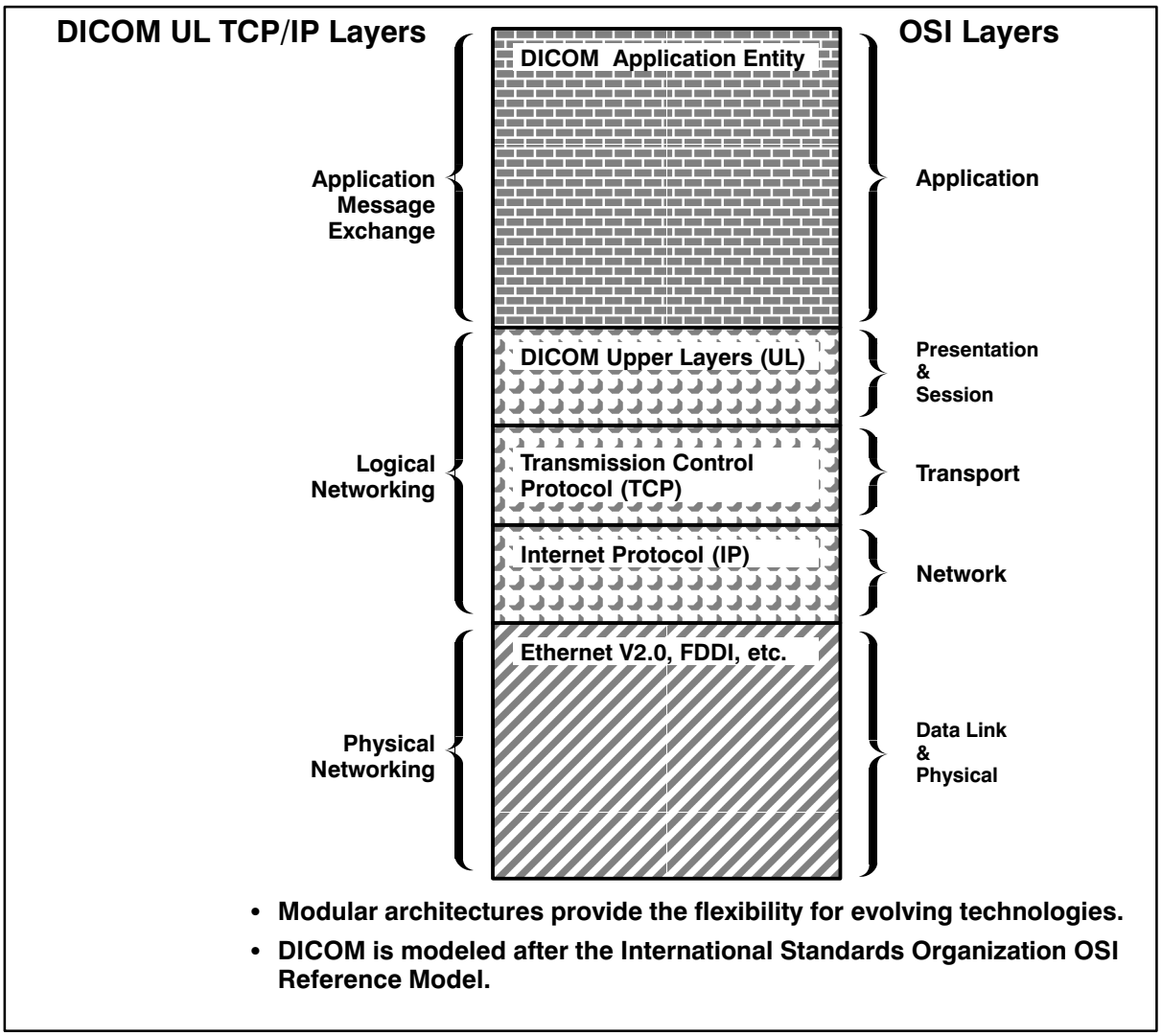
1. Application Message Exchange Layer
2. Logical Networking Layer
3. Physical Networking Layer

DICOM defines one **Application Message Exchange Layer** which may operate over two logical/physical networking protocols:

1. DICOM Upper Layers (UL) with TCP/IP
2. OSI protocol

ID/Net v3.0 has selected the DICOM UL with TCP/IP. Illustration 2–4 shows how the DICOM UL TCP/IP network protocol relates to the OSI Reference Model.

ILLUSTRATION **2–4**
**DICOM UL TCP/IP AND OSI LAYERS**




In the Logical Networking Layer the ID/Net architecture uses DICOM UL protocol (standardized by DICOM v3.0 Part 8) and Transmission Control Protocol/Internet Protocol (TCP/IP). TCP is a robust protocol which guarantees reliable delivery of the application messages. IP provides mechanisms which support the routing of data within a hospital or to remote hospitals over a variety of physical networks. The ID/Net Physical Networking Layer generally relies on Ethernet v2.0 as the Datalink and Physical Network Layer. Other physical network technologies may be combined with Ethernet v2.0 (e.g. FDDI or Wide Area Networks (WAN's)).

It should be noted that TCP, IP, and Ethernet are not specific to the DICOM standard and are multi-industry standards implemented in off-the-shelf commercial products. The DICOM Upper Layers (UL) and the DICOM Application Layer are specific to the DICOM standard. The DICOM Application Layer is introduced in more detail in section 3.

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# SECTION 3 – APPLICATION LAYER CONCEPTS USED IN DICOM V3.0 AND ID/NET

## 3–1 OVERVIEW

This section of the document describes some of the fundamental concepts and models which are used by the Application layer standardized by DICOM v3.0 and used by ID/Net Implementations. DICOM v3.0 uses Object Oriented Design concepts and the OSI Reference Model.

All parts of the DICOM v3.0 standard were unanimously approved in October of 1993. Part 10 of the DICOM Standard – Media Storage and File Formats, as well as additional parts which are under development as of early 1994, are not discussed in this section.

The reader interested in a complete presentation of these concepts should refer to the DICOM v3.0 standard. The last part in this section provides an overview of the nine DICOM v3.0 Parts.

## 3–2 CONFORMANCE STATEMENTS

A DICOM v3.0 Conformance Statement is available for every piece of GE Imaging Equipment having an ID/Net Interface (as is required by DICOM). The Conformance Statement explicitly states the network capabilities and options implemented by that device. For example, a Conformance Statement identifies which Information Object Definitions (MR image, Patient/Study (RIS) object, etc.) may be sent and/or received. It also identifies which Service Classes have been implemented (Storage, Query/Retrieve, Print, etc.).

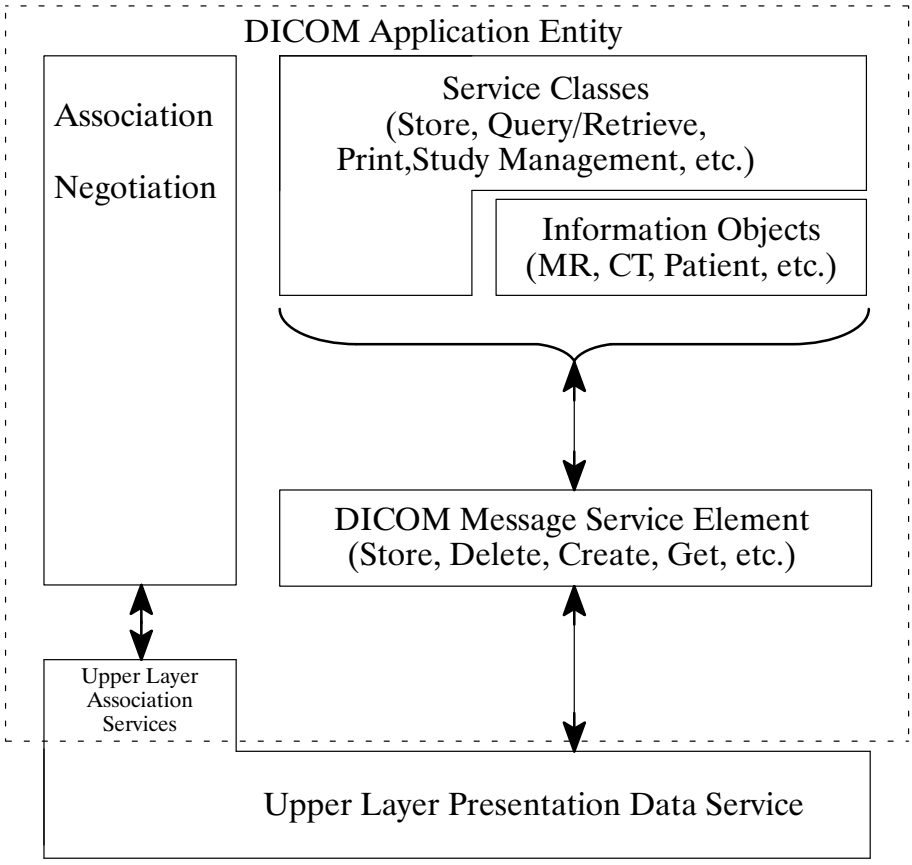
The purpose of the Conformance Statement is to define the capabilities of a specific device and allow the reader to determine what exact functionality is available. That is, Conformance Statements allow implementations to assess the level of interoperability between two DICOM compliant devices.

## 3–3 DICOM V3.0 APPLICATION LAYER CONCEPTS

An Application Entity (AE) is an OSI Application Layer function which includes the mechanisms by which applications exchange information on a network. The basic concepts of an Application Entity, as used in the DICOM v3.0 standard, are described in this section (see Illustration 3–1 for a pictorial representation of the DICOM Application Entity).

The DICOM model is based on an object-oriented model. Object-oriented modeling uses abstract data objects (e.g., the definition of MR images, CT images, etc.) to represent a class of real-world objects. Object-oriented modeling also defines generic "methods" (e.g., Store, Delete, Create, Get, etc.) which act upon the data objects. The combination of a method and a data object being used by two peer AEs over an association constitutes an instance of communication. Illustration 3–1 shows the relationship of the DICOM objects model.

ILLUSTRATION **3–1**
**DICOM OBJECTS RELATIONSHIP MODEL**



An AE uses the following concepts:

1. Information Object Definitions (data object definitions)
2. DICOM Message Service Element Services (generic methods)
3. Service Object Pair (SOP) Classes (the method and data object combined)
4. Service Classes (a set of related SOP Classes)
5. Association Negotiation (negotiate how data will be encoded and the type of data to be exchanged)

Each of these concepts is defined in further detail in sections 3–3–1 through 3–3–5.

### **3–3–1** Information Object Definition

An Information Object Definition (IOD) is the specification used to define an abstract data object (the information to exchange). The goal of an IOD is to provide an unambiguous specification about related pieces of information. IODs do not represent a specific instance of the data object, but rather a class of similar data objects which have the same properties. IODs provide the mechanisms to specify data objects such as images (e.g., MR, CT, NM, etc.) and also image related data objects such as curves, overlays, Radiology Information System (RIS) information, etc.

In DICOM an IOD consists of an Entity Relationship Model, information entities, modules, and attributes. The content of an IOD is similar to a memo. A memo consists of words (called attributes), sentences (a set of related words, called modules), paragraphs (a set of related sentences, called information entities), and finally the memo (a set of related paragraphs, described by an Entity Relationship Model).

### **3–3–2** DICOM Message Service Element (DIMSE) Services

Specifying an IOD is key for communication. However, it is not sufficient. Services (methods) which operate on IODs need to be standardized. DICOM defines a set of generic services (such as Store, Create, Delete, Get, etc.) which act upon instances of an IOD. These services are called the DICOM Message Service Element (DIMSE).

### **3–3–3** Service Object Pair (SOP) Class

The coupling of one or more DIMSE Services with one specific IOD results in a Service Object Pair Class (SOP Class). A SOP Class specification contains the rules which are applied to the DIMSE Services and a related IOD. A SOP Class is equivalent to an “object class” in the object-oriented model (the data plus the methods).

A SOP Class is the key specification building block for the successful communication between two AEs. However, like the IOD, the SOP Class does not represent a specific instance of communication. When a specific instance of communication does occur it is defined as a SOP Instance. SOP Instances are used to represent real-world occurrences of images, studies, patients, etc.

The analogy of a sentence can be used to describe the MR Storage SOP Class. The IOD acts as the noun (an MR image). The DIMSE Service acts as the verb (Store). The SOP Class is similar to a generic sentence (Store an MR image). The SOP Instance is similar to a specific sentence (Store this MR image).

### **3–3–4** Service Class

A Service Class represents a specific function which is to be accomplished by peer AEs and is defined by a set of related SOP Classes. For example, the features needed to query for image information and to retrieve the actual image data are very closely related. To achieve these features two SOP Classes are required, one to gather image information (query) and one to get the image data (retrieve). The Query/Retrieve Service Class combines these related SOP Classes into one Service Class.

The Service Class defines two roles which are used by communicating AEs, the Service Class User (SCU) and Service Class Provider (SCP). These roles are based on the "client/server model". The SCU acts as the "client" while the SCP acts as the "server". For example, for the Storage Service Class, the SCU acts as the image send device while the SCP acts as the image receive device.

### **3–3–5** Association Negotiation

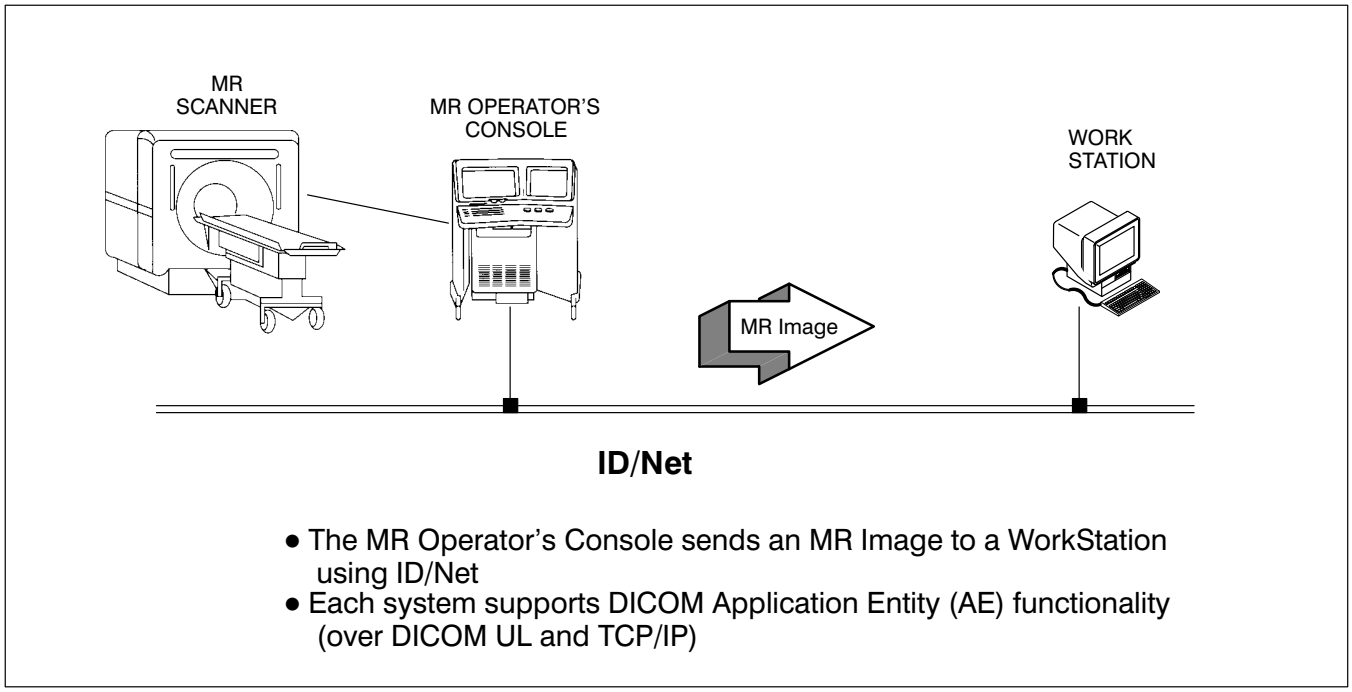
Association establishment is the first phase of communication between peer AEs. The AEs use the association establishment to negotiate how data will be encoded and the type of data to be exchanged. Some of these negotiated parameters include Application Context, Abstract Syntaxes, Transfer Syntaxes, and Application Association Information.

The method of negotiation used in DICOM v3.0 is fairly simple. The device which initiates the association proposes a list of possible options for each negotiated parameter. The initiating device must be capable of supporting all of the options which it proposes. The responding device selects which of the options it can support and returns this information to the initiating device. This commonly agreed upon set of options is then available on the corresponding association.

### **3–3–6** Example of AE Concepts

Following is an example of two systems which need to send/receive an MR image. This example illustrates how DICOM is used to achieve this image exchange.

ILLUSTRATION **3–2**
**EXAMPLE OF AE CONCEPTS**

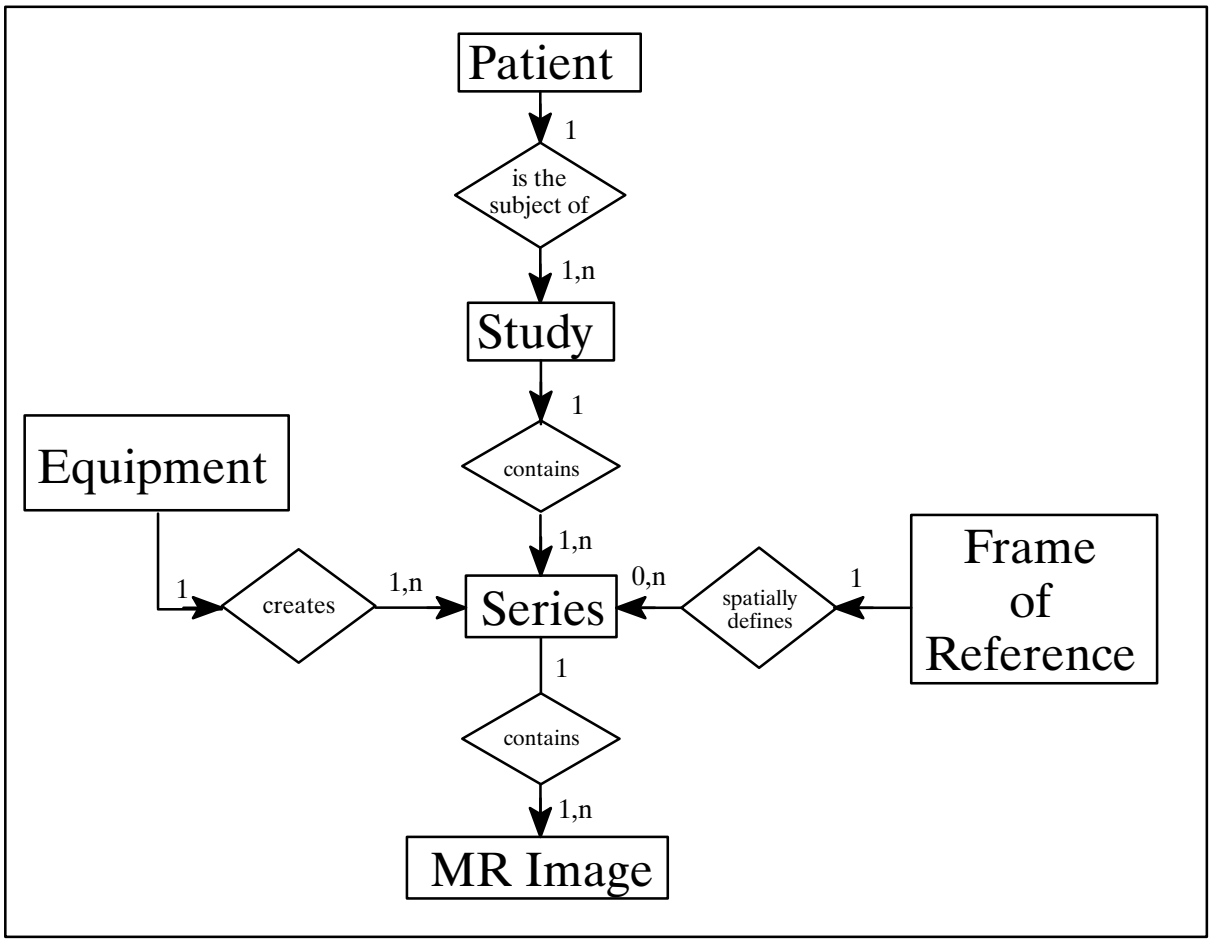



In order to understand how to exchange this MR image, both the MR Scanner and the Workstation need to implement the DICOM Application Entity concepts previously discussed.

To determine the data structure that defines an MR image each device must understand the **MR Image Information Object Definition**.

The MR Image IOD contains the **Attributes** which describe the complete set of data needed to define the image. Some of the Attributes are Patient Name, Date of Scan, MR Acquisition Type, Echo Time, Pixel Data, etc. Associated Attributes are grouped into **Modules**. Modules contain the exact definition of each Attribute, including whether the Attributes are required or optional and the rules of how these Attributes are related. A few of the Modules are: Patient Identification Module, Image Pixel Module, Overlay Plane Module, Lookup Table Module, etc. Associated Modules are grouped into **Information Entities**. The key Information Entities include Patient, Study, Series, Equipment and Image. As an example, the Image Information Entity includes the Image Pixel Module, Overlay Plane Module, and the Lookup Table Module. The relationship of the Information Entities is described by an **Entity Relationship Model** (see Illustration 3–2 for an example of an Entity Relationship Model and DICOM Standard Part 3, section 5 for information on how to interpret Entity relationship diagrams).

ILLUSTRATION **3–3**
**MR IMAGE ENTITY RELATIONSHIP DIAGRAM**




To determine how to send/receive the MR image each device must understand the **C–STORE DIMSE Service**. This is the generic service (method) which is used to send or receive any image, e.g., MR, CT, Nuclear, etc.

To determine how to couple the MR Image IOD and the C–STORE DIMSE Service each device must understand the **MR Storage SOP Class**. In this example, only one DIMSE Service is coupled with the MR Image IOD. However, other examples may include multiple DIMSE Services coupled with one IOD.

The MR Storage Service Class is one of the SOP Classes specified by the DICOM Storage Service Class. Each AE must understand which role it wishes to play for the MR Storage SOP Class. The MR Scanner, which is sending the image, will act as the **Storage Service Class User** (SCU). The Workstation, which is receiving the image, will act as the **Storage Service Class Provider** (SCP).

To establish an **Association** between the two devices so the image may be sent, both AE's must understand the negotiation process. Two of the key parameters which will be negotiated during Association Establishment are the **Abstract Syntax** and **Transfer Syntax**. The Abstract Syntax identifies the SOP Class. In this example, the Abstract Syntax is the MR Storage SOP Class (i.e., the MR Image IOD and the C–STORE DIMSE Service). The Transfer Syntax identifies the type of pixel data encoding which will be used to send this image, e.g., compressed or uncompressed pixel data.

In this example, the MR Scanner may initiate the Association by proposing several Abstract and Transfer Syntaxes. The responding Workstation will identify the Syntaxes it can support in its response to the MR Scanner.

**3–3–6–1** Communication Scenario

Now lets go through the order that the steps occur in the actual transmission of the image.

The MR Scanner first initiates an association to the Workstation. It offers an Abstract Syntax which represents the MR Storage SOP Class with two Transfer Syntaxes, compressed or uncompressed pixel data. The Workstation responds by accepting the MR Storage SOP Class and selecting the uncompressed Transfer Syntax (it could not support compression). The association is now established.

The MR Scanner constructs the image per the MR IOD and uses the C–STORE DIMSE Service to send that IOD. The result will form a message including a command (C–STORE) and a Data Set (the MR IOD encoded Attributes). The actual image or MR Image SOP Instance is identified by a unique identifier or UID (see section 3–4) .

The Workstation receives this MR Image SOP Instance and stores the information in it's database. The Workstation returns a "successful" response using the STORE DIMSE Service. The image has now been successfully received.

At this time the MR Scanner may send more images or release the association.

**Notice:** The above example illustrates a simple transfer of images. If both the MR Scanner and the Workstation had implemented additional SOP Classes, such as Query/Retrieve, these features could also be used on the same association.

## 3–4 UNIQUE IDENTIFIERS (UIDS)

Unique Identifiers (UIDs) provide the capability to uniquely identify a wide variety of items. It guarantees uniqueness across countries, sites, vendors and equipment. This scheme is used to uniquely identify items such as Service Object Pairs (SOP) Classes, images, instances, network negotiation parameters, etc.

The UID identification scheme is based on the OSI Information Object as defined by the ISO 8824 standard. All UIDs, used within the context of the DICOM Standard, are based upon registered values as defined by ISO 9843-3 to ensure global uniqueness.

There is a root portion of the UID which uniquely identifies GE Medical Systems. The root is registered with ISO and therefore guarantees that GE-specific UIDs are unique among vendors.

Per the DICOM v3.0 standard, three types of UID values are used:

1. The DICOM UID values which are defined in the DICOM Standard (such as SOP class UIDs).
2. GE-specific UID values which are defined in the ID/Net DICOM Conformance Statement for GE products (such as product Implementation Class UID's).
3. GE–specific UID values dynamically generated by GE product implementations (such as Image SOP Instance UIDs).

## 3–5 RELATIONSHIP OF CONCEPTS TO THE PARTS OF THE DICOM V3.0 STANDARDS

DICOM v3.0 is comprised of nine Parts which were balloted and approved in October, 1993. As of early 1994, three additional Parts related to Media Storage and File Format were placed under review. The nine Parts of the DICOM v3.0 Standard and the areas which are covered are:

| PART | TITLE |
|---|---|
| 1. | **Introduction and Overview** |
| 2. | **Conformance Requirements**<br>Includes requirements for accurately writing a DICOM Conformance Statement. |
| 3. | **Information Objects Definitions**<br>Includes IODs for MR, CT, Ultrasound, Nuclear, etc. It also includes IOD's for Network Filming and Imaging Study Management (often called HIS/RIS Interfacing). |
| 4. | **Service Classes Specifications**<br>Includes definitions of Service Class concepts, the SCU/SCP roles, and definitions of Service Classes (i.e. Image Storage, Query/Retrieve, Network Print, Study Management, Results Management, etc.). |
| 5. | **Data Structure and Encoding**<br>Includes DICOM data set structure, Data Element encoding rules, value encoding definitions (e.g., short string, unsigned short int, etc.). Attribute types, UID encoding rules and registration, and Transfer Syntax specifications. The support of JPEG lossless compression is also fully specified. |
| 6. | **Data Dictionary**<br>Includes Element list which is made up of Attribute Names and descriptions,Data Element Tags (Group and Element numbers), Value Representations and Multiplicity. |
| 7. | **Message Exchange**<br>Includes association negotiation information and structures, DIMSE operation and notification rules and DIMSE service and protocol definitions (e.g., C-STORE, C-ECHO). |
| 8. | **Network Communication Support for Message Exchange**<br>Includes Association Establishment protocol and encoding, including the DICOM Upper Layer protocol used with TCP/IP. |
| 9. | **Point-to-point Communication**<br>Includes 50-pin hardware specification and communication protocol. This is the ACR−NEMA specific hardware interface which was defined in Version 2 of the Standard. It has been included as Part 9 of the DICOM Standard for historical purposes. |

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# SECTION 4 – REFERENCES

## 4–1 NORMATIVE REFERENCES

- DICOM – Part 1: Document Structure
- DICOM – Part 2: Conformance
- DICOM – Part 3: Information Object Definitions
- DICOM – Part 4: Service Class Specifications
- DICOM – Part 5: Data Structure and Encoding
- DICOM – Part 6: Data Dictionary
- DICOM – Part 7: Message Exchange
- DICOM – Part 8: Network Communication Support for Message Exchange

## 4–2 RELATED PUBLICATIONS OF INTEREST

- DICOM v3.0 Standard (printed copy):
  ACR–NEMA / DICOM Representative
  NEMA
  2101 L Street, NW, Suite 300
  Washington DC 20037
  USA
  (202 457–1965)
- DICOM v3.0 (electronic copy):
  Available through anonymous ftp from Pennsylvania State University
  ftp address: **ftp.xray.hmc.psu.edu**
- SCAR 1994 “Buying Imaging Products with a DICOM Interface – Made Easy”
  Van Syckle, Sippel–Schmidt, Parisot

## 4–3 DICOM SOFTWARE COMMONLY AVAILABLE

DICOM v3.0 Shareware (RSNA 1993 Central Test Node Software) available via anonymous ftp over internet:

- Mallinckrodt Institute of Radiology
  ftp address: **wuerlim.wustl.edu** (128.252.115.18)
- Institute OFFIS, Oldenburg University (Germany), CERIUM in Rennes, France, and CEN/TC251/WG4
  ftp address: **ftp.uni–oldenburg.de**

## 4–4 DEFINITIONS

Many of the terms defined here are used in sections 2 and 3 of this document and in the ID/Net DICOM Conformance Statement of each GEMS product.

**Abstract Syntax:** The Abstract Syntax identifies the Service/Object Pair (SOP) Class which is used when two peer DICOM Application Entities communicate. The Abstract Syntax is negotiated at the time of Association Establishment.

**ACR-NEMA:** A standards body sponsored by the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA).

**Application Context:** An Application Context is a name which is used to identify the use of the DICOM Application Services over an association. It is negotiated between two peers during association establishment.

**Application Entity (AE):** An Application Entity is an OSI Application Layer function which includes the mechanisms by which applications exchange information on a network. Oversimplistically, an AE is a program which contains network communications capabilities and which runs on a computer.

**Association Establishment:** An Association represents a level of connectivity between to AEs. An Association Establishment is the first phase of communication between two peer DICOM AEs. The two peers use this method to negotiate some communication parameters such as Abstract Syntax, Transfer Syntax, etc.

**Attributes:** Attributes are properties which describe an Information Object Definition. An Attribute is identified by a name and its associated Data Element Tag (group and element number).

**Conformance Statement:** The Conformance Statement states which options and features of DICOM have been implemented by a specific product (e.g. which IOD's, which Service Classes, etc.). It specifies in technical detail how a particular implementation meets the conformance requirements set forth by DICOM v3.0. Every device which claims DICOM conformance must openly publish a DICOM conformance statement, written in the format specified by DICOM Part 2.

**Data Element:** A Data Element is an encoded Attribute and is part of a Data Dictionary. The Data Element Tag is used to uniquely identify the piece of information within the Dictionary. An Element Number is combined with a Group Number to make up a tag. For example, Study (Exam) Number is Group 20 Element 10. The group and element number tag are encoded in the Data Set (and, hence, the data stream.)

**DICOM:** The acronym of the final version of the standard produced by the ACR-NEMA committee is officially called: Digital Imaging and Communications in Medicine (DICOM v3.0), and was unanimously approved in October 1993.

**DIMSE:** DICOM Message Service Element. The DICOM v3.0 Standard defines the services and protocols used by an Application Entity to exchange messages. These services and protocols define the DICOM Message Service Element (DIMSE). DIMSE defines generic "operations" (such as Store, Move, Find, Get, etc.) which can be used in specifying SOP Classes. DIMSE are defined in DICOM v3.0 Part 7.

**Element:** Informal term used to reference a Data Element.

**Full Fidelity Storage:** The characteristic of a receiving device to be able to receive and store all attributes, including private attributes, specified for a given Image Information Object Definition.

**Group:** A Group is a collection of data elements within a message and is part of a Data Dictionary Tag (see Tag).

**Information Entity:** An Information Entity is a subset of an Information Object Definition (e.g., CT image or MR image). It is a group of related Modules.

**Information Object:** Informal term used to reference an Information Object Definition.

**Information Object Definition (IOD):** An IOD is a data model which is an abstraction of real-world information (e.g., an MR Image or CT Image) and which is acted upon by one or more DIMSE operations. An IOD consists of a data model describing the interpretation of the information and the attributes which define it.

**Module:** A Module is a set of Attributes within an Information Object which are logically related to each other. For example, the "Patient Identification Module" may be defined by the following attributes: Patient Name, Patient ID, and Patient Birthdate, and Patient Sex.

**Service Class:** A Service Class defines a specific function which is to be accomplished by connecting AEs. A Service Class specifies a set of one or more Service/Object Pairs (SOP) which perform a function across a network and provide interoperability between two application entities. Examples of a Service Class include image storage, query/retrieve, etc.

**Service Class Provider (SCP):** A Service Class Provider acts in a "server" role to the Service Class during a network communications exchange. An SCP performs operations requested by an SCU and may also provide notifications to the SCU. An example of a **Storage** Service Class Provider would be the image storage device. In this case, the image storage device is storing the image as requested by the SCU.

**Service Class User (SCU):** A Service Class User acts in a "client" role to the Service Class during a network communications exchange. An SCU requests that an SCP perform operations. An example of a **Storage** Service Class User would be the image send device. In this case, the image send device will send an image by requesting the SCP to store that image.

**Service/Object Pair (SOP) Class:** A SOP Class is defined by the union of an IOD and a DIMSE Service Group. The SOP Class definition contains the rules and semantics which may extend or restrict the definitions of the DIMSE Service Group or the IOD attributes. A DICOM Application Entity may support one or more SOP Classes. Each SOP Class is identified by a SOP Class UID.

**SOP Instance:** A representation of a specific occurrence of a SOP class.

**Tag:** The Tag is used to uniquely identify information within a Data Dictionary. A Group Number is combined with an Element Number to make up a tag. For example, Study (Exam) Number is Group 20 Element 10. The group and element number tag are encoded in the data stream. In v2.0, the Group was used to convey semantic information (e.g., Group 10 is Image Information). However, in DICOM v3.0 the Group semantic information has been replaced with the Module concept.

**Transfer Syntax:** The Transfer Syntax represents the type of data encoding which is used when two peer DICOM Application Entities communicate. The Transfer Syntax is negotiated at the time of Association Establishment. Examples of Transfer Syntaxes are Little Endian, Big Endian, JPEG lossless compression, etc.

**Unique Identifier (UID):** A Unique Identifier is a method which is used to create a globally unique ASCII-numeric string. It guarantees uniqueness across multiple countries, sites, vendors and equipment. The UID encoding method which is used in DICOM v3.0 is ISO compliant. A few examples for uses of UIDs are SOP Class UID, Image UID, network negotiation parameters, etc.

**Upper Layer (UL):** The Upper Layer is part of the DICOM Logical Network Layer of software. The Upper Layer performs such functions as the Association Establishment (including Abstract and Transfer Syntax negotiation), the encoding and decoding of a DICOM message stream, etc.

## 4–5 SYMBOLS AND ABBREVIATIONS

| | |
|---|---|
| **ACC** | American College of Cardiology |
| **ACR** | American College of Radiology |
| **AE** | Application Entity |
| **ANSI** | American National Standards Institute |
| **DICOM** | Digital Imaging and Communications in Medicine |
| **DIMSE** | DICOM Message Service Element |
| **GEMS** | GE Medical Systems |
| **HIS** | Hospital Information System |
| **ID/NET** | Integrated DICOM/Network |
| **IOD** | Information Object Definition |
| **IS&C** | Image Save & Carry |
| **ISO** | International Standards Organization |
| **JIRA** | Japanese Industry Radiology Aparatus |
| **NEMA** | National Electrical Manufacturers Association |
| **OSI** | Open Systems Interconnection |
| **RIS** | Radiology Information System |
| **SCP** | Service Class Provider |
| **SCU** | Service Class User |
| **SOP** | Service/Object Pair |
| **TCP/IP** | Transmission Control Protocol/Internet Protocol |
| **UID** | Unique Identifier |
| **UL** | Upper Layer |

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GE Medical Systems

# Technical Publications

## Direction 2184231–100

**Revision 3**

# ADVANTAGE SIM 3.0
# Conformance Statement for DICOM V3.0

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# TABLE OF CONTENTS

# TABLE OF CONTENTS (CONT.)

# TABLE OF CONTENTS (CONT.)

# TABLE OF CONTENTS (CONT.)

# TABLE OF CONTENTS (CONT.)

# TABLE OF CONTENTS (CONT.)

# REVISION HISTORY

| REV | DATE | REASON FOR CHANGE |
|---|---|---|
| 0 | March 14, 1997 | Document format changed to correspond to new GE template<br>Document number added<br>GE private attributes removed from RT Plan<br>RT Machine Class and Instance UIDs added to Beam Sequence in RT Plan, and RT Plan documented as standard extended object.<br>Final Cumulative Meterset Weight (300A,010E) added to RT Beams module in RT Plan.<br>Study Date and Time and Patient Birth Date added as non–zero length to GE Plan. |
| 1 | June 9, 1997 | Note for ‘Control Point Index’ in RT Beams Module (Section 6–4–5–3) changed to ‘0 for first control point, 1 for second control point’<br>Block Transmission Attribute added in RT Plan<br>Document modified following new GE template modifications |
| 2 | June 25, 1997 | Changed Advantage Sim version number and platform name |
| 3 | August 19, 1997 | Note added in chapter 2 |

## LIST OF EFFECTIVE PAGES

| PAGE NUMBER | REVISION NUMBER | PAGE NUMBER | REVISION NUMBER | PAGE NUMBER | REVISION NUMBER |
|---|---|---|---|---|---|
| Title page | 3 | | | | |
| i thru viii | 3 | | | | |
| 1–1 thru 1–6 | 3 | | | | |
| 2–1 thru 2–12 | 3 | | | | |
| 3–1 thru 3–6 | 3 | | | | |
| 4–1 thru 4–8 | 3 | | | | |
| 5–1 thru 5–8 | 3 | | | | |
| 6–1 thru 6–8 | 2 | | | | |
| 7–1 thru 7–14 | 2 | | | | |

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# SECTION 1 – INTRODUCTION

## 1–0 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 Image Information Object Implementation*, which defines the GEMS equipment compliance to DICOM requirements for the implementation of an RT Image information object.

**Section 5**, *RT Structure Set Information Object Implementation*, which defines the GEMS equipment compliance to DICOM requirements for the implementation of an RT Structure Set information object.

**Section 6**, *RT Plan Information Object Implementation*, which defines the GEMS equipment compliance to DICOM requirements for the implementation of an RT Plan information object.

**Section 7**, *GE Private DICOM RT Plan Information Object Implementation*, which defines the technical details of the GE Private DICOM RT Plan Information Object Definition (IOD) created by Advantage Sim.

## 1–1 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 Advantage Sim application. It is entitled:

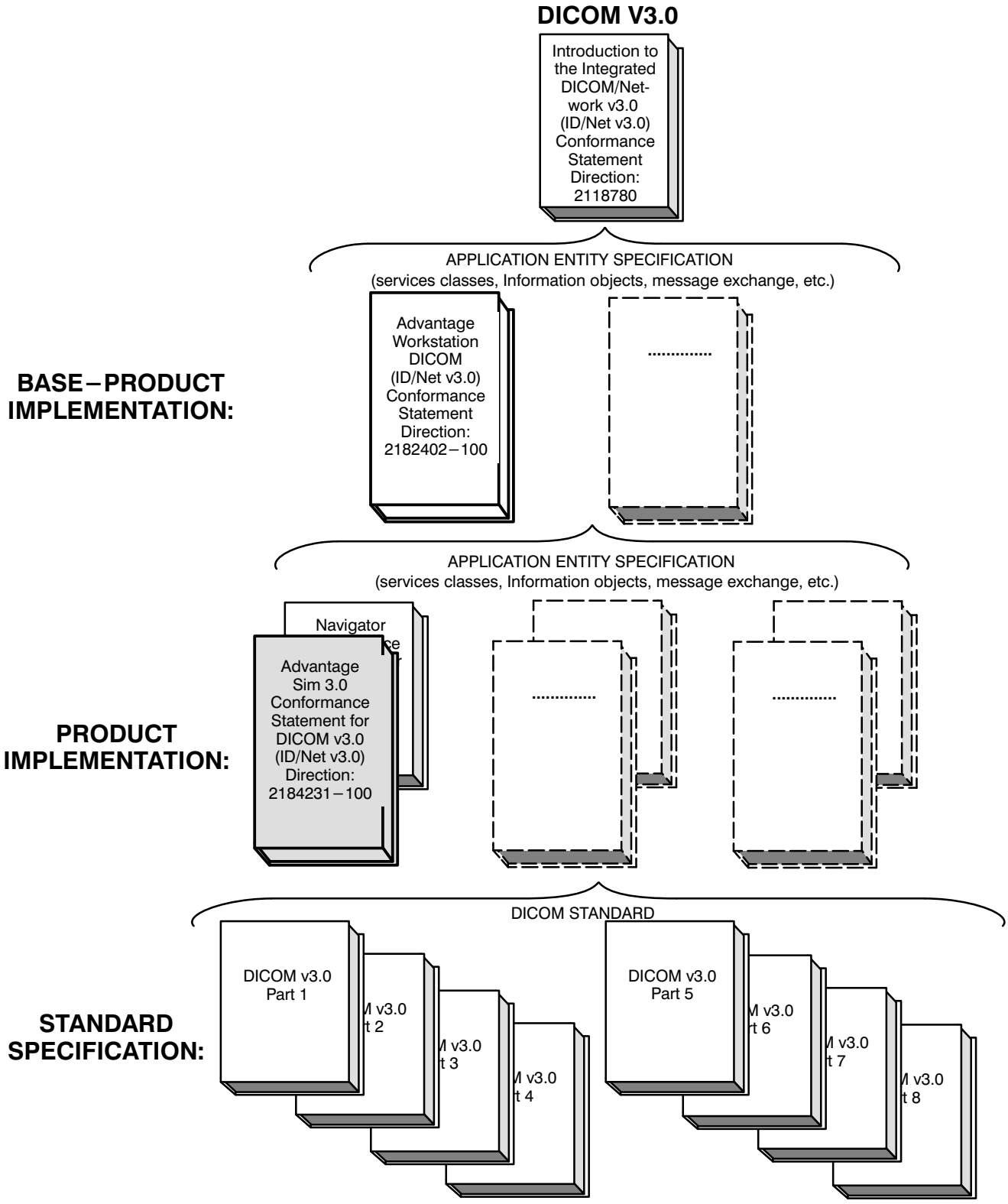
*ADVANTAGE SIM 3.0*
*Conformance Statement for DICOM V3.0*
*Direction .....# 2184231–100.*

This DICOM Conformance Statement documents the DICOM compatibility of the Advantage Sim 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*
*DICOM (ID/Net v3.0) Conformance Statement*
*Direction .....# 2182402–100.*

Those sections of the Advantage Sim 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 including Network Architecture and basic DICOM concepts, please refer to the *Introduction.*

For the convenience of software developers, there is "collector" Direction available. By ordering the collector, the Introduction described above and all of the currently published DICOM v3.0 Product Conformance Statements will be received. The collector Direction is:

*ID/Net v3.0 Conformance Statements*
*Direction: 2117016*

For more information regarding DICOM, copies of the Standard may be obtained by written request or phone by contacting:

NEMA Publication
1300 North 17th Street
Suite 1847
Rosslyn, VA 22209
USA
Phone: (703) 841–3200

## 1–2 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.*

## 1–3 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 DICOM (ID/Net v3.0) Conformance Statement, Direction: 2182402–100* 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.

## 1–4 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. 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 or radiotherapy equipment performance and/or function.

## 1–5 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 PS 3.3 (Information Object Definition), and DICOM Supplement 11 (Radiotherapy Objects).

## 1–6 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 Supplement 11 (Radiotherapy Objects).

## 1–7 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 Integrated DICOM/Network v3.0 (ID/Net v3.0) Conformance Statement, Direction: 2118780.*

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

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# SECTION 2 – NETWORK CONFORMANCE STATEMENT

## 2–0 Introduction

This section of the DICOM Conformance Statement specifies the compliance to DICOM conformance requirements for the relevant **Networking** features on this GEMS product. Those sub–sections which are different from the document *Advantage Workstation DICOM (ID/Net v3.0) Conformance Statement, Direction 2182402–100* appear here. Note that the format of this section strictly follows the format defined in DICOM Standard PS 3.2 (Conformance). Please refer to that part of the standard while reading this section.

Please also note the details of the DICOM conformance related to other Information Objects supported by this product are included in subsequent sections of this DICOM Conformance Statement.

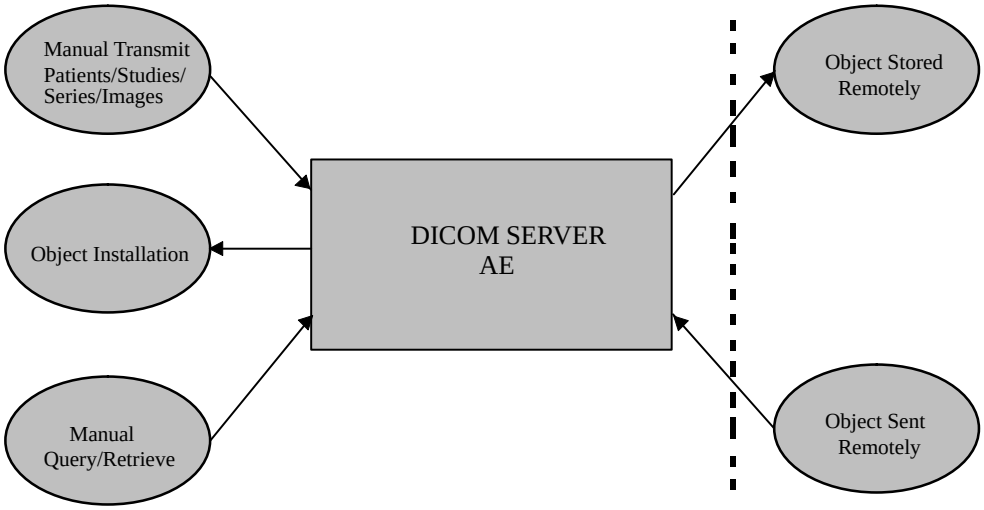
Advantage Sim is a radiotherapy virtual simulation application which is installed on the same hardware platform as the base application, Advantage Workstation. This base application is a Networked Medical Imaging Console dedicated to Examination Review and Diagnosis. The workstation uses DICOM services to import images for possible further analysis or processing, and to export images and radiotherapy data to other vendors.

## 2–1 Implementation Model

### 2–1–1 Application Data Flow Diagram

The Basic and Specific Application models for this device are shown in Illustration 2–1.

ILLUSTRATION **2–1**
**SPECIFIC AE APPLICATION MODEL**




The DICOM SERVER Application Entity (AE) is an application which handles DICOM protocol communication. The DICOM SERVER AE is automatically brought up when the Advantage Workstation is powered on.

All remote DICOM's AE must be manually configured on the Advantage Workstation, at any time by an Operator or a GE field engineer.

The DICOM SERVER AE is invoked by the following Real World Activities:

- Manual Transmit Patients/Studies/Series/Images from the Advantage Workstation to a Remote Host
- Image Sent Remotely from a Remote Host to the Advantage Workstation
- Manual Query/Retrieve

Manual Transmit Patients/Studies/Series/Images consists of an Operator selecting within a Patient/Study/Series Folder one or several images to be sent on one or several Remote System(s). Selection of Images is done from the operator console screens (known as BROWSER); declaration of Remote Systems is done on a specific menu (known as NETWORK MANAGEMENT menu); selection of Remote Systems is done by on a specific pop–up window (known as LIST OF REMOTE HOSTS); visualisation of the transfer status is done in a specific message window.

Manual Query/Retrieve consists of an Operator querying a Remote database to obtain a list of data at Patient/Study/Series/Image level, in order to retrieve some images. Query is Selective, based on criteria described elsewhere in this document.

**2–1–2** Functional Definition of AE's

The DICOM SERVER Application Entity supports the following functions:

- Access patient demographics and pixel data in the local database.
- Build a DICOM format data set.
- Initiate a DICOM association to send the object(s) to a Remote Host AE.
- Respond to DICOM associations transmitting object(s) to be stored on the Advantage Workstation.
- Initiate a DICOM association to ask for remote patient demographics.
- Initiate a DICOM association to ask for transmit images from a Remote Host to the Advantage Workstation.

**Note:** Advantage Sim *creates* the following DICOM object types: SC Image, RT Image, RT Structure Set, RT Plan, and GE Private DICOM RT Plan.

**2–1–3** Sequencing of Real–World Activities

Not Applicable

## 2–2 AE Specifications

### 2–2–1 DICOM SERVER AE Specification

For the Advantage Sim product, the DICOM SERVER Application Entity provides Standard Conformance to the following classes as an **SCU**:

| SOP Class Name | SOP Class UID |
|---|---|
| RT Image Storage | 1.2.840.10008.5.1.4.1.1.481.1 |
| RT Structure Set Storage | 1.2.840.10008.5.1.4.1.1.481.3 |
| RT Plan Storage | 1.2.840.10008.5.1.4.1.1.481.5 |
| GE Private DICOM RT Plan Storage | 1.2.840.113619.4.5.249 |
| SC Image Storage (Advantage Sim implementation) | 1.2.840.10008.5.1.4.1.1.7 |
| CT Image Storage (Advantage Workstation implementation) | 1.2.840.10008.5.1.4.1.1.2 |

For the Advantage Sim product, the DICOM SERVER Application Entity provides Standard Conformance to the following classes as an **SCP**:

| SOP Class Name | SOP Class UID |
|---|---|
| RT Image Storage | 1.2.840.10008.5.1.4.1.1.481.1 |
| SC Image Storage (Advantage Workstation implementation) | 1.2.840.10008.5.1.4.1.1.7 |
| CT Image Storage (Advantage Workstation implementation) | 1.2.840.10008.5.1.4.1.1.2 |

In addition to the above classes, he DICOM SERVER Application Entity also provides Standard Conformance to the classes described in Section 2–2–1 of *Advantage Workstation DICOM (ID/Net v3.0) Conformance Statement, Direction 2182402–100.*

**Note:** All the images will be transmitted with the same elements which were received, except Window Center (0028, 1050), Window Width (0028, 1051), and Photometric Interpretation (0028, 0004) which may be modified.

#### 2–2–1–1 Association Establishment Policies

##### 2–2–1–1–1 General

The DICOM Application Context Name (ACN), which is always proposed, is:

| Application Context Name | 1.2.840.10008.3.1.1.1 |
|---|---|

The Maximum Length PDU negotiation is included in all association establishment requests.

However, the Maximum Length PDU for an association initiated by the DICOM SERVER AE can not be greater than:

| Maximum Length PDU | 16 Kbytes |
|---|---|

**Note:** 0 as PDU Length is not supported in this implementation.
Maximum Length PDU can be configured at installation time.

The SOP class Extended Negotiation is not supported.

The maximum number of Presentation Context Items that will be proposed is 11.

The user info items sent by this product are:

- Maximum PDU Length
- Implementation UID

**2–2–1–1–2** Number of Associations

The DICOM SERVER AE will initiate only one DICOM association at a time to perform an image storage as an SCU to a Remote Host AE.

The DICOM SERVER AE can have a maximum of 4 DICOM associations open simultaneously to receive an image store or respond to an echo.

The DICOM SERVER AE will initiate only one DICOM association at a time to perform a Query/Retrieve operation with a Remote Host AE.

**2–2–1–1–3** Asynchronous Nature

Asynchronous mode is not supported. All operations will be performed synchronously.

**2–2–1–1–4** Implementation Identifying Information

The Implementation UID for this DICOM v3.0 Implementation is:

| **Advantage Sim Implementation UID** | **1.2.840.113619.6.49** |
|---|---|

**2–2–1–2** Association Initiation Policy

The DICOM SERVER AE initiates a new association for the Patient Folders (or Studies/Series/Images) selected by a user it attempts to transfer. This association corresponds to 1 Real–World Activity: Manual Transmit Patients/Studies/Series/Images.

**Note:** The Length to End field (0000, 0001) is sent in this implementation.

**2–2–1–2–1** Real–World Activity “Manual Transmit Patients/Studies/Series/Images”

**2–2–1–2–1–1** Associated Real–World Activity

The Operator selects in the BROWSER one or several Patient Folders/Studies/Series/ Images to be sent.

Then he or she either drags–and–drops the selection on the icon representing the Remote Host, or clicks on a “push” icon and selects a destination by choosing a Remote Host in the LIST OF REMOTE HOSTS.

This operation will cause

- the Advantage Workstation to build a DICOM image from its data,
- the DICOM SERVER AE to initiate a DICOM association, negociate with the Remote AE an appropriate Abstract and Transfer Syntax,
- if the negociation is successful, the DICOM SERVER AE to emit C–STORE command to send the image.

**2–2–1–2–1–2** Proposed Presentation Contexts

In addition to the non–radiotherapy Presentation Contexts described in Section 2–2–1–2–1–2 of *Advantage Workstation DICOM (ID/Net v3.0) Conformance Statement, Direction 2182402–100,* Advantage Sim proposes the following Presentation Contexts:

| Presentation Context Table – Proposed | | | | | |
|---|---|---|---|---|---|
| Abstract Syntax | | Transfer Syntax | | Role | Extended Negotiation |
| Name | UID | Name List | UID List | | |
| RT Image Storage | 1.2.840.10008.5.1.4.1.1.481.1 | Implicit VR Little Endian | 1.2.840.10008.1.2 | SCU | None |
| RT Structure Set Storage | 1.2.840.10008.5.1.4.1.1.481.3 | Implicit VR Little Endian | 1.2.840.10008.1.2 | SCU | None |
| RT Plan Storage (Standard Extended object – see 2–4–1–1) | 1.2.840.10008.5.1.4.1.1.481.5 | Implicit VR Little Endian | 1.2.840.10008.1.2 | SCU | None |
| GE Private DICOM RT Plan Storage | 1.2.840.113619.4.5.249 | Implicit VR Little Endian | 1.2.840.10008.1.2 | SCU | None |
| SC Image Storage (Advantage Sim 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 (Advantage Workstation implementation) | 1.2.840.10008.5.1.4.1.1.2 | Implicit VR Little Endian | 1.2.840.10008.1.2 | SCU | None |

**2–2–1–2–1–2–1** SOP Specific Conformance Statement for All Storage SOP Classes

This implementation can perform multiple C-STORE operations over a single association.

Upon receiving a C-STORE confirmation containing a Successful status, this implementation will perform the next C-STORE operation. The association will be maintained if possible.

Upon receiving a C–STORE confirmation containing an Error or a Refused status, this implementation will terminate the association. The current C–STORE is considered as failed.

Upon receiving a C–STORE confirmation containing a Warning Status (e.g. xB000, xB007, xB006), this implementation will treat it as a success response.

Each C–STORE operation supports an “Association Etablishment Timer”. This timer starts when the association request is sent and stops when the association is established. This timer is set to 60 seconds by default.

Each C–STORE operation also supports an “Store Timer”. This timer starts once a C–STORE request has been emitted by DICOM SERVER AE and stops once a C–STORE confirmation sent by the Remote Host AE has been received. This Timer is set to 60 minutes by default.

Each C–STORE operation also supports a “Inactivity Timer”. This timer detects an network inactivity during a C–STORE operation (no packets received from the Remote Host AE). This timeout is set to 180 seconds by default.

If any of the 3 timers expires, the connection is closed and the operation is considered as failed.

The “Association Etablishment Timer”, the “Store Timer” and the “Inactivity Timer” can be configured at any time by a GE field engineer.

When the DICOM SERVER AE initiates an association to issue a C–STORE, the image will be transmitted with the same elements in which it was received.

**2–2–1–2–2** Real–World Activity “Manual Query/Retrieve”

**2–2–1–2–2–1** Associated Real–World Activity

The Operator can query a Remote database by clicking on the icon representing the Remote Host. A new BROWSER (known as REMOTE BROWSER) appears on the screen(s).

Then the Operator can select in the REMOTE BROWSER one or several Patient Folders/Studies/Series/Images to be sent to the Advantage Workstation.

Then he or she either drags–and–drops the selection on the icon representing the Advantage Workstation, or clicks on a “pull” icon, in order to receive the selected images.

These operations will cause

- the DICOM SERVER AE to initiate a DICOM association
- the DICOM SERVER AE to emit a C–FIND request to get a list of patients regarding specific criteria listed below
- optionally, the DICOM SERVER AE to emit a C–MOVE request to specify a selected list of Patients Folders/Studies/Series/Images to be sent by the Remote Host to the Advantage Workstation.

**2–2–1–2–2–2** Proposed Presentation Contexts

| Presentation Context Table – Proposed | | | | | |
|---|---|---|---|---|---|
| Abstract Syntax | | Transfer Syntax | | Role | Extended Negotiation |
| Name | UID | Name List | UID List | | |
| Study Root FIND | 1.2.840.10008.5.1.4.1.2.2.1 | Implicit VR Little Endian | 1.2.840.10008.1.2 | SCU | None |
| Study Root MOVE | 1.2.840.10008.5.1.4.1.2.2.2 | Implicit VR Little Endian | 1.2.840.10008.1.2 | SCU | None |
| Patient Root MOVE | 1.2.840.10008.5.1.4.1.2.1.2 | Implicit VR Little Endian | 1.2.840.10008.1.2 | SCU | None |

**2–2–1–2–2–2–1** SOP Specific Conformance Statement for Study Root FIND SOP Class

This implementation performs a C–FIND operation over an association.

Each C–FIND operation supports an “Association Etablishment Timer”. This timer starts when the association request is sent and stops when the association is established. This timer is set to 60 seconds by default.

Each C–FIND operation also supports an “Find Timer”. This timer starts once a C–FIND request has been emited by DICOM SERVER AE and stops once a C–FIND confirmation sent by the Remote Host AE has been received. This Timer is set to 60 minutes by default.

Each C–FIND operation also supports a “Inactivity Timer”. This timer detects an network inactivity during a C–FIND operation (no packets received from the Remote Host AE). This timeout is set to 90 seconds by default.

The following required and optional keys are supported for Study Root FIND. The fields Patient's Name, Patient ID, Study Date and Study Time may be queried based on operator specifications. All other values for fields are requested as part of the query.

**Note:** The key Study Time can be set active/inactive in the selective query request at any time by a GE field engineer.

**2–2–1–2–2–2–1–1** Study Level Keys for Study Root Query/Retrieve Information Model

| Description | Element Tag | Type | Notes |
|---|---|---|---|
| Study Date | (0008, 0020) | R | |
| Study Time | (0008, 0030) | R | |
| Accession Number | (0008, 0050) | R | |
| Patient's Name | (0010, 0010) | R | |
| Patient's ID | (0010, 0020) | R | |
| Study ID | (0020, 0010) | R | |
| Study Instance UID | (0020, 000D) | U | |
| Study Description | (0008, 1050) | O | |
| Name of Physician(s) Reading Study | (0008, 1060) | O | |

**2–2–1–2–2–2–1–2** Series Level Keys for Study Root Query/Retrieve Information Model

| Description | Element Tag | Type | Notes |
|---|---|---|---|
| Modality | (0008, 0060) | R | |
| Series Number | (0020, 0011) | R | |
| Series Instance UID | (0020, 000E) | U | |
| Series Description | (0008, 103E) | O | |
| Manufacturer | (0008, 0070) | O | |

**2–2–1–2–2–2–1–3** Image Level Keys for Study Root Query/Retrieve Information Model

| Description | Element Tag | Type | Notes |
|---|---|---|---|
| Image Number | (0020, 0013) | R | |
| SOP Instance UID | (0008, 0018) | U | |
| other optional attributes | | O | |

**2–2–1–2–2–2–1–4** Search Method

Only hierarchical queries are supported.

**2–2–1–2–2–2–2** SOP Specific Conformance Statement for MOVE SOP Classes

Each C–MOVE operation supports an "Association Etablishment Timer". This timer starts when the association request is sent and stops when the association is established. This timer is set to 60 seconds by default.

Each C–MOVE operation also supports an “Move Timer”. This timer starts once a C–MOVE request has been emitted by DICOM SERVER AE and stops once a C–MOVE confirmation sent by the Remote Host AE has been received. This Timer is set to 60 minutes by default.

Each C–MOVE operation also supports a “Inactivity Timer”. This timer detects an network inactivity during a C–MOVE operation (no packets received from the Remote Host AE). This timeout is set to 300 seconds by default.

**2–2–1–3** Association Acceptance Policy

When the DICOM SERVER AE accepts an association, it will receive any images transmitted on that association and store the images on disk. The DICOM Server AE places no limitations on who may connect to it.

**2–2–1–3–1** Real–World Activity “Image Installation”

The DICOM SERVER AE accepts an association when it receives a valid association request from a DICOM Storage SCU.

**2–2–1–3–1–1** Associated Real–World Activity

The DICOM SERVER AE is indefinitely listening for associations. No operator action is required to receive an image.

**2–2–1–3–1–2** Accepted Presentation Contexts

In addition to the non–radiotherapy Presentation Contexts described in Section 2–2–1–2–1–2 of *Advantage Workstation DICOM (ID/Net v3.0) Conformance Statement, Direction 2182402–100*, Advantage Sim accepts the following Presentation Contexts:

| Presentation Context Table – Accepted | | | | | |
|---|---|---|---|---|---|
| Abstract Syntax | | Transfer Syntax | | Role | Extended Negotiation |
| Name | UID | Name List | UID List | | |
| RT Image Storage | 1.2.840.10008.5.1.4.1.1.481.1 | Implicit VR Little Endian | 1.2.840.10008.1.2 | SCP | None |
| SC Image Storage (Advantage Workstation implementation) | 1.2.840.10008.5.1.4.1.1.7 | Implicit VR Little Endian | 1.2.840.10008.1.2 | SCP | None |
| CT Image Storage (Advantage Workstation implementation) | 1.2.840.10008.5.1.4.1.1.2 | Implicit VR Little Endian | 1.2.840.10008.1.2 | SCP | None |

**2–2–1–3–1–2–1** SOP Specific Conformance Statement for Verification SOP Class

The DICOM Server AE provides standard conformance to the DICOM Verification Service Class.

**2–2–1–3–1–2–2** SOP Specific Conformance Statement for All Storage SOP Classes

The DICOM Server AE conforms to the SOP’s of the Storage Service Class at Level 2 (Full), as described in Section B.4.1 of Part 4 of the DICOM Standard document.

**Information Object Reception**

If the DICOM SERVER AE returns to the Remote Host AE SCU one of the following status codes, then the C–STORE operation was unsuccessful and the object will not be installed:

- 0110 (Processing Failure) Indicates that an internal system call has failed while processing the object.
- A700 (Out of Resources) Indicates that there was not enough disk space or some other internal resource (such as memory) to store the object. The user should attempt recovery by removing some objects from the Advantage Workstation system.

When a C–STORE operation is successful, the object has been written to disk and declared in the local database. The object will then be accessed in the same manner as any other object by the applications on the Advantage Workstation.

Objects may be deleted when instructed to do so by the user or when the object data is found to be not in conformance with the DICOM standard. Thus the duration of the storage of the object is determined by users of the Advantage Workstation or by the validation process.

**Information Object Declaration**

If the object declaration is unsuccessful, a message will appear in the Message Log informing the user of the failure and the object file will be removed by default.

If the object declaration process finds that an element is not encoded according to the DICOM standard, it will fail to install the object and the file will be removed. A physical disk area may be specifiied by a GE field engineer to keep the object files not installed.

For image objects, the overlay planes (groups 60xx) are burnt into the pixel data and deleted from the original image. An Stand Alone Overlay image will have pixel data created from the overlay data which will be stored with the image.
An image containing overlay planes must fulfil the following conditions in order to be accepted by the Advantage Workstation:

- Overlay planes must be encoded in groups 6000 and 6002 (not embedded in image pixel data),
- Overlays planes must have the same size as the image,
- Bits Allocated (0028, 0100) for the image must be 16.

**Note:** The rescale slope (0028,1053) field is ignored, and in all cases for display the system uses a value of 1 by default.

**Note:** **In order to have significant information for the image declaration, the fields Patient's Name (0010, 0010) and Patient ID (0010, 0020) should not be empty.**

**Note:** **In order for CT Images to be usable by the Advantage Sim application, the field Patient Position (0018,5100) is strongly recommended. This information is required to correctly position the patient on the treatment table. If this attribute is absent, Head–First Supine ('HFS') will be the only choice offered within the Advantage Sim application.**

**Note:** **In order to correctly reference CT Images from a GE Private DICOM RT Plan object, Advantage Sim requires that the Study ID (0020,0010), Series Number (0020,0011), and Image Number (0020,0013) be non–zero length. Only CT scanners supporting these attributes are compatible with Advantage Sim.**

**2–3 Communication Profiles**

**2–3–1** Supported Communication Stacks (parts 8,9)

DICOM Upper Layer (Part 8) is supported using TCP/IP.

**2–3–2** TCP/IP Stack

The TCP/IP stack is inherited from a UNIX Operating System.

**2–3–2–1** API

Not applicable to this product.

**2–3–2–2** Physical Media Support

DICOM is indifferent to the physical medium over which TCP/IP executes (e.g. Ethernet V2.0, IEEE 802.3, ATM, FDDI).

**2–3–3** Point–to–Point Stack

Not applicable to this product.

**2–4 Extensions/Specializations/Privatizations**

**2–4–1** Standard Extended/Specialized/Private SOPs

**2–4–1–1** Standard Extended RT Plan SOP Class

The RT Plan SOP Instances created by Advantage Sim contain two additional elements in the Beam Sequence (300A,00B0) contained within the RT Beams module (see Section 6–4–5–3 of this document). These two attributes are the Referenced SOP Class UID (0008,1150) and Referenced SOP Instance UID (0008,1155) of the GE Private DICOM Treatment Machine object used for the beam. These attributes have no meaning outside the Advantage Sim application, and are provided to resolve future issues of backward compatibility within the Advantage Sim product line. These attributes should be ignored by SCP implementations interpreting these objects.

**2–5 Configuration**

**2–5–1** AE Title/Presentation Address Mapping

The Local AE Title is configurable. This must be configured by a GE Field Engineer during installation.

**2–5–2** Configurable Parameters

The following fields are configurable for this AE (local):

- Local AE Title
- Local IP Address

**Note:** For all connections, the DICOM SERVER AE Title is TCP/IP Port 4006.

The following fields are configurable for every remote DICOM AE:

- Remote AE Title
- Responding TCP/IP Port
- Remote IP Address
- Remote Provider Type (Query/Retrieve Level supported by the Remote Host AE)

The following parameters are configurable (see above for complete description):

- Association Etablishment Timer
- Store, Find, Move Timers
- Inactivity Timers
- Maximum Length PDU

**Note:** All configuration must be performed by a GE Field Engineer.

## 2–6 Support of Extended Character Sets

Advantage Sim will support only the ISO–IR 100 (IS) 8859–1: 1987 (Latin alphabet N 1, supplementary set) as extended character sets. Any incoming SOP instance that is encoded using another extended character set will not be installed in the local database.

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# SECTION 3 – SECONDARY CAPTURE INFORMATION OBJECT IMPLEMENTATION

## 3–0 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.

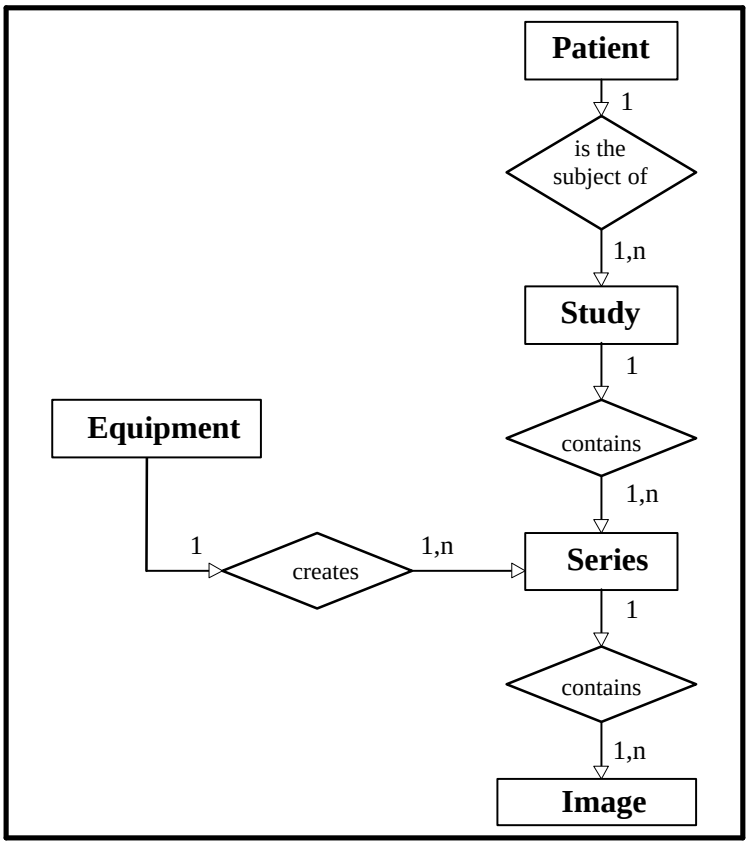
Note that the implementation described in this section relates to generation of SC Images by the Advantage Sim product only. The Advantage Sim application does not display SC Images directly, but relies on the Advantage Workstation product for this function. SC Image conformance for Advantage Workstation is described in a related document entitled *Advantage Workstation DICOM (ID/Net v3.0) Conformance Statement, Direction 2182402–100.*

## 3–1 SC Image IOD Implementation

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

## 3–2 SC Image IOD Entity–Relationship Model

ILLUSTRATION **3–1**
**SC IMAGE ENTITY RELATIONSHIP DIAGRAM**



The Entity–Relationship diagram for the SC Image interoperability schema is shown in Illustration 3–1. 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.

**3–2–1** 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.

**3–2–2** Advantage Sim Mapping of DICOM entities

DICOM entities map to the Advantage Sim entities in the following manner :

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

## 3–3 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 | 3–4–1–1 |
| Study | General Study | M | 3–4–2–1 |
| | Patient Study | U | not used |
| Series | General Series | M | 3–4–3–1 |
| Equipment | General Equipment | U | 3–4–4–1 |
| | SC Equipment | M | 3–4–4–2 |
| Image | General Image | M | 3–4–5–1 |
| | Image Pixel | M | 3–4–5–2 |
| | SC Image | M | 3–4–5–3 |
| | Overlay Plane | U | not used |
| | Modality LUT | U | not used |
| | VOI LUT | U | not used |
| | SOP Common | M | 3–4–5–4 |

## 3–4 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.

### 3–4–1 Patient Entity Modules

#### 3–4–1–1 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 |

**3–4–2** Study Entity Modules

**3–4–2–1** 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 if present in those images, otherwise zero–length |
| Accession number | (0008,0050) | 2 | Duplicated from patient model images if present in those images, otherwise zero–length |

**3–4–3** Series Entity Modules

**3–4–3–1** 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 | |
| Series Description | (0008,103E) | 3 | 'SC Image (Adv Sim 3.0)' |

**3–4–4** Equipment Entity Modules

**3–4–4–1** 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 | 'Advantage Sim' |
| Device Serial Number | (0018,1000) | 3 | <station host ID> |
| Software Versions | (0018,1020) | 3 | '3.0.x' (single–valued) |

**3–4–4–2** SC Equipment

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Conversion Type | (0008,0064) | 1 | 'WSD' |
| 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 | 'Advantage Sim' |
| Secondary Capture Device Software Version | (0018,1019) | 3 | '3.0.x' |

**3–4–5** Image Entity Modules

**3–4–5–1** General Image

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Image Number | (0020,0013) | 2 | |
| Patient Orientation | (0020,0020) | 2C | Zero–length |
| Image Date | (0008,0023) | 2C | |
| Image Time | (0008,0033) | 2C | |
| Image Type | (0008,0008) | 3 | 'DERIVED\SECONDARY' (Value 3 and Value 4 not supplied) |
| Image Comments | (0020,4000) | 3 | '*Plan_name*: (*Plan_date_time*)' where *Plan_name* is the Plan Label of the referenced RT Plan, and *Plan_date_time* is the save date/ time of referenced RT Plan |

**3–4–5–2** 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 Advantage Sim 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 |

**3–4–5–3** SC Image

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Date of Secondary Capture | (0018,1012) | 3 | |
| Time of Secondary Capture | (0018,1014) | 3 | |

**3–4–5–4** 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 ‘1.2.840.113619.2.49’ |
| Specific Character Set | (0008,0005) | 1C | ‘ISO_IR 100’ |
| Instance Creation Date | (0008,0012) | 3 | |
| Instance Creation Time | (0008,0013) | 3 | |
| Instance Creator UID | (0008,0014) | 3 | ‘1.2.840.113619.6.49’ |

# SECTION 4 – RT IMAGE INFORMATION OBJECT IMPLEMENTATION

## 4–0 Introduction

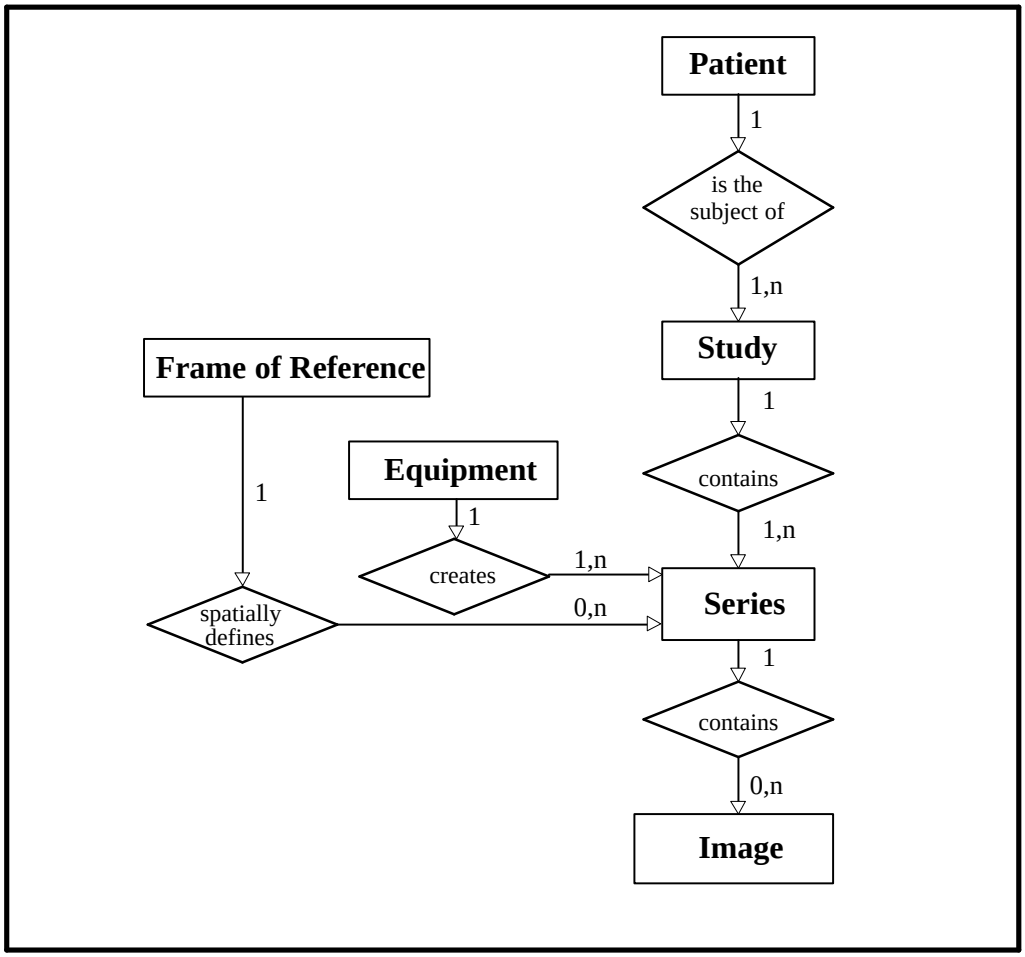
This section specifies the use of the DICOM RT Image IOD to represent the information included in images produced by this implementation. Corresponding attributes are conveyed using the module construct.

## 4–1 RT Image IOD Implementation

This section defines the implementation of the RT Image information object in the Advantage Sim application. It refers to DICOM V3.0 Standard, Supplement 11 to Part 3 (Information Object Definitions). The Advantage Sim application does not display RT Images directly, but relies on the Advantage Workstation product for this function.

## 4–2 RT Image IOD Entity–Relationship Model

ILLUSTRATION **4–1**
**RT IMAGE ENTITY RELATIONSHIP DIAGRAM**



The Entity–Relationship diagram for the RT Image interoperability schema is shown in Illustration 4–1. 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.

**4–2–1** Entities Description

Refer to DICOM Standard Supplement 11 to Part 3 (Information Object Definitions) for a description of each of the entities contained within the RT Image information object.

**4–2–2** Advantage Sim Mapping of DICOM entities

DICOM entities map to the Advantage Sim entities in the following manner :

| DICOM | Advantage Sim |
|---|---|
| Patient Entity | Patient Entity (Advantage Workstation) |
| Study Entity | Examination Entity (Advantage Workstation) |
| Series Entity | Series Entity (Advantage Workstation) |
| Frame of Reference Entity | No mapping |
| Equipment Entity | Workstation on which Advantage Sim application is running |
| Image Entity | Screen Save of *DRR (digitally–reconstructed radiograph) image only* (generated from within application using Advantage Sim menu option in main panel). Advantage Sim does not directly display RT Images. |

## 4–3 RT Image IOD Module Table

Within an entity of the DICOM RT 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 4–1 identifies the defined modules within the entities which comprise the DICOM RT Image Information Object Definition. Modules are identified by Module Name.

See DICOM Standard Supplement 11 to Part 3 for a complete definition of the entities, modules, and attributes.

TABLE 4–1
**RT IMAGE INFORMATION OBJECT DEFINITION (IOD) MODULE TABLE**

| Entity Name | Module Name | Usage | Reference |
|---|---|---|---|
| Patient | Patient | M | 4–4–1–1 |
| Study | General Study | M | 4–4–2–1 |
| | Patient Study | U | not used |
| Series | RT Series | M | 4–4–3–1 |
| Frame of Reference | Frame of Reference | U | not used |
| Equipment | General Equipment | M | 4–4–4–1 |
| Image | General Image | M | 4–4–5–1 |
| | Image Pixel | M | 4–4–5–2 |
| | Contrast/bolus | C | not used |
| | Cine | C | not used |
| | Multi–Frame | C | not used |
| | RT Image | M | 4–4–5–3 |
| | Modality LUT | U | not used |
| | VOI LUT | U | not used |
| | Approval | U | not used |
| | Curve | U | not used |
| | Audio | U | not used |
| | SOP Common | M | 4–4–5–4 |

## 4–4 Information Module Definitions

Please refer to DICOM Standard Supplement 11 to Part 3 (Information Object Definitions) for a description of each of the entities and modules contained within the RT Image Information Object.

### 4–4–1 Patient Entity Modules

#### 4–4–1–1 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 |

### 4–4–2 Study Entity Modules

#### 4–4–2–1 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 if present in those images, otherwise zero–length |
| Accession number | (0008,0050) | 2 | Duplicated from patient model images if present in those images, otherwise zero–length |

### 4–4–3 Series Entity Modules

#### 4–4–3–1 RT Series

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Modality | (0008,0060) | 1 | 'RTIMAGE' |
| Series Instance UID | (0020,000E) | 1 | Created for first image in series, otherwise copied from existing images in series |
| Series Number | (0020,0011) | 2 | |
| Series Description | (0008,103E) | 3 | 'Adv Sim 3.0 RT Images' |

**4–4–4** Equipment Entity Modules

**4–4–4–1** 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 | 'Advantage Sim' |
| Device Serial Number | (0018,1000) | 3 | <station host ID> |
| Software Versions | (0018,1020) | 3 | '3.0.x' (single–valued) |

**4–4–5** Image Entity Modules

**4–4–5–1** General Image

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Image Number | (0020,0013) | 2 | |
| Patient Orientation | (0020,0020) | 2C | Zero–length |
| Image Date | (0008,0023) | 2C | |
| Image Time | (0008,0033) | 2C | |
| Image Comments | (0020,4000) | 3 | '*Plan_name*: (*Plan_date_time*)' where *Plan_name* is the Plan Label of the referenced RT Plan, and *Plan_date_time* is the save date/ time of referenced RT Plan |

**4–4–5–2** 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 Advantage Sim 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 |

**4–4–5–3** RT Image

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| RT Image Label | (3002,0002) | 1 | Name of associated beam in referenced RT Plan |
| RT Image Name | (3002,0003) | 3 | '*Plan_name*: (*Plan_date_time*)' where *Plan_name* is the Plan Label of the referenced RT Plan, and *Plan_date_time* is the save date/time of referenced RT Plan |
| Operators' Name | (0008,1070) | 2 | Zero–length |
| Image Type | (0008,0008) | 1 | 'DERIVED\SECONDARY\DRR' |
| Conversion Type | (0008,0064) | 2 | 'WSD' |
| Reported Values Origin | (3002,000A) | 2C | 'PLAN' |
| RT Image Plane | (3002,000C) | 1 | 'NORMAL' |
| X–Ray Image Receptor Angle | (3002,000E) | 2 | 0 |
| Image Plane Pixel Spacing | (3002,0011) | 2 | Pixels will always be square |
| RT Image Position | (3002,0012) | 2 | First pixel transmitted always has negative x and positive y values (i.e. image viewed from treatment machine gantry with eyes fixed along gantry X axis and top of head towards gantry wall) |
| Radiation Machine Name | (3002,0020) | 2 | Name (including suffix) of machine associated with beam in Advantage Sim |
| Primary Dosimeter Unit | (300A,00B3) | 2 | Zero–length |
| Radiation Machine SAD | (3002,0022) | 2 | Source–axis distance of machine associated with beam in Advantage Sim |
| RT Image SID | (3002,0026) | 2 | Equal to SAD of machine associated with beam in Advantage Sim (i.e. image is always projected onto isocenter) |
| Referenced RT Plan Sequence | (300C,0002) | 3 | References RT Plan stored immediately before screen save was performed in Advantage Sim. If last saved RT Plan has been subsequently modified in Advantage Sim application, screen save option shall be inhibited. |
| >Referenced SOP Class UID | (0008,1150) | 1C | '1.2.840.10008.5.1.4.1.1.481.5' (RT Plan) |
| >Referenced SOP Instance UID | (0008,1155) | 1C | SOP Instance UID of referenced RT Plan |
| Referenced Beam Number | (300C,0006) | 3 | Beam Number of beam in referenced RT Plan |
| Exposure Sequence | (3002,0030) | 3 | |
| >Beam Limiting Device Sequence | (300A,00B6) | 3 | Sequence will always contain exactly two items |
| >>RT Beam Limiting Device Type | (300A, 00B8) | 1C | Will be 'X', 'Y', 'ASYMX', 'ASYMY', 'MLCX' or 'MLCY', according to collimator type of machine associated with beam in Advantage Sim |
| >>Number of Leaf/Jaw Pairs | (300A,00BC) | 1C | For 'MLCX' or 'MLCY' collimators, equal to the number of leaf pairs in the MLC collimator jaw of the machine associated with beam in Advantage Sim |

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| >>Leaf Position Boundaries | (300A,00BE) | 2C | Provided only for ‘MLCX’ and ‘MLCY’ collimators |
| >>Leaf/Jaw Positions | (300A,011C) | 1C | |
| >Number of Blocks | (300A,00F0) | 1C | Number of blocks or cutouts defined for beam in Advantage Sim |
| >Block Sequence | (300A,00F4) | 2C | |
| >> Source to Block Tray Distance | (300A,00F6) | 2C | Source to Block Tray Distance obtained from machine associated with beam in Advantage Sim |
| >>Block Type | (300A,00F8) | 1C | ‘SHIELDING’ |
| >>Block Divergence | (300A,00FA) | 2C | Zero–length |
| >>Block Number | (300A,00FC) | 1C | Blocks will be numbered from 1 to n in order presented in sequence |
| >>Block Name | (300A,00FE) | 3 | Name of block or cutout defined in Advantage Sim |
| >>Material ID | (300A,00E1) | 2 | Zero–length |
| >>Block Number of Points | (300A,0104) | 2C | In Advantage Sim there is no software limit imposed on the number of points in a block shape |
| >>Block Data | (300A,0106) | 2C | |
| Gantry Angle | (300A,011E) | 3 | |
| Beam Limiting Device Angle | (300A,0120) | 3 | |
| Patient Support Angle | (300A,0122) | 3 | |

**4–4–5–4** SOP Common

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| SOP Class UID | (0008,0016) | 1 | ‘1.2.840.10008.5.1.4.1.1.481.1’ |
| SOP Instance UID | (0008,0018) | 1 | UID root will be ‘1.2.840.113619.2.49’ |
| Specific Character Set | (0008,0005) | 1C | ‘ISO_IR 100’ |
| Instance Creation Date | (0008,0012) | 3 | |
| Instance Creation Time | (0008,0013) | 3 | |
| Instance Creator UID | (0008,0014) | 3 | ‘1.2.840.113619.6.49’ |

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# SECTION 5 – RT STRUCTURE SET INFORMATION OBJECT IMPLEMENTATION

## 5–0 Introduction

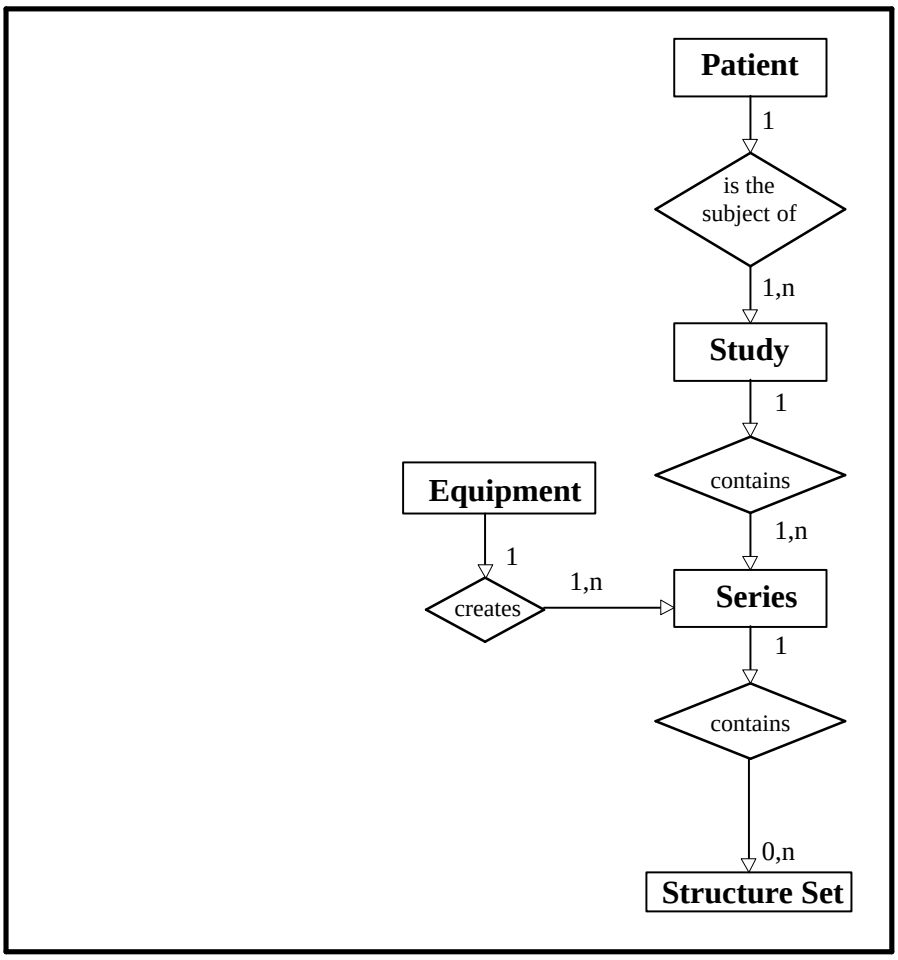
This section specifies the use of the DICOM RT Structure Set IOD to represent the information included in structure sets produced by this implementation. Corresponding attributes are conveyed using the module construct.

## 5–1 RT Structure Set IOD Implementation

This section defines the implementation of the RT Structure Set information object in the Advantage Sim application. It refers to DICOM V3.0 Standard, Supplement 11 to Part 3 (Information Object Definitions).

## 5–2 RT Structure Set IOD Entity–Relationship Model

ILLUSTRATION **5–1**
**RT STRUCTURE SET ENTITY RELATIONSHIP DIAGRAM**



The Entity–Relationship diagram for the RT Structure Set interoperability schema is shown in Illustration 5–1. 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.

**5–2–1** Entities Description

Refer to DICOM Standard Supplement 11 to Part 3 (Information Object Definitions) for a description of each of the entities contained within the RT Structure Set information object.

**5–2–2** Advantage Sim Mapping of DICOM entities

DICOM entities map to the Advantage Sim entities in the following manner :

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

## 5–3 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 5–1 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 Supplement 11 to Part 3 for a complete definition of the entities, modules, and attributes.

TABLE 5–1
**RT STRUCTURE SET INFORMATION OBJECT DEFINITION (IOD) MODULE TABLE**

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

## 5–4 Information Module Definitions

Please refer to DICOM Standard Supplement 11 to Part 3 (Information Object Definitions) for a description of each of the entities and modules contained within the RT Structure Set Information Object.

### 5–4–1 Patient Entity Modules

#### 5–4–1–1 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 |

### 5–4–2 Study Entity Modules

#### 5–4–2–1 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 if present in those images, otherwise zero–length |
| Accession number | (0008,0050) | 2 | Duplicated from patient model images if present in those images, otherwise zero–length |

### 5–4–3 Series Entity Modules

#### 5–4–3–1 RT Series

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Modality | (0008,0060) | 1 | 'RTSTRUCT' |
| Series Instance UID | (0020,000E) | 1 | Created for first image in series, otherwise copied from existing images in series |
| Series Number | (0020,0011) | 2 | |
| Series Description | (0008,103E) | 3 | 'Adv Sim 3.0 RT Structure Sets' |

**5–4–4** Equipment Entity Modules

**5–4–4–1** 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 | 'Advantage Sim' |
| Device Serial Number | (0018,1000) | 3 | <station host ID> |
| Software Versions | (0018,1020) | 3 | '3.0.x' (single–valued) |

**5–4–5** Structure Set Entity Modules

**5–4–5–1** Structure Set

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Structure Set Label | (3006,0002) | 1 | Equal to comment entered when saving Advantage Sim Plan, truncated to 16 characters |
| Structure Set Name | (3006,0004) | 3 | Equal to comment entered when saving Advantage Sim Plan (non–truncated) |
| Structure Set Date | (3006,0008) | 2 | |
| Structure Set Time | (3006,0009) | 2 | |
| Referenced Frame of Reference Sequence | (3006,0010) | 3 | Sequence will always contain exactly one item, corresponding to the frame of reference of the CT images |
| >Frame of Reference UID | (0020,0052) | 1C | Duplicated from patient model images if present in those images, otherwise a unique UID will be created by Advantage Sim |
| >RT Referenced Study Sequence | (3006,0012) | 3 | Sequence will always contain exactly one item, corresponding to the Study containing the CT images |
| >>Referenced SOP Class UID | (0008,1150) | 1C | |
| >>Referenced SOP Instance UID | (0008,1155) | 1C | |
| >>RT Referenced Series Sequence | (3006,0014) | 1C | Sequence will always contain exactly one item, corresponding to the Series containing the CT images |
| >>>Series Instance UID | (0020,000E) | 1C | |
| >>>Contour Image Sequence | (3006,0016) | 1C | Sequence will contain all images used in building the Advantage Sim patient model, even if some images have no corresponding contour |
| >>>>Referenced SOP Class UID | (0008,1150) | 1C | |
| >>>>Referenced SOP Instance UID | (0008,1155) | 1C | |
| Structure Set ROI Sequence | (3006,0020) | 3 | Always provided unless there have been no structures defined in Advantage Sim, in which case the sequence will be absent |

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| >ROI Number | (3006,0022) | 1C | Advantage Sim will number structures in increasing numeric order, starting from 1, as they are found in the plan |
| >Referenced Frame of Reference UID | (3006,0024) | 1C | Equal to Frame of Reference UID (0020,0052) above |
| >ROI Name | (3006,0026) | 2C | Equal to Advantage Sim structure name |
| >ROI Generation Algorithm | (3006,0036) | 2C | Zero–length |

**5–4–5–2** ROI Contour

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| ROI Contour Sequence | (3006,0039) | 1 | Sequence will always contain all the structures defined in the Structure Set Module, in the same sequential order |
| >Referenced ROI Number | (3006,0084) | 1 | |
| >ROI Display Color | (3006,002A) | 3 | Contains RGB values corresponding to color used for displaying contour in Advantage Sim application |
| >Contour Sequence | (3006,0040) | 3 | Provided if ROI has contours which have been defined by Advantage Sim, otherwise sequence will not be transmitted |
| >>Contour Image Sequence | (3006,0016) | 3 | Sequence will always contain exactly one item (referenced CT image) |
| >>>Referenced SOP Class UID | (0008,1150) | 1C | |
| >>>Referenced SOP Instance UID | (0008,1155) | 1C | |
| >>Contour Geometric Type | (3006,0042) | 1C | ‘CLOSED_PLANAR’ for structures, ‘POINT’ for markers |
| >>Contour Slab Thickness | (3006,0044) | 3 | For structures, equal to the sum of the zplus and zminus half thicknesses in Advantage Sim. Not provided for markers. |
| >>Number of Contour Points | (3006,0046) | 1C | In Advantage Sim there is no limit imposed on the number of points in a contour shape |
| >>Contour Data | (3006,0050) | 1C | Z coordinate of contour data may differ slightly from Z coordinate of referenced slice. This variation should be of the order of half the (x,y) resolution of the reconstructed patient model. Coordinates are in DICOM coordinate system, *not* Voxtool RAS coordinate system. |

**5–4–5–3** RT ROI Observations

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| RT ROI Observations Sequence | (3006,0080) | 1 | Sequence will always contain all the structures defined in the Structure Set Module, in the same sequential order |
| >Observation Number | (3006,0082) | 1 | Advantage Sim will number observations in increasing numeric order, starting from 1 (i.e. Observation Number will correspond to ROI Number) |
| >Referenced ROI Number | (3006,0084) | 1 | |
| >ROI Observation Label | (3006,0085) | 3 | Equal to Advantage Sim structure name, truncated to 16 characters |
| >RT ROI Interpreted Type | (3006,00A4) | 2 | Mapping between RT DICOM and Advantage Sim types will be as follows:<br>Zero–length = 'UNKNOWN' in Adv Sim<br>'EXTERNAL' = 'BODY' in Adv Sim<br>'ORGAN' = 'ORGAN' in Adv Sim<br>'GTV' = 'TUMOR' in Adv Sim<br>'PTV' = 'TARGET' in Adv Sim<br>'MARKER' = 'MARKER' in Adv Sim |
| >ROI Interpreter | (3006, 00A6) | 2 | Zero–length |

**5–4–5–4** SOP Common

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| SOP Class UID | (0008,0016) | 1 | '1.2.840.10008.5.1.4.1.1.481.3' |
| SOP Instance UID | (0008,0018) | 1 | UID root will be '1.2.840.113619.2.49' |
| Specific Character Set | (0008,0005) | 1C | 'ISO_IR 100' |
| Instance Creation Date | (0008,0012) | 3 | |
| Instance Creation Time | (0008,0013) | 3 | |
| Instance Creator UID | (0008,0014) | 3 | '1.2.840.113619.6.49' |

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# SECTION 6 – RT PLAN INFORMATION OBJECT IMPLEMENTATION

## 6–0 Introduction

This section specifies the use of the DICOM RT Plan IOD to represent the information included in plans produced by this implementation. Corresponding attributes are conveyed using the module construct.

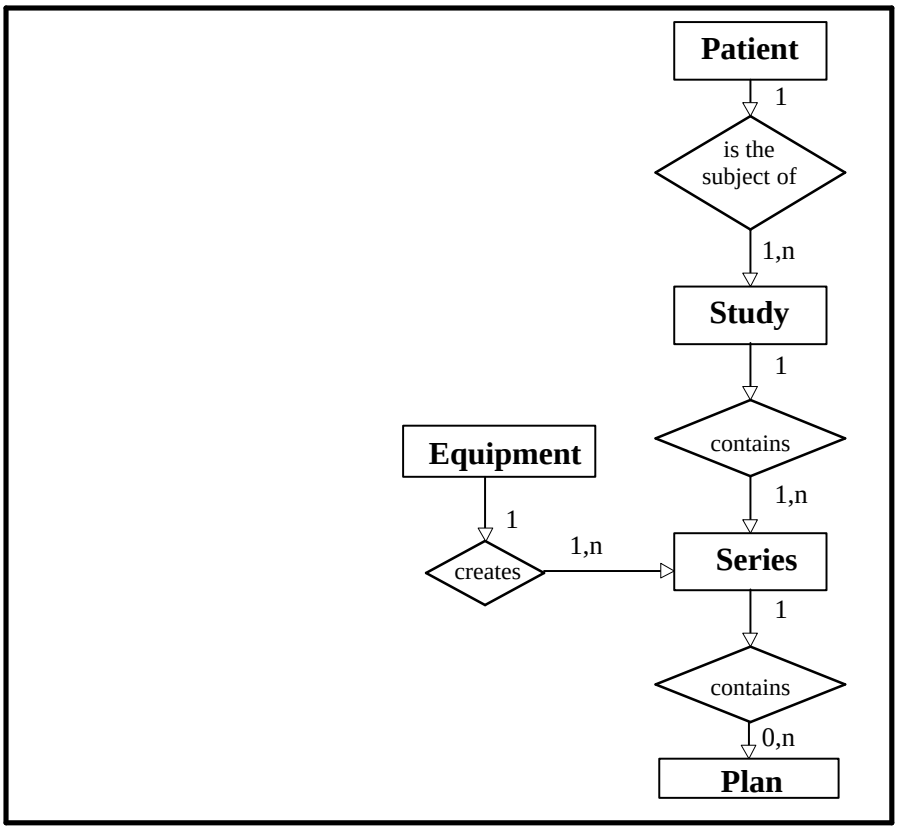
Advantage Sim implements the RT Plan IOD as a Standard Extended object, containing two additional elements in the Beam Sequence (300A,00B0) contained within the RT Beams module (see Section 6–4–5–3 of this document). These two attributes are the Referenced SOP Class UID (0008,1150) and Referenced SOP Instance UID (0008,1155) of the GE Private DICOM Treatment Machine object used for the beam. These attributes have no meaning outside the Advantage Sim application, and are provided to resolve future issues of backward compatibility within the Advantage Sim product line. These attributes should be ignored by SCP implementations interpreting these objects.

## 6–1 RT Plan IOD Implementation

This section defines the implementation of the RT Plan information object in the Advantage Sim application. It refers to DICOM V3.0 Standard, Supplement 11 to Part 3 (Information Object Definitions).

## 6–2 RT Plan IOD Entity–Relationship Model

ILLUSTRATION **6–1**
**RT PLAN ENTITY RELATIONSHIP DIAGRAM**



The Entity–Relationship diagram for the RT Plan interoperability schema is shown in Illustration 6–1. 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.

### **6–2–1** Entities Description

Refer to DICOM Standard Supplement 11 to Part 3 (Information Object Definitions) for a description of each of the entities contained within the RT Plan information object.

### **6–2–2** Advantage Sim Mapping of DICOM entities

DICOM entities map to the Advantage Sim entities in the following manner :

| **DICOM** | **Advantage Sim** |
|---|---|
| Patient Entity | Patient Entity (Advantage Workstation) |
| Study Entity | Examination Entity (Advantage Workstation) |
| Series Entity | Series Entity (Advantage Workstation) |
| Equipment Entity | Workstation on which Advantage Sim application is running |
| Plan Entity | Advantage Sim geometric information related to defined beams |

## 6–3 RT Plan IOD Module Table

Within an entity of the DICOM RT Plan 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 6–1 identifies the defined modules within the entities which comprise the DICOM RT Plan Information Object Definition. Modules are identified by Module Name.

See DICOM Standard Supplement 11 to Part 3 for a complete definition of the entities, modules, and attributes.

TABLE 6–1
**RT PLAN INFORMATION OBJECT DEFINITION (IOD) MODULE TABLE**

| Entity Name | Module Name | Usage | Reference |
|---|---|---|---|
| Patient | Patient | M | 6–4–1–1 |
| Study | General Study | M | 6–4–2–1 |
| | Patient Study | U | not used |
| Series | RT Series | M | 6–4–3–1 |
| Equipment | General Equipment | M | 6–4–4–1 |
| Plan | RT General Plan | M | 6–4–5–1 |
| | RT Prescription | U | not used |
| | RT Tolerance Tables | U | not used |
| | RT Patient Setup | U | 6–4–5–2 |
| | RT Fraction Scheme | U | not used |
| | RT Beams | C | 6–4–5–3 |
| | RT Brachy Application Setups | C | not used |
| | Approval | U | not used |
| | Audio | U | not used |
| | SOP Common | M | 6–4–5–4 |

## 6–4 Information Module Definitions

Please refer to DICOM Standard Supplement 11 to Part 3 (Information Object Definitions) for a description of each of the entities and modules contained within the RT Plan Information Object.

### 6–4–1 Patient Entity Modules

#### 6–4–1–1 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 |

### 6–4–2 Study Entity Modules

#### 6–4–2–1 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 if present in those images, otherwise zero–length |
| Accession number | (0008,0050) | 2 | Duplicated from patient model images if present in those images, otherwise zero–length |

### 6–4–3 Series Entity Modules

#### 6–4–3–1 RT Series

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Modality | (0008,0060) | 1 | 'RTPLAN' |
| Series Instance UID | (0020,000E) | 1 | Created for first image in series, otherwise copied from existing images in series |
| Series Number | (0020,0011) | 2 | |
| Series Description | (0008,103E) | 3 | 'Adv Sim 3.0 RT Plans' |

**6–4–4** Equipment Entity Modules

**6–4–4–1** 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 | 'Advantage Sim' |
| Device Serial Number | (0018,1000) | 3 | <station host ID> |
| Software Versions | (0018,1020) | 3 | '3.0.x' (single–valued) |

**6–4–5** Plan Entity Modules

**6–4–5–1** RT General Plan

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| RT Plan Label | (300A,0002) | 1 | Equal to comment entered when saving Advantage Sim Plan, truncated to 16 characters |
| RT Plan Name | (300A,0003) | 3 | Equal to comment entered when saving Advantage Sim Plan (non–truncated) |
| Operators' Name | (0008,1070) | 2 | Equal to operator name entered when saving Advantage Sim Plan |
| RT Plan Date | (300A,0006) | 2 | |
| RT Plan Time | (300A,0007) | 2 | |
| RT Plan Geometry | (300A,000C) | 1 | 'PATIENT' |
| Reference Structure Set Sequence | (300C,0060) | 1C | Sequence will always contain exactly one item, referencing RT Structure Set saved at same time as Plan |
| >Referenced SOP Class UID | (0008,1150) | 1C | '1.2.840.10008.5.1.4.1.1.481.3' (RT Structure Set) |
| >Referenced SOP Instance UID | (0008,1155) | 1C | |

**6–4–5–2** RT Patient Setup

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Patient Setup Sequence | (300A,0180) | 1 | Sequence will always contain exactly one item |
| >Patient Setup Number | (300A,0182) | 1 | 1 |
| >Patient Position | (0018,5100) | 1C | Patient treatment position in Advantage Sim application. May be different from patient orientation in CT images used to build patient model when patient has been scanned 'FFS' or 'FFP'. In these cases, patient may be 'flipped' to 'HFS' and 'HFP' respectively for simulation, if operator selects this option. |

**6–4–5–3** RT Beams

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Beam Sequence | (300A,00B0) | 1 | Always provided unless no beams have been defined in Advantage Sim, in which case the entire module will be absent |
| >Beam Number | (300A,00C0) | 1 | Advantage Sim will number beams in increasing numeric order, starting from 1, as they are found in the Plan |
| >Beam Name | (300A,00C2) | 3 | Equal to Advantage Sim beam name |
| >Beam Type | (300A,00C4) | 1 | 'STATIC' |
| >Radiation Type | (300A,00C6) | 2 | Zero–length if not defined for current beam, otherwise 'PHOTON' or 'ELECTRON' |
| >Treatment Machine Name | (300A,00B2) | 2 | Name (including suffix) of machine associated with beam in Advantage Sim. If treatment machine has not been defined in Advantage Sim for one or more beams, it will not be possible to save the plan. |
| >Referenced SOP Class UID | (0008,1150) | 3 | Private (GE) SOP Class of machine used to define current beam. Equal to '1.2.840.113619.4.5.251'. GE Standard Extended attribute. |
| >Referenced SOP Instance UID | (0008,1155) | 3 | Private (GE) SOP Instance of machine used to define current beam. GE Standard Extended attribute. |
| >Source–Axis Distance | (300A,00B4) | 3 | Source–axis distance of machine associated with beam in Advantage Sim |
| >Beam Limiting Device Sequence | (300A,00B6) | 1 | Sequence will always contain exactly two items |
| >>RT Beam Limiting Device Type | (300A,00B8) | 1 | Will be 'X', 'Y', 'ASYMX', 'ASYMY', 'MLCX' or 'MLCY', according to collimator type of machine associated with beam in Advantage Sim |
| >>Number of Leaf/Jaw Pairs | (300A,00BC) | 1 | |
| >>Leaf Position Boundaries | (300A,00BE) | 2C | Provided only for 'MLCX' and 'MLCY' collimators |
| >Referenced Patient Setup Number | (300C,006A) | 3 | 1 (i.e. references only patient setup specified in RT Patient Setup module) |
| >Treatment Delivery Type | (300A,00CE) | 3 | 'TREATMENT' |
| >Number of Wedges | (300A,00D0) | 1 | 0 |
| >Number of Compensators | (300A,00E0) | 1 | 0 |
| >Number of Boli | (300A,00ED) | 1 | 0 |
| >Number of Blocks | (300A,00F0) | 1 | Equal to number of Blocks or Cutouts defined for beam in Advantage sim |
| >Block Sequence | (300A,00F4) | 1C | Provided if Number of Blocks greater than 0 |
| >>Source to Block Tray Distance | (300A,00F6) | 2C | Equal to Source to Block Tray Distance obtained from machine definition of machine associated with beam in Advantage Sim |
| >>Block Type | (300A,00F8) | 1C | 'SHIELDING' |

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| >>Block Divergence | (300A,00FA) | 2C | Zero–length |
| >>Block Number | (300A,00FC) | 1C | Blocks will be numbered from 1 to n in order presented in sequence |
| >>Block Name | (300A,00FE) | 3 | Equal to block name entered in Advantage Sim |
| >>Material ID | (300A,00E1) | 2C | Zero–length |
| >>Block Thickness | (300A,0100) | 2C | Zero–length |
| >>Block Transmission | (300A,0102) | 2C | Zero–length. This attribute was not provided in the pilot version of Advantage Sim (version 2.0.11a). |
| >>Block Number of Points | (300A,0104) | 2C | In Advantage Sim there is no software limit imposed on the number of points in a block shape |
| >>Block Data | (300A,0106) | 2C | |
| >Final Cumulative Meterset Weight | (300A,010E) | 2C | 100 |
| >Number of Control Points | (300A,0110) | 1 | 2 (static beam) |
| >Control Point Sequence | (300A,0111) | 1 | Sequence will contain exactly two items. First item will contain all relevant beam parameters. Second element will contain only the attribute Cumulative Meterset Weight (300A,0134), with a value of 100. |
| >>Control Point Index | (300A,0112) | 1C | 0 for first control point, 1 for second control point |
| >>Cumulative Meterset Weight | (300A,0134) | 2C | 0 for first control point, 100 for second control point |
| >>Nominal Beam Energy | (300A,0114) | 3 | Provided for first control point only if beam energy defined in Advantage Sim, otherwise attribute not provided |
| >>Beam Limiting Device Position Sequence | (300A,011A) | 1C | Provided for first control point only. Sequence will contain exactly two items. |
| >>>RT Beam Limiting Device Type | (300A,00B8) | 1C | Provided for first control point only |
| >>>Leaf/Jaw Positions | (300A,011C) | 1C | Provided for first control point only |
| >>Gantry Angle | (300A,011E) | 1C | Provided for first control point only |
| >>Gantry Rotation Direction | (300A,011F) | 1C | Provided (value ‘NONE’) for first control point only |
| >>Beam Limiting Device Angle | (300A,0120) | 1C | Provided for first control point only |
| >>Beam Limiting Device Rotation Direction | (300A,0121) | 1C | Provided (value ‘NONE’) for first control point only |
| >>Patient Support Angle | (300A,0122) | 1C | Provided for first control point only |
| >>Patient Support Rotation Direction | (300A,0123) | 1C | Provided (value ‘NONE’) for first control point only |
| >>Table Top Eccentric Angle | (300A,0125) | 1C | Provided (value 0) for first control point only (no eccentric rotation possible in Advantage Sim) |
| >>Table Top Eccentric Rotation Direction | (300A,0126) | 1C | Provided (value ‘NONE’) for first control point only |
| >>Table Top Vertical Position | (300A,0128) | 2C | Provided (zero–length) for first control point only |

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| >>Table Top Longitudinal Position | (300A,0129) | 2C | Provided (zero–length) for first control point only |
| >>Table Top Lateral Position | (300A,012A) | 2C | Provided (zero–length) for first control point only |
| >>Isocenter Position | (300A,012C) | 2C | Provided for first control point only |

**6–4–5–4** SOP Common

| **Attribute Name** | Element Tag | **TP** | **Notes** |
|---|---|---|---|
| SOP Class UID | (0008,0016) | 1 | ‘1.2.840.10008.5.1.4.1.1.481.5’ |
| SOP Instance UID | (0008,0018) | 1 | UID root will be ‘1.2.840.113619.2.49’ |
| Specific Character Set | (0008,0005) | 1C | ‘ISO_IR 100’ |
| Instance Creation Date | (0008,0012) | 3 | |
| Instance Creation Time | (0008,0013) | 3 | |
| Instance Creator UID | (0008,0014) | 3 | ‘1.2.840.113619.6.49’ |

# SECTION 7 – GE PRIVATE DICOM RT PLAN INFORMATION OBJECT IMPLEMENTATION

## 7–0 Introduction

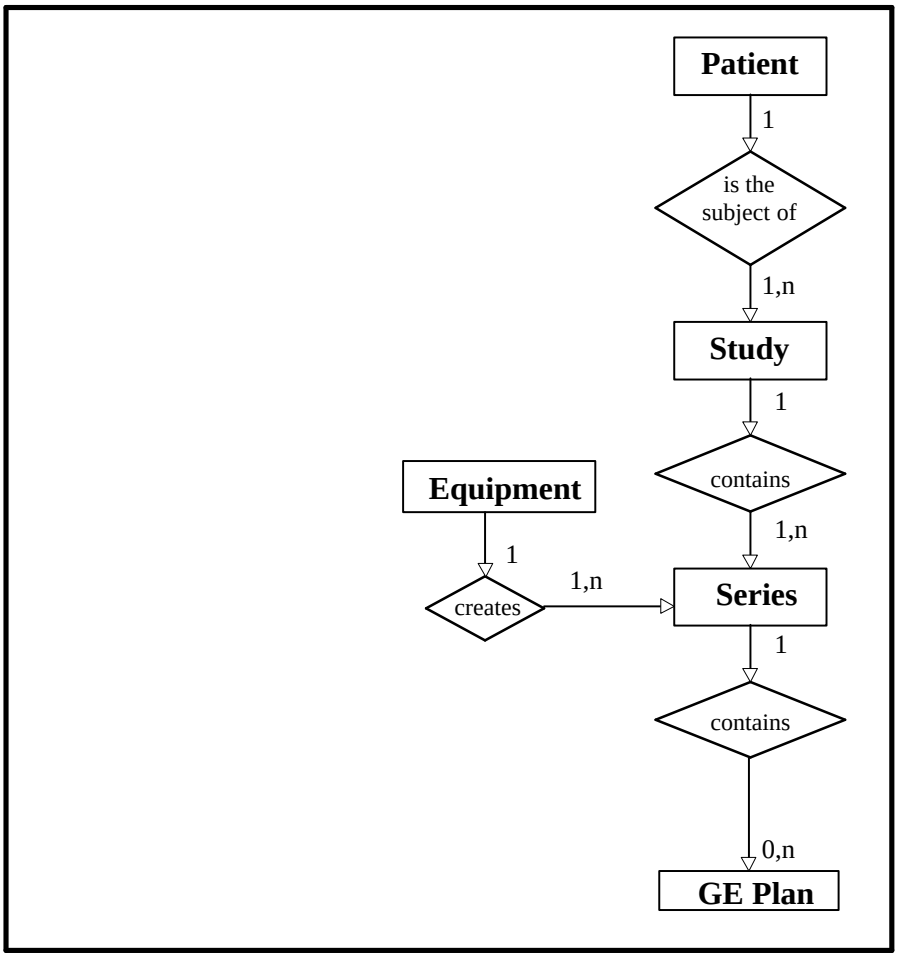
This section specifies the use of the GE Private DICOM RT Plan IOD to represent the information included in plans produced by this implementation. Corresponding attributes are conveyed using the module construct.

## 7–1 GE Private DICOM RT Plan IOD Implementation

This section defines the implementation of the GE Private DICOM RT Plan information object in the Advantage Sim application.

## 7–2 GE Private DICOM RT Plan IOD Entity–Relationship Model

ILLUSTRATION **7–1**
**GE PRIVATE DICOM RT PLAN ENTITY RELATIONSHIP DIAGRAM**



The Entity–Relationship diagram for the GE Private DICOM RT Plan interoperability schema is shown in Illustration 7–1. 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.

### 7–2–1 Entities Description

Each of the entities contained within the GE Private DICOM RT Plan information object is fully described in Section 7–4.

### 7–2–2 Advantage Sim Mapping of DICOM entities

DICOM entities map to the Advantage Sim 2 entities in the following manner :

| DICOM | Advantage Sim |
|---|---|
| Patient Entity | Patient Entity (Advantage Workstation) |
| Study Entity | Examination Entity (Advantage Workstation) |
| Series Entity | No mapping |
| GE Plan Entity | Advantage Sim information relating to defined structures, markers, and beams |

## 7–3 GE Private DICOM RT Plan IOD Module Table

Within an entity of the GE Private DICOM RT Plan 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 7–1 identifies the defined modules within the entities which comprise the GE Private DICOM RT Plan Information Object Definition. Modules are identified by Module Name.

TABLE 7–1
**GE PRIVATE DICOM RT PLAN INFORMATION OBJECT DEFINITION (IOD) MODULE TABLE**

| Entity Name | Module Name | Usage | Reference |
|---|---|---|---|
| Patient | Patient | M | 7–4–1–1 |
| Study | General Study | M | 7–4–2–1 |
| Equipment | General Equipment | U | 7–4–3–1 |
| GE Plan | RT Plan General Information | M | 7–4–4–1 |
| | RT Structure Sequence | U | 7–4–4–2 |
| | RT Marker Sequence | U | 7–4–4–3 |
| | RT Beam Sequence | U | 7–4–4–4 |
| | SOP Common | M | 7–4–4–5 |

## 7–4 Information Module Definitions

### 7–4–1 Patient Entity Modules

#### 7–4–1–1 Patient Module

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Patient's Name | (0010,0010) | 1 | Duplicated from patient model images |
| 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 |

### 7–4–2 Study Entity Modules

#### 7–4–2–1 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 if present in those images, otherwise zero–length. Note: this attribute was not provided by Advantage Sim 1.2. |
| Accession number | (0008,0050) | 2 | Zero–length |

### 7–4–3 Equipment Entity Modules

#### 7–4–3–1 General Equipment

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Manufacturer | (0008,0070) | 2 | 'GE MEDICAL SYSTEMS' |
| Manufacturer's Model Name | (0008,1090) | 3 | 'Advantage Sim' |
| Device Serial Number | (0018,1000) | 3 | <station host ID> |
| Software Versions | (0018,1020) | 3 | '3.0.x' (single–valued) |

**7–4–4** Radiotherapy Plan Entity Modules

**7–4–4–1** RT Plan General Information

**WARNING**

**THE RT PLAN GENERAL INFORMATION MODULE CONTAINS THE MANDATORY ATTRIBUTE TREATMENT POSITION (0249,D0) WHICH WAS NOT PRESENT IN THE GE PRIVATE DICOM RT PLAN INFORMATION OBJECT CREATED BY THE PREVIOUS VERSION OF ADVANTAGE SIM (VERSION 1.2). RECEIVING IMPLEMENTATIONS MUST READ AND INTERPRET THIS ATTRIBUTE TO CORRECTLY TREAT THE PATIENT.**

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Plan Creation Date | (0249,11) | 1 | Date the plan was created |
| Plan Creation Time | (0249,13) | 1 | Time the plan was created |
| Operator Name | (0249,14) | 2 | Name of operator which defined the RT Plan. Always non–zero length for Advantage Sim. |
| Plan Comment | (0249,16) | 2 | User–defined comments on the RT Plan. Always non–zero length for Advantage Sim. |
| Plan Image Sequence | (0249,18) | 3 | Introduces sequence of items describing images used in defining the RT Plan. All referenced images shall belong to the same series. Always provided by Advantage Sim. |
| >Exam/Series/Image Identifier | (0249,1A) | 3 | Exam/Series/Image identifier (e.g. ‘e6270/s2/i4’), as provided by image source (e.g. CT scanner). Always provided by Advantage Sim. |
| >Additional Image Identifier | (0249,1B) | 3 | Additional identifier aiding in uniquely identifying image. Always provided by Advantage Sim. |
| Build Resolution | (0249,1C) | 3 | Resolution used to build 3D model. Defined terms: LOW, HIGH. Always provided by Advantage Sim. |
| Modality | (0008,0060) | 1 | Type of equipment that originally acquired the data used to create the objects in this series. Always equal to ‘RT’ for Advantage Sim. |
| Series Instance UID | (0020,000E) | 1 | A number that identifies this series. For Advantage Sim, the Series UID shall be equal to the Study Instance UID concatenated with the string ‘.249’. If the resulting string exceeds 64 characters, as many characters as necessary shall be removed from the front of the string. |
| Series Number | (0020,0011) | 1 | A number that identifies this series. For AdvantageSim this value shall be ‘350’. |
| Series Description | (0008,103E) | 2 | User–provided description of the series. Always equal to ‘Radiotherapy’ for Advantage Sim. |

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Image Number | (0020,0013) | 1 | The plan number. This value will be created by Advantage Sim during storage, but is not guaranteed to be unique. |
| Treatment Position | (0249,D0) | 1 | Patient position during treatment, as described in DICOM Part 3 Section C.7.3.1.1.2. May be different from scanned orientation when patient has been scanned FFS or FFP, and 'flip' patient option is selected in Advantage Sim (in which case treatment orientations will be HFS and HFP respectively). **Note: This attribute was not supplied in Advantage Sim 1.2 because treatment orientation was always the same as scanned orientation.** |

**7–4–4–2** RT Structure Sequence

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Structure Sequence | (0249,20) | 1 | Introduces sequence of items describing structures defined for plan. Sequence shall not be empty. |
| >Structure Name | (0249,22) | 1 | Name of structure |
| >Structure Type | (0249,24) | 1 | Type of structure. Defined terms: BODY, ORGAN, TUMOR, TARGET, UNKNOWN. The Structure Type for the external body contour (if it exists) shall always be BODY. |
| >Structure Color | (0249,28) | 3 | Representation color of structure. Defined terms: RED, BLUE, GREEN, YELLOW, PINK, VIOLET. Always provided by Advantage Sim. |
| >Slab Sequence | (0249,30) | 3 | Introduces sequence of items describing slabs defined for structure. If present, sequence shall not be empty. |
| >>Slab Image Sequence | (0249,32) | 3 | Introduces sequence describing image used in defining the slab. Sequence shall always contain exactly one item. |
| >>>Exam/Series/Image Identifier | (0249,1A) | 3 | Exam/Series/Image identifier (e.g. 'e6270/s2/i4'), as provided by image source (e.g. CT scanner). Always provided by Advantage Sim. |
| >>Z Plus Thickness | (0249,36) | 1C | Thickness of slab (mm) in +z direction (see 7–4–4–2–1 and 7–4–4–2–2). Required if Slab Sequence is present. |
| >>Z Minus Thickness | (0249,38) | 1C | Thickness of slab (mm) in –z direction (see 7–4–4–2–1 and 7–4–4–2–2). Required if Slab Sequence is present. |
| >>Slab Shape | (0249,3A) | 1C | Sequence of 3D points defining slab shape (see 7–4–4–2–1 and 7–4–4–2–3). Required if Slab Sequence is present. Z coordinate of contour data may differ slightly from Z coordinate of referenced slice. This variation should be of the order of half the (x,y) resolution of the reconstructed patient model. |

**7–4–4–2–1** DICOM Coordinate System

Structures will be represented using the DICOM (LPS) coordinate system as defined in DICOM Part 3 Section C.7.6.2.1. Note that this is not the same as the RAS coordinate system used in the *Advantage Sim* user interface.

**7–4–4–2–2** Slab Thickness

For acquisition slices with gantry tilt, Z Plus Thickness and Z Minus Thickness shall be equal to the *perpendicular* thickness of the slice, not the thickness projected onto the z–axis.

**7–4–4–2–3** Slab Shape

The 'Slab Shape' attribute defines a list of 3D points lying in a plane. These points are assumed to form a closed contour, and will be listed as $x_1$, $y_1$, $z_1$, $x_2$, $y_2$, $z_2$, $x_3$, $y_3$, $z_3$,...$x_n$, $y_n$, $z_n$ using the DICOM coordinate system. The z coordinates of each point in a contour will normally be the same, except when the contour is defined on a CT slice acquired with gantry 'tilt'.

In general structures may be bifurcated, and may be 'annular' in nature (i.e. have a contour completely enclosed within another). It is up to the receiving application to detect these situations and take action as necessary.

**7–4–4–3** RT Marker Sequence

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Marker Sequence | (0249,40) | 1 | Introduces sequence of items describing markers defined for plan. Sequence shall not be empty. |
| >Marker Name | (0249,42) | 1 | Name of marker |
| >Marker Color | (0249,44) | 3 | Representation color of marker. Always equal to 'YELLOW' for Advantage Sim. |
| >Marker Position | (0249,46) | 1 | Marker coordinates expressed in DICOM coordinate system. See 7–4–4–2–1. |

**7–4–4–4** RT Beam Sequence

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| Beam Group Sequence | (0249,50) | 1 | Introduces sequence of items describing beam groups defined for plan. Sequence shall not be empty. See 7–4–4–4–1. |
| >Group Name | (0249,51) | 1 | Group name. Must be unique within plan. |
| >Group Properties | (0249,52) | 2 | Beam Group properties. Defined terms: EQUAL_ANGLES, COMM_ISOCENTER. |
| >Beam Sequence | (0249,54) | 3 | Introduces sequence of items describing beams defined for group. If present, sequence shall not be be empty. |
| >>Machine Reference Sequence | (0249,60) | 1C | Introduces sequence describing machine used in defining the beam. Sequence shall always contain exactly one item. If a machine has not been defined for one or more beams in Advantage Sim, it will not be possible to save the plan. Required if Beam Sequence is present. |
| >>>Referenced SOP Class UID | (0008,1150) | 2C | Uniquely identifies the referenced machine SOP Class. Required if Beam Sequence is present. |

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| >>>Referenced SOP Instance UID | (0008,1155) | 2C | Uniquely identifies the referenced machine SOP Instance. Required if Beam Sequence is present, |
| >>>Machine Name | (0249,62) | 2C | Name of referenced machine (including suffix). Required if Beam Sequence is present. |
| >>Beam Name | (0249,64) | 1C | Beam name. Required if Beam Sequence is present. Must be unique within plan. |
| >>Particle Type | (0249,66) | 2 | Beam particle type. Defined terms: PHOTON, ELECTRON. Zero–length if beam particle type is not defined. |
| >>Nominal Particle Energy | (0249,68) | 2 | Nominal energy of beam in MV/MeV. Zero–length if nominal beam energy is not defined. |
| >> Block Sequence | (0249,70) | 3 | Introduces sequence of blocks. Shall be permitted only if if Particle Type is PHOTON. Absent if no blocks are defined for beam. |
| >>> Block Name | (0249,72) | 1C | Block name. Required if Block Sequence is present. |
| >>> Block Shape | (0249,74) | 1C | List of 2D points defining block shape at isocenter. Required if Block Sequence is present. See 7–4–4–4–2. |
| >> Cutout Sequence | (0249,80) | 3 | Introduces sequence of cutouts. Shall be permitted only if Particle Type is ELECTRON. Absent if no cutouts are defined for beam. |
| >>> Cutout Name | (0249,82) | 1C | Cutout name. Required if Cutout Sequence is present. |
| >>> Cutout Shape | (0249,84) | 1C | List of 2D points defining cutout shape at isocenter. Required if Cutout Sequence is present. See 7–4–4–4–2. |
| >>Collimator Name | (0249,90) | 1C | Name of collimator as defined in machine definition. Required if Beam Sequence is present. |
| >>Collimator Type | (0249,92) | 1C | Collimator type for beam. Enumerated values: SYMMETRIC, ASYMMETRICX, ASYMMETRICY, BIASYMMETRIC, MULTILEAFX, MULTILEAFY. Required if Beam Sequence is present. |
| >>Dynamic Segment Sequence | (0249,A0) | 1C | Introduces sequence of beam segments for a dynamic beam. For Advantage Sim, sequence shall always contain exactly one item (i.e. static beam). Required if Beam Sequence is present. See 7–4–4–4–3. |
| >>>Table Angle | (0249,A2) | 2C | Table angle in degrees expressed using IEC–1217 convention. Shall be non–zero length for first item in sequence. Required if Dynamic Segment Sequence is present. |
| >>>Gantry Angle | (0249,A4) | 2C | Gantry angle in degrees expressed using IEC–1217 convention. Shall be non–zero length for first item in sequence. Required if Dynamic Segment Sequence is present. |
| >>>Collimator Angle | (0249,A6) | 2C | Collimator angle in degrees expressed using IEC–1217 convention. Shall be non–zero length for first item in sequence. Required if Dynamic Segment Sequence is present. |

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| >>>Isocenter Position | (0249,A8) | 2C | Isocenter coordinates expressed in DICOM coordinate system (see 7–4–4–2–1). Shall be non–zero length for first item in sequence. Required if Dynamic Segment Sequence is present. |
| >>>Source–Surface Distance | (0249,A9) | 3 | Distance between beam source and patient surface (SSD) in mm. See 7–4–4–4–4. |
| >>>X Symmetric Opening | (0249,AA) | 2C | Full–width of IEC–1217 X collimator opening in mm. Shall be non–zero length for first item in sequence. Required if Dynamic Segment Sequence is present and Collimator Type is SYMMETRIC or ASYMMETRICY. See 7–4–4–4–5. |
| >>>Y Symmetric Opening | (0249,AC) | 2C | Full–width of IEC–1217 Y collimator opening in mm. Shall be non–zero length for first item in sequence. Required if Dynamic Segment Sequence is present and Collimator Type is SYMMETRIC or ASYMMETRICX. See 7–4–4–4–5. |
| >>>X Positive Jaw Position | (0249,AE) | 2C | Position of positive X asymmetric collimator jaw in mm. Shall be non–zero length for first item in sequence. Required if Dynamic Segment Sequence is present and Collimator Type is ASYMMETRICX, BIASYMMETRIC, or MULTILEAFY. See 7–4–4–4–5 and 7–4–4–4–6. |
| >>>X Negative Jaw Position | (0249,B0) | 2C | Position of negative X asymmetric collimator jaw in mm. Shall be non–zero length for first item in sequence. Required if Dynamic Segment Sequence is present and Collimator Type is ASYMMETRICX, BIASYMMETRIC, or MULTILEAFY. See 7–4–4–4–5 and 7–4–4–4–6. |
| >>>Y Positive Jaw Position | (0249,B2) | 2C | Position of positive Y asymmetric collimator jaw in mm. Shall be non–zero length for first item in sequence. Required if Dynamic Segment Sequence is present and Collimator Type is ASYMMETRICY, BIASYMMETRIC, or MULTILEAFX. See 7–4–4–4–5 and 7–4–4–4–6. |
| >>>Y Negative Jaw Position | (0249,B4) | 2C | Position of negative Y asymmetric collimator jaw in mm. Shall be non–zero length for first item in sequence. Required if Dynamic Segment Sequence is present and Collimator Type is ASYMMETRICY, BIASYMMETRIC, or MULTILEAFX. See 7–4–4–4–5 and 7–4–4–4–6. |
| >>> Leaf Positions | (0249,B6) | 2C | Positions of leaves in mm, in the order $L_{1N}$, $L_{1P}$, $L_{2N}$, $L_{2P}$,...$L_{NN}$, $L_{NP}$. where N are the most negative leaves and P are the most positive leaves. Shall be non–zero length for first item in sequence. Required if Dynamic Segment Sequence is present and Collimator Type is MULTILEAFX or MULTILEAFY. See 7–4–4–4–5 and 7–4–4–4–6. |

**7–4–4–4–1** Machine Conventions

All machine coordinates used to describe treatment beams are specified in the coordinate systems defined by the IEC Standard *IEC 1217: Radiotherapy equipment – Coordinates, movements and scales (1996)*

**7–4–4–4–2** Block and Cutout Shapes

The 'Block Shape' and 'Cutout Shape' attributes each define a list of 2D points lying in the plane through the beam isocenter and perpendicular to the beam axis. These points are assumed to form a closed contour, and will be listed as $x_1$, $y_1$, $x_2$, $y_2$, $x_3$, $y_3$,...$x_n$, $y_n$.

Block and Cutout shapes are defined such that the points represent a closed curve, the *interior* of which contains the attenuating material, and the *exterior* of which does not contain attenuating material. To define a 'hollow' block or cutout where there is an internal 'hole', the application must define a 'cut' (of zero width) in the exterior of the block or cutout.

**7–4–4–4–3** Dynamic Segment Sequence

Each external beam can be represented by a sequence of one or more Dynamic Segment Sequence items. For conventional fixed beams, there will be exactly one item in the sequence, and all required (Type 2) attributes except those not relevant to the specified collimator type will be of non–zero length. For dynamic beams, there will be a sequence of dynamic segments, where unchanged attributes may have zero–length. For example, a standard arced beam will have two items in the sequence: the first will describe all the necessary beam parameters, and the second will have all parameters zero–length except the gantry angle, which will indicate the stop gantry angle. **All beams supplied by Advantage Sim will be static, i.e. will contain exactly one item in the Dynamic Segment Sequence.**

**7–4–4–4–4** Source–Surface Distance

For *Advantage Sim*, SSD stored is the distance from the beam origin to the first point encountered in the 3D patient model. This may not correspond to the distance calculated using the 'BODY' structure. The presence of a treatment table which has not been removed using the ''Remove Couch'' option may also modify the stored SSD value.

**7–4–4–4–5** Jaw and Leaf Conventions

The negative jaws and leaves are located on the side with the most negative coordinate in the IEC collimator axis perpendicular to the jaw or leaf edge. The positive jaws and leaves are located on the side with the most positive coordinate in the IEC collimator axis perpendicular to the jaw or leaf edge. Leaf pair 1 is located at the most negative position in the IEC collimator axis parallel to the leaf edges. The jaw or leaf position is defined as the coordinate along the corresponding axis using the IEC coordinate conventions (e.g. for a 10 cm symmetric field implemented with a pair of X–asymmetric jaws, X Negative Jaw Position = – 50, X Positive Jaw Position = + 50).

**7–4–4–4–6** Collimator Representation

The six types of collimator defined by the ‘Collimator Type’ attribute each require different combinations of the collimator definition attributes, according to the following rules:

- SYMMETRIC collimators require that ‘X Symmetric Opening’ and ‘Y Symmetric Opening’ be defined.
- ASYMMETRICX collimators require that ‘Y Symmetric Opening’, ‘X Positive Jaw Position’, and ‘X Negative Jaw Position’ be defined.
- ASYMMETRICY collimators require that ‘X Symmetric Opening’, ‘Y Positive Jaw Position’, and ‘Y Negative Jaw Position’ be defined.
- BIASYMMETRIC collimators require that ‘X Positive Jaw Position’, ‘X Negative Jaw Position’, ‘Y Positive Jaw Position’, and ‘Y Negative Jaw Position’ be defined.
- MULTILEAFX collimators require that ‘Leaf Positions’, ‘Y Positive Jaw Position’, and ‘Y Negative Jaw Position’ be defined.
- MULTILEAFY collimators require that ‘Leaf Positions’, ‘X Positive Jaw Position’, and ‘X Negative Jaw Position’ be defined.

**7–4–4–5** SOP Common

| Attribute Name | Element Tag | TP | Notes |
|---|---|---|---|
| SOP Class UID | (0008,0016) | 1 | ‘1.2.840.113619.4.5.249’ |
| SOP Instance UID | (0008,0018) | 1 | UID root will be ‘1.2.840.113619.2.49’ |
| Instance Creation Date | (0008,0012) | 3 | |
| Instance Creation Time | (0008,0013) | 3 | |

## 7–5 Private Data Dictionary for GE Private DICOM RT Plan

**Private Creator Identification GEMS_RTEN_01**

| Attribute Name | Element Tag | VR | VM |
|---|---|---|---|
| Plan Creation Date | (0249,11) | DA | 1 |
| Plan Creation Time | (0249,13) | TM | 1 |
| Operator Name | (0249,14) | PN | 1 |
| Plan Comment | (0249,16) | LO | 1 |
| Plan Image Sequence | (0249,18) | SQ | 1 |
| Exam/Series/Image Identifier | (0249,1A) | LO | 1 |
| Additional Image Identifier | (0249,1B) | IS | 1 |
| Build Resolution | (0249,1C) | CS | 1 |
| Structure Sequence | (0249,20) | SQ | 1 |
| Structure Name | (0249,22) | SH | 1 |
| Structure Type | (0249,24) | CS | 1 |
| Structure Color | (0249,28) | CS | 1 |
| Slab Sequence | (0249,30) | SQ | 1 |
| Slab Image Sequence | (0249,32) | SQ | 1 |
| Z Plus Thickness | (0249,36) | DS | 1 |
| Z Minus Thickness | (0249,38) | DS | 1 |
| Slab Shape | (0249,3A) | DS | 3–n |
| Marker Sequence | (0249,40) | SQ | 1 |
| Marker Name | (0249,42) | SH | 1 |
| Marker Color | (0249,44) | CS | 1 |
| Marker Position | (0249,46) | DS | 3 |
| Beam Group Sequence | (0249,50) | SQ | 1 |
| Group Name | (0249,51) | SH | 1 |
| Group Properties | (0249,52) | CS | 0–n |
| Beam Sequence | (0249,54) | SQ | 1 |
| Machine Reference Sequence | (0249,60) | SQ | 1 |
| Machine Name | (0249,62) | SH | 1 |
| Beam Name | (0249,64) | SH | 1 |
| Particle Type | (0249,66) | CS | 1 |
| Nominal Particle Energy | (0249,68) | DS | 1 |
| Block Sequence | (0249,70) | SQ | 1 |
| Block Name | (0249,72) | LO | 1 |
| Block Shape | (0249,74) | DS | 2–n |
| Cutout Sequence | (0249,80) | SQ | 1 |

| Attribute Name | Element Tag | VR | VM |
|---|---|---|---|
| Cutout Name | (0249,82) | LO | 1 |
| Cutout Shape | (0249,84) | DS | 2–n |
| Collimator Name | (0249,90) | SH | 1 |
| Collimator Type | (0249,92) | CS | 1 |
| Dynamic Segment Sequence | (0249,A0) | SQ | 1 |
| Table Angle | (0249,A2) | DS | 1 |
| Gantry Angle | (0249,A4) | DS | 1 |
| Collimator Angle | (0249,A6) | DS | 1 |
| Isocenter Position | (0249,A8) | DS | 3 |
| Source–Surface Distance | (0249,A9) | DS | 1 |
| X Symmetric Opening | (0249,AA) | DS | 1 |
| Y Symmetric Opening | (0249,AC) | DS | 1 |
| X Positive Jaw Position | (0249,AE) | DS | 1 |
| X Negative Jaw Position | (0249,B0) | DS | 1 |
| Y Positive Jaw Position | (0249,B2) | DS | 1 |
| Y Negative Jaw Position | (0249,B4) | DS | 1 |
| Leaf Positions | (0249,B6) | DS | 2–n |
| Treatment Position | (0249,D0) | CS | 1 |

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