TECHNICAL REPORT

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First edition
2002-03

Medical electrical equipment – Guidelines for implementation of DICOM in radiotherapy

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

MEDICAL ELECTRICAL EQUIPMENT – GUIDELINES FOR IMPLEMENTATION OF DICOM IN RADIOTHERAPY

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical specifications, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this technical report may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

Technical reports do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful by the maintenance team.

IEC 62266, which is a technical report, has been prepared by subcommittee 62C: Equipment for radiotherapy, nuclear medicine and radiation dosimetry, of IEC technical committee 62: Electrical equipment in medical practice.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
62C/309/CDV	62C/321/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This technical report does not follow the rules for structuring International Standards as given in Part 2 of the ISO/IEC Directives.

NOTE This report has been reproduced without significant modification of its original content or drafting.

This document, which is purely informative, is not to be regarded as an International Standard.

The committee has decided that the contents of this publication will remain unchanged until 2007. At this date, the publication will be

- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

MEDICAL ELECTRICAL EQUIPMENT – GUIDELINES FOR IMPLEMENTATION OF DICOM IN RADIOTHERAPY

1 Introduction to this document

For a number of years, the International Electrotechnical Commission (IEC) worked on the development of a standard addressing Electronic Data Exchange in Radiotherapy. At about the same time, another group with international representation had been working to extend the DICOM (Digital Imaging and Communication in Medicine) standard initially used for diagnostic images to include images/data used in radiotherapy. Ultimately, a decision was made by the IEC to adopt four DICOM RT objects as an IEC standard which appeared in April 1998 as IEC 61852 'Medical Electrical Equipment – Digital Imaging and Communication System in Medicine (DICOM) – Radiotherapy Objects First Edition'. The present document has been developed to introduce and to call attention to the complexity of the DICOM standard with its radiotherapy extension. It also addresses the importance of a complete evaluation of the "DICOM Conformance Statement" prepared by manufacturers, and the need for a qualified individual such as a medical physicist to evaluate the compatibility of pieces of radiotherapy equipment impact in the clinic of electronic data transfer, and the integrity of data exchange.

This document gives a brief introduction to DICOM including its extension to Radiotherapy. Parts of this document are derived from the brochure produced by the DICOM WG 7 responsible for producing the RT extension to the DICOM Standard. This document outlines preliminary steps required to implement and test a DICOM interface to a medical application system.

The DICOM standard has been published[1a] by the National Electrical Manufacturers Association of America. Based on this standard there are a number of DICOM development tool kits produced by academia and available in the public domain. There are also commercial toolkits produced by a number of vendors. Details of these can be obtained on the Internet. The DICOM newsgroup[1b] on the Internet provides state of the art news on DICOM Standard development, related products, problems etc. Some of the Internet references have links to other companies' DICOM-related Web sites which are extremely useful for further information on DICOM related subjects.

NOTE This document is an implementation guide. For full normative description of the DICOM standard consult the official standard[1a].

2 Introduction to DICOM

In the 1980's with the development and proliferation of medical imaging equipment, it became clear to radiologists and the manufacturers of medical imaging equipment that the tremendous growth in image acquisition systems, display workstations, archiving systems, and hospital-radiology information systems made vital the connectivity and interoperability of all pieces of equipment. In order to simplify and improve equipment connectivity, medical professionals (American College of Radiology – ACR) joined forces with medical equipment manufacturers (US National Electrical Manufacturers Association – NEMA) in an international effort to develop DICOM, the Digital Imaging and Communications in Medicine Standard. When DICOM interface is implemented into a medical device, it can be directly connected to another DICOM-compatible device, eliminating the need for a custom interface. DICOM was first developed to address connectivity and inter-operability problems in radiology, but today there are sections of the DICOM standard which define radiotherapy objects. Fig 1 shows the scope of the DICOM connectivity of these objects as supported by the standard.

The DICOM[1a] Standard currently provides the following Services:

- **Network Image Transfer:** Provides the capability for two devices to communicate by sending objects such as radiology images (eg CT, MR, CR, X-Ray Angiography & RF, PET, NM, US etc) or RT images and data (RT Structure Set, Plan, Image, Dose, & Treatment Record). It also allows the facility to identify and retrieve/transfer images/data from the remote devices. Network transfer is currently the most common connectivity feature supported by DICOM products.
- **On-Line Imaging Study Management:** Provides medical devices with the network capability to integrate with various information systems eg Hospital Information System (HIS) for clinical and administrative data, and Radiotherapy Information System (RIS) for radiology and radiotherapy images and data.
- **Network Print Management:** Provides the capability to print images on a networked printer/camera. An example of this is multiple scanners or workstations printing images on a single shared hardcopy media.
- **Open Media Interchange:** Provides the capability to manually exchange objects (images or RT objects) and related information (such as reports or filming information). DICOM standardizes a common file format, a medical directory structure, and a physical media (eg CD, floppy disk). Examples include the exchange of images for a publication and mailing a patient imaging study for remote consultation.
- **Workflow Management:** The standard has been extended to define Modality Worklist and General Purpose Worklist which are designed to request, schedule, and describe the performance of imaging and other procedures. Integration of these procedures provide harmonisation with other standardization bodies. Further services in this area are being considered.

The DICOM standard is structured as:

Open Networking (Parts 1-9)

Part 1 – Introduction and Overview – describes the overall structure of the Standard.

Part 2 – Conformance – Explicit statement of Objects (eg CT, MR, RT Images), Service Classes (such as Storage, Query/Retrieve) and Communication Profile supported (such as TCP/IP, Ethernet).

Part 3 – Information Object Definitions (IOD) – specifies the structure and attributes of objects which are operated by Service Classes. These objects include images, studies, and patient.

Part 4 – Service Class Specifications – defines the operations that can be performed on instances of Information Objects (defined in Part 3) to provide a specific service such as Storage, Query/Retrieve, Print.

NOTE Parts 3 and 4 of the standard represent the core of the DICOM Open Network formalism. Services Classes defined in part 4 are combined with specific Information Object Definitions (IODs) defined in part 3 to form a service-object pair (SOP). The SOP is the basic building block of DICOM communication. Further an SOP can either be a Client (Service Class User – SCU) or a server (Service Class Provider – SCP). So for the two DICOM compliant partners to communicate with each one of the partners must define its role as an SCU and the other as an SCP.

Part 5 – Data Structures and Encoding – specifies the encoding of the data content of messages which are exchanged to accomplish the operations used by the Service Classes (Part 4)

Part 6 – Data Dictionary – defines the individual information attributes that represent the data content (Part 5) of instances of Information Objects.

Part 7 – Message Exchange – specifies the operations and protocol used to exchange messages. These operations are used to accomplish the services defined by the Service Classes (Part 4)

Part 8 – Network Communication Support for Message Exchange – defines the services and protocols used to exchange messages (Part 7) directly on OSI (Open Systems Interconnection) and TCP/IP networks.

Part 9 – Point-to-Point Communication Support for Message Exchange- defines the services and protocols used to exchange messages (Part 7) on the DICOM 50-pin interface. (Included for compatibility with ACR/NEMA 2). It is no longer used with DICOM3.0.

Open Media Storage (Parts 10-12)

Part 10 – Media Storage and File Formats for Media Interchange – standardises the overall open Storage Media architecture used by this part, including the definition of a generic File Format, a Basic File Service and a Directory concept.

Part 11 – Media Storage Application Profiles – Standardises a number of choices related to a specific clinical need (selection of a Physical Medium and Media Format as well as specific Service/Object Pair Classes). It aims at facilitating the inter-operability between implementations which claim conformance to the same Application Profile. Part 11 is intended to be extended as the clinical needs for Media Storage Interchange evolve.

Part 12 – Media Formats and Physical Media for Data Interchange – defines a number of selected Physical Medium and corresponding Media Formats. These Media Formats and Physical Medium selections are referenced by one or more of the Application Profiles of Part 11. Part 12 is to be extended as the technologies related to Physical Medium evolve.

Point-to-Point Print Print Management (Part 13)

Part 13 – Print Management Point-to-Point Communication Support – specifies the services and protocol necessary to support the communication of DICOM Print Management Application Entities over point-to-point links between print users and print providers.

Greyscale Standard Display Function (Part 14)

Part 14 – Grayscale Standard Display Function – specifies standardised Display Function for display of grayscale images.

Security Profiles (Part 15)

This standard provides mechanism that could be used to implement security policies with regard to the interchange of DICOM objects between Application Entities.

3 DICOM RT Extension

During the RSNA 1994 at Chicago, a meeting was held at which a clear need was expressed for standardization of the way radiotherapy data (such as external beam and brachytherapy treatment plans, doses, and images) are transferred from one piece of equipment to another. The importance of such a standard was clear. The cost of developing custom interfaces, especially in radiotherapy departments where multi-vendor installations are common, is high, an expense which must be passed on to the user. Not only are such developments costly, they can be technically difficult, slowing down the progress of integration of the radiotherapy department, and are also safety critical. Although a standard such as DICOM does not eliminate these issues, it can facilitate development of safe, reliable inter-operability.

As a result of the RSNA meeting, an ad-hoc Working Group, later to become DICOM Working Group 7 (Radiotherapy Objects) was formed under the auspices of NEMA. Participating members of this group include many manufacturers of radiotherapy equipment, some academics, and also members involved with the AAPM and the IEC.

In 1997, four DICOM RT objects were ratified: RT Structure Set, RT Plan, RT Dose, and RT Image. These objects were integrated into Part 3 of the DICOM standard published in 1998.

An additional three objects: RT Beam Treatment Record, RT Brachy Treatment Record & RT Treatment Summary Records were finalised in 1998 which subsequently appeared in DICOM standard in 1999.

4 DICOM RT Capabilities

In order to understand what DICOM objects can and cannot provide it is important for radiotherapy professionals to distinguish between DICOM connectivity and application interoperability. DICOM connectivity refers to the DICOM message exchange standard responsible for establishing connections and exchanging properly structured messages so that an information object sent from one node will be completely received by the receiving node. In other words, the successful transfer of information: the successful "plug and exchange" between two pieces of medical equipment.

Beyond connectivity lies application interoperability – the ability to process and manipulate information objects. DICOM plays a crucial role in enabling such interoperability, but sometimes "plug and play" at this level requires more than the standardized definition and coding of information provided by DICOM. Specification and testing of the clinical application capabilities and data flow needs to be performed by the healthcare facility to ensure effective integration of the various DICOM applications. For example, transfer of IMRT (intensity-modulated) data from an IMRT-capable treatment planning system requires a record and verify or treatment system capable of managing such dynamic treatments. As we will see later, DICOM requires implementers to explicitly specify these application-specific information needs in a DICOM Conformance Statement which will provide the basis for achieving such application interoperability.

The key feature of DICOM is the capability of "connectivity". This refers to the protocols established by DICOM which permit the establishment of connections and the exchange of properly structured messages so that an information object sent from one piece of equipment will be received intact by another piece of equipment.

5 DICOM RT Objects

The DICOM RT objects, added to part 3 of the DICOM Standard, are defined as:

- **RT Structure Set**, containing information related to patient anatomy, for example structures, markers, and isocenters. These entities are typically identified on devices such as CT scanners, physical or virtual simulation workstations, or treatment planning systems.
- **RT Plan**, containing geometric and dosimetric data specifying a course of external beam and/or brachytherapy treatment, for example beam angles, collimator openings, beam modifiers, and brachytherapy channel and source specifications. The RT Plan entity may be created by a simulation workstation, and subsequently enriched by a treatment planning system before being passed on to a record and verify system or treatment device. An instance of the RT Plan object usually references a RT Structure Set instance to define a coordinate system and set of patient structures.
- **RT Image**, specifying radiotherapy images which have been obtained on a conical imaging geometry, such as those found on conventional simulators and portal imaging devices. It can also be used for calculated images using the same geometry, such as digitally reconstructed radiographs (DRRs).
- RT Dose, containing dose data generated by a treatment planning system in one or more of several formats: three-dimensional dose data, isodose curves, DVHs, or dose points.
- **RT Beam Treatment Record**: This scope of the RT Beam Treatment Record is external beam session record during a radiotherapy treatment course with an optional treatment summary indicating the cumulative state of a treatment course.

- RT Brachy Treatment Record: This scope of the RT Brachy Treatment Record is brachytherapy treatment session record during a radiotherapy treatment course with an optional treatment summary indicating the cumulative state of a treatment course.
- RT Treatment Summary Record: The scope of this object is treatment summaries indicating the cumulative state of a treatment course.

Fig 2 describes the DICOM Information Model with the additional RT objects.

6 A DICOM Example (including RT Objects)

To illustrate, see Fig 3, how DICOM, including RT objects, can be used during an external beam patient treatment, here is a list of possible treatment steps, and their associated DICOM objects:

1. The patient is scanned on a CT scanner, producing a DICOM CT image study. Other DICOM image modalities, such as MR, could also be produced.
2. A virtual simulation application queries the scanner using DICOM, retrieves the images, and performs a virtual simulation. An RT Structure Set object is produced, containing identified structures such as the tumor and critical organs. An associated RT Plan is also created, containing beam geometry information. Digitally-reconstructed radiographs (DRRs) may also be created as RT Image objects.
3. A treatment planning system (TPS) then reads the CT Images, RT Structure Set, and RT Plan. It adds beam modifiers, modifies the beam geometries where necessary, and also calculates dosimetry data for the plan. A new RT Plan object is created, and RT Image DRRs may also be produced.
4. A record and verify system then obtains the completed RT Plan object, and uses the data contained within it to initialize a linac treatment. Alternatively, the linac itself could make use of the object directly. An Electronic Portal Imaging Device (EPID) can create RT Image verification images, or compare acquired images with DRRs created by the above steps.
5. Periodically during the course of treatment, the linac or record and verify system creates Treatment Record objects, generally one for each treatment session.

The above sequence illustrates just one scenario. In reality there is a wide variety of different utilizations possible, and DICOM RT objects have been designed with this flexibility in mind.

7 The DICOM Conformance Statement (DCS)

It is not enough for a vendor to simply claim conformance to DICOM, and the statement "This product has DICOM" has even less meaning in the radiotherapy domain, in which inter operability is a very complex issue. A vendor must produce a DICOM Conformance Statement (DCS). Part 2 of the DICOM Standard[1a] describes the format of such a statement. It stipulates that a DCS should contain DICOM Objects, Services and their Roles, and the Communication media implemented by a manufacturer. The standard does not stipulate to list the Object modules and their relevant attributes implemented. This information is vital to aid and establish inter-connectivity between the two systems intending to communicate to each other. A prospective purchaser of a new equipment must study the DCS supplied by a vendor to ensure successful communication between his/her and the vendor's equipment.

A typical 'Example' of a DCS for RT Plan IOD as SCP is given in Annex A of this document where Chapters 1-7 of the DCS contains information stipulated by the DICOM standard. Appendices A-C of the DCS gives additional information which is useful and necessary for practical application. Appendix A of this DCS specifies the RT Plan modules and their attributes implemented by the Example. Appendix B lists the status code returned by the Example DCS and Appendix C lists the DICOM attributes which do not map exactly on to the example DCS.

Connectivity between two pieces of equipment can be evaluated ahead of time by the use of the equipment's DCSs. However, for RT applications, it is not usually possible to determine inter-operability – this must be done by extensive testing. Nevertheless, conformance statements provide a foundation to determine connectivity and assess the potential inter-operability of two products, and in some cases identify potential problems without ever having physically connected them.

Radiotherapy professionals should insist upon a conformance statement for any device that claims to be DICOM conformant with RT Objects. Many manufacturers make their conformance statements available on the Internet.

Developing and testing product inter-operability is a time consuming process. This is particularly so in radiotherapy, where the complexity of the objects far exceeds those found in nearly all other modalities. After over a year of behind-the-scenes effort, many manufacturers are now selling or demonstrating versions of their products with DICOM RT Objects.

8 DICOM Storage Media Concept

The DICOM Storage Media Standard[1a] (parts 10-12) defines concept to implement DICOM based distributed processing which is different from that of the Network Distributed Processes. In the Storage Media concept no direct link is available between the two systems. Instead the information is stored by a system on a removable media according to the directory and file formats defined by the DICOM Media Storage Standard. The storage media eg CD, floppy disk can be used by another system conforming to the DICOM Media Storage Standard.

A DICOM Media Storage DCS is also a pre-requisite for a storage device produced by a system. The salient part of the DCS is an Application Profile (AP) which contains necessary information which is the format of the media and the extent of information contained on the media.

The DICOM Toolkits available from a number of vendors contain facilities for developing DICOM Media Storage on a removable physical media. There are a number of vendors/users producing images/information on physical media (e.g. CD ROM, MOD and soon DVD) based on the DICOM Media Storage Standard for use by other systems.

9 DICOM Implementation Guide

This section provides guidelines for implementing a DICOM interface to an application system:

1. From the communication requirement specifications of a system for which the DICOM Interface is to be developed:
   - Deduce the DICOM Objects (e.g. images) to be implemented,
   - For each Object define the Service Class that is required,
   - For each Service Class establish whether the DICOM interface has is to developed as a Service Class Provider (Server) or a Service Class User (Client) of the service,
2. Each Object defines Mandatory, Conditional and User Optional modules. Define which of the User Optional modules are to be implemented.
3. Each module contains mandatory or optional attributes. It is recommended to list all the mandatory and optional attributes within all the modules implemented.
4. There are a number of commercially available DICOM Toolkits based on the DICOM standard. A Toolkit usually provides an environment to develop DICOM interface to an application system and some of these also provide initial testing facilities.

There are also a number of public domain Toolkits available on the Internet which are not normally used to develop a DICOM interface to an application system to be developed as a commercial product. Notwithstanding that, these toolkits provide an easy to understand and implement DICOM interface. These toolkits also provide a very convenient initial test environment.

As it is obvious from (1) – (3), that there are a number of options available in implementing a DICOM interface to an application system. A DCS contains the Objects and the associated Service Classes implemented by an application system. A good DCS must also include the Object modules and their attributes implemented. The next step is to consult the DCS, usually published on the Internet, of a system you are intending to interconnect with. From the comparisons of two DCSs, it should be possible to deduce the level of interconnectivity of the two systems.

For a complicated DICOM RT Object (eg RT Plan), different implementers are likely to implement different module/attribute options. Before an implementation is started, it is suggested to consult major providers of already existing DICOM interfaces about the commonly accepted implementations and the way the attributes are used officially. In any case where an implementer is uncertain about how the attributes are used, the DICOM WG7 committee for RT Objects should be contacted for advice on correct usage.

It is also important for two or more implementers intending to inter-communicate to decide upon the common set of module/attribute options and check the consistency of the attribute usage of each module against the DICOM standard. In case of uncertainty, the DICOM WG7 should be contacted to avoid possible implementations that contradict the officially established usage. Some implementations may become invalidated in the course of other implementations which correctly use the standard definition.

10 DICOM Testing

The DICOM standard does not specify a test suite or a compliance verification mechanism. There are working groups/centers developing compliance verification tools, but it is still the users responsibility to define initial cross-platform test plans to demonstrate compliance between the new and existing pieces of equipment.

To verify a DICOM interface, the following steps are usually conducted:

- Test the conformance of the application system against the DCS produced. This is an in-house test to check that the system meets the DCS.
- There are a number of public domain DICOM test environments available on the Internet which can provide initial test facilities.
- To test it more rigorously there are also commercially available DICOM test centers. So far these are only available for the non-RT environment.
- Arrange one or more cross vendor testing with third party equipment. This should determine the level of inter-connectivity between various equipment.

11 Caution to Users

The DICOM standard follows the IEC convention in all cases except for the patient coordinate system which is the only known inconsistency between the DICOM standard and the IEC. The IEC, through its publication IEC 61217, Amendment 1 (1999) defines patient coordinate systems for radiotherapy equipment. As the DICOM defines the patient co-ordinate system that is related to the portrayal of cross-sectional images, an amendment to IEC 61217 includes transformation matrices to allow conversion of patient coordinates from the DICOM convention to the IEC convention.

The health care facility is responsible for confirming the veracity of data transferred using the DICOM standard. This requires specification of the needed capabilities, evaluations of the accuracy data transfer, and testing of the implementation of these data by the receiving station.

Although DICOM compliance is a necessary condition for radiation oncology information to be transferred among pieces of radiation oncology equipment, it is not necessarily a sufficient condition. DICOM provides a common interface language, and DICOM compliance ensures that all equipment "speaks the same language". However, DICOM compliance does not ensure that the information passed from one piece of equipment to another will be compatible with the capabilities of the receiving equipment, such that the two systems can inter-operate. The situation is analogous to communication among people: A communication language (say, English or French) might be defined, but one also needs a mechanism, such as a telephone or email connection, to actually effect the transfer of information from one individual to another. Thus, purchasers of radiation oncology equipment must verify that their equipment will actually communicate with other equipment and successfully transfer information using the DICOM protocols and definitions.

12 Concluding remarks

DICOM has been demonstrated successfully in a number of international conferences and exhibitions. It has increasingly gained confidence from the equipment vendors and users. The DICOM interface is beginning to become pre-requisite for acquisition modalities, highly desirable for RT & image processing, and hardcopy systems.

The DICOM Standard Committee is the governing body with members drawn from user and vendor organisations, government agencies and other standard developing organisations with NEMA secretariat.

The DICOM is expanding its scope from radiology and cardiology imaging to radiotherapy, reporting about findings and information exchange between imaging system and information systems. Addition to the Standard are made as new DICOM Supplements that are incorporated into the standard and the maintenance work is carried out via Correction Proposals.

13 References

(1) The DICOM Standard

(a) The Digital Imaging and Communications in Medicine (DICOM) Standard
David Snavely, Industry Manager
NEMA PS3.1-15 (2000)
National Electrical Manufacturers Association (NEMA) Publication Sales
1300N 17th Street, Suite 1847
Rosslyn, Va 22209, USA Phone (703) 841 3285 Fax (703) 841 3385
http://www.nema.org/nema/medical/dicom/

(b) DICOM newsgroup
Comp.protocols.Dicom

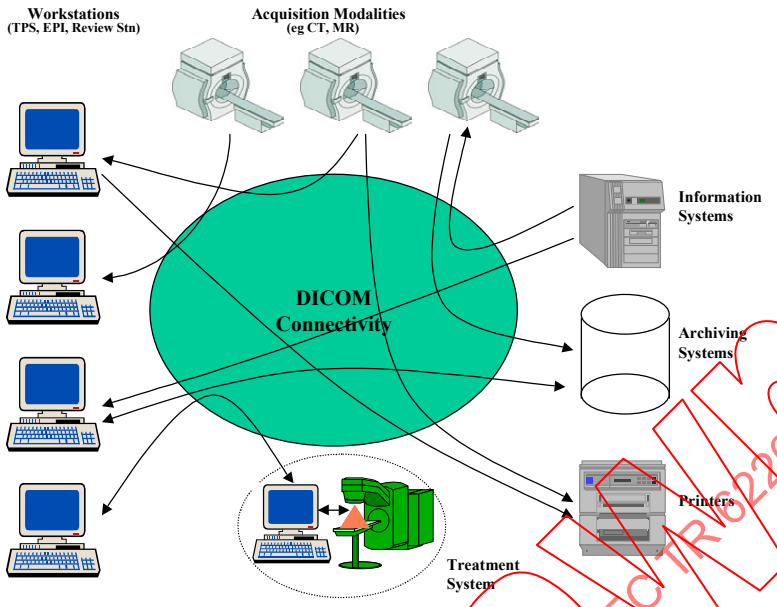

Fig 1 The Scope of DICOM Connectivity

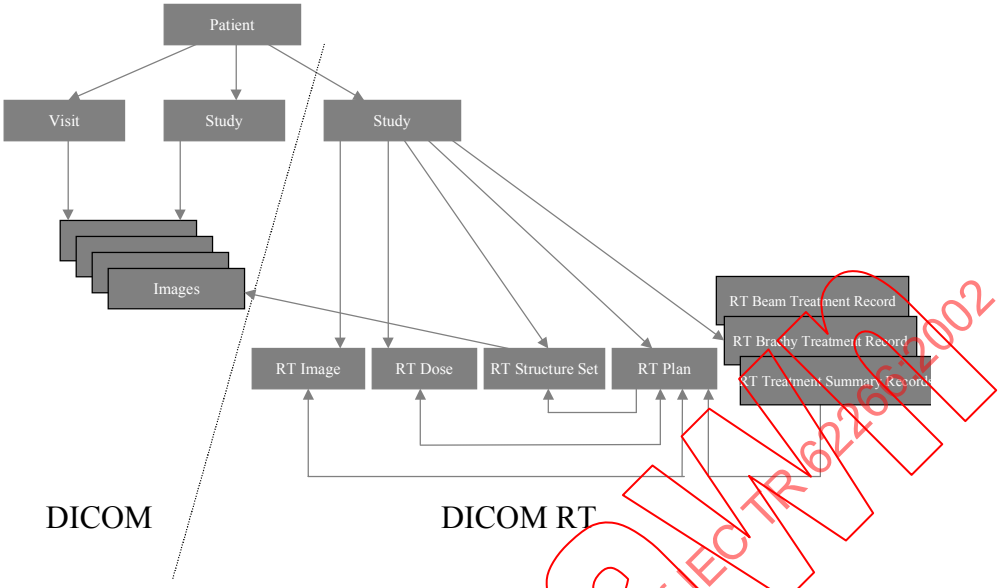

Fig 2 DICOM Information Model (with RT Extensions)

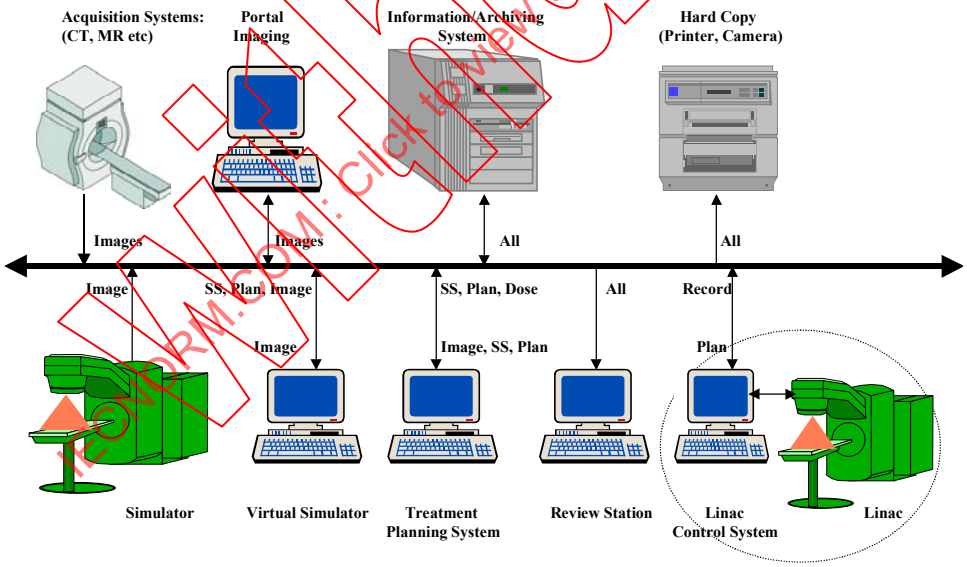

Fig 3 A DICOM Example (inc RT Objects)

(During an external beam patient treatment)

Annex A

XYZ/Company Oncology Systems Ltd
An Example DICOM Conformance Statement
for XYZ/Product Treatment System

A.1 Introduction

This chapter provides general information about the purpose, scope and contents of this Conformance Statement.

A.1.1 Scope and field of application

The scope of this DICOM Conformance Statement is to facilitate data exchange with equipment of XYZ/COMPANY Oncology Systems Ltd. This document specifies the compliance to the DICOM standard (formally called the NEMA PS 3.X-1998 standards). It contains a short description of the applications involved and provides technical information about the data exchange capabilities of the equipment. The main elements describing these capabilities are the supported DICOM Service Object Pair (SOP) Classes, Roles, Information Object Definitions (IOD) and Transfer Syntax's.

The field of application is the integration of the XYZ/COMPANY Oncology Systems equipment into an environment of medical devices.

This Conformance Statement should be read in conjunction with the DICOM standard and its addenda.

A.1.2 Intended audience

This Conformance Statement is intended for:

- (potential) customers,
- system integrators of medical equipment,
- marketing staff interested in system functionality,
- software designers implementing DICOM interfaces

It is assumed that the reader is familiar with the DICOM standard.

A.1.3 Contents and structure

The DICOM Conformance Statement is contained in chapter A.2 through A.7 and follows the contents and structuring requirements of DICOM PS 3.2-1998 Additionally, the Appendices following chapter A.7 specify the details of the applied IODs, SCP-specific status codes and extended configuration details.

A.1.4 Used definitions, terms and abbreviations

- DICOM definitions, terms and abbreviations are used throughout this Conformance Statement. For a description of these, see DICOM PS 3 1998.
- The word XYZ/COMPANY in this document refers to XYZ/COMPANY Oncology Systems Ltd.
- The word XYZ/PRODUCT in this document refers to the XYZ/COMPANY Oncology Systems Precise Treatment System Product, Release 1.0.

A.1.5 References

[DICOM PS 3 1998]

The Digital Imaging and Communications in Medicine (DICOM) standard:

NEMA PS 3.X (X refers to the part 1 – 13) and Supplements.

National Electrical Manufacturers Association (NEMA) Publication Sales

1300 N. 17th Street, Suite 1847

Rosslyn, Va. 22209, United States of America

A.1.6 Important note to the reader

This Conformance Statement by itself does not guarantee successful interoperability of XYZ/COMPANY equipment with non-XYZ/COMPANY equipment. The user (or user's agent) should be aware of the following issues:

- Scope

  The goal of DICOM is to facilitate inter-connectivity rather than interoperability. Interoperability refers to the ability of application functions, distributed over two or more systems, to work successfully together. The integration of medical devices into a networked environment may require application functions that are not specified within the scope of DICOM. Consequently, using only the information provided by this Conformance Statement does not guarantee interoperability of XYZ/COMPANY equipment with non-XYZ/COMPANY equipment. It is the user's responsibility to analyse thoroughly the application requirements and to specify a solution that integrates XYZ/COMPANY equipment with non-XYZ/COMPANY equipment.

- Validation

  XYZ/COMPANY equipment has been carefully tested to assure that the actual implementation of the DICOM interface corresponds with this Conformance Statement. Where XYZ/COMPANY equipment is linked to non-XYZ/COMPANY equipment, the first step is to compare the relevant Conformance Statements. If the Conformance Statements indicate that successful information exchange should be possible, additional validation tests will be necessary to ensure the functionality, performance, accuracy and stability of prescription and prescription related data. It is the responsibility of the user (or user's agent) to specify the appropriate test suite and to carry out the additional validation tests.

- New versions of the DICOM Standard

  The DICOM Standard will evolve in future to meet the user's growing requirements and to incorporate new features and technologies. XYZ/COMPANY is actively involved in this evolution and plans to adapt its equipment to future versions of the DICOM Standard. In order to do so, XYZ/COMPANY reserves the right to make changes to its products or to discontinue its delivery. The user should ensure that any non-XYZ/COMPANY provider linking to XYZ/COMPANY equipment also adapts to future versions of the DICOM Standard. If not, the incorporation of DICOM enhancements into XYZ/COMPANY equipment may lead to loss of connectivity and/or incompatibility.

A.2 Implementation Model

XYZ/PRODUCT is a networked information system comprising Control Systems and Operators Consoles for use with XYZ/COMPANY Linear Accelerators, together with a centralised Patient database for Prescription Preparation, Verification and Recording purposes.

A.2.1 Application Data Flow Diagram

XYZ/PRODUCT behaves as a single Application Entity (AE). The related Implementation Model is shown in Fig 4.

A.2.2 Functional definition of Application Entity

The XYZ/PRODUCT application entity acts as Service Class Provider (SCP) of Verification and Storage Service Classes.

The Application Entity is active when the XYZ/PRODUCT system is switched on.

A.2.3 Sequencing of Real-World Activities

Not applicable.

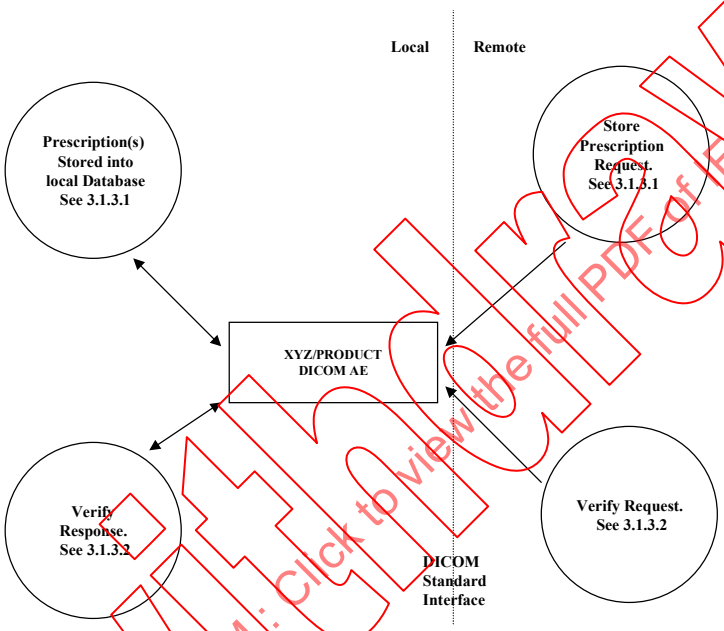

Fig 4 XYZ/PRODUCT Implementation Model

A.3 AE Specifications

A.3.1 XYZ/PRODUCT AE Specification

The XYZ/PRODUCT Application Entity provides Standard Conformance to the following DICOM V3.0 SOP classes as an SCP:

Table 1 – SOP Classes supported by XYZ/PRODUCT as SCP

SOP Class Name	UID
RT Plan Storage – STORE	1.2.840.10008.5.1.4.1.1.481.5
Verification	1.2.840.10008.1.1

A.3.2 Association Establishment Policies

A.3.2.1 Association Establishment Policies

A.3.2.1.1 General

The maximum PDU size for XYZ/PRODUCT is configurable from a minimum of 1024 bytes to a maximum of 31000 bytes. (The default is 16K = 16384 bytes).

A.3.2.1.2 Number of Associations

XYZ/PRODUCT will support one active association as a Service Class Provider at a time.

The number of simultaneous pending associations supported is configurable. The default is 5.

A.3.2.1.3 Asynchronous Nature

XYZ/PRODUCT does not support asynchronous operations and will not perform asynchronous window negotiation.

A.3.2.1.4 Implementation Identifying Information

The Implementation Class UID is: 1.3.46.423632.128000

The implementation version name is: XYZ/PRODUCT_1.0

A.3.2.2 Association Initiation Policy

XYZ/PRODUCT does not initiate associations.

A.3.2.3 Association Acceptance Policy

The XYZ/PRODUCT Application Entity accepts associations for the following purposes:

- To allow remote applications to store prescriptions into the XYZ/PRODUCT database (see section A.3.2.3.1 below)
- To allow remote applications to verify application level communication with XYZ/PRODUCT (see section A.3.2.3.2 below)

XYZ/PRODUCT may accept association requests from remote stations depending on the XYZ/PRODUCT configuration:

- The Application Entity rejects association requests from unknown applications i.e. applications that offer an unknown “calling AE title” or reside on an unrecognised TCP/IP host. An application is known if and only if it is defined during configuration of the XYZ/PRODUCT system.
- The Application Entity rejects association requests that incorrectly address the XYZ/PRODUCT AE, i.e. from applications that offer a wrong “called AE title”. The XYZ/PRODUCT AE title is defined during configuration of the system (See Section A.6.1.1).

A.3.2.3.1 Store Prescriptions into XYZ/PRODUCT Database

A.3.2.3.1.1 Associated Real World Activity

XYZ/PRODUCT accepts associations from remote systems that wish to send prescriptions for storage into the XYZ/PRODUCT database.

A.3.2.3.1.2 Presentation Context Table

Any of the presentation contexts shown in Table 2 below are acceptable:

Table 2 – Acceptable Presentation Contexts for XYZ/PRODUCT Prescription Storage

Presentation Context Table					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name List	UID List		
RT Plan Storage – STORE	1.2.840.10008.5.1.4.1.1.481.5	Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
		Explicit VR Little Endian	1.2.840.10008.1.2.1	SCP	None
		Explicit VR Big Endian	1.2.840.10008.1.2.2	SCP	None

A.3.2.3.1.3 C-STORE SCP Conformance

XYZ/PRODUCT provides standard conformance.

The AE is a Conformance Level 0 Storage SCP: not all DICOM Type 1 and 2 attributes are stored.

APPENDIX A.1 specifies which attributes from the received C-STORE requests are stored for internal XYZ/PRODUCT use.

All other received attributes will be discarded.

APPENDIX B lists the specific C-STORE response status codes returned by the AE.

The duration of the storage of the prescription is determined by the operator of the XYZ/PRODUCT system.

A.3.2.3.1.4 Presentation Context Acceptance Criterion

XYZ/PRODUCT accepts all contexts in the intersection of the proposed and acceptable presentation contexts. There is no check for duplicate contexts. Duplicate contexts are accepted.

A.3.2.3.1.5 Transfer Syntax Selection Policies

XYZ/PRODUCT prefers its native byte ordering (Little Endian), and will prefer explicit over implicit VR.

A.3.2.3.2 Verify Application Level Communication

A.3.2.3.2.1 Associated Real World Activity

XYZ/PRODUCT accepts associations from systems that wish to verify the application level communication using the C-ECHO command.

A.3.2.3.2.2 Presentation Context Table

Any of the presentation contexts shown in Table 3 below are acceptable:

Table 3 – Acceptable Presentation Contexts for Verification

Presentation Context Table					
Abstract Syntax		Transfer Syntax		Role	Extended Negotiation
Name	UID	Name List	UID List		
Verification	1.2.840.10008.1.1	Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
		Explicit VR Little Endian	1.2.840.10008.1.2.1	SCP	None
		Explicit VR Big Endian	1.2.840.10008.1.2.2	SCP	None

A.3.2.3.2.3 C-ECHO SCP Conformance

XYZ/PRODUCT provides standard conformance.

A.3.2.3.2.4 Presentation Context Acceptance Criterion

XYZ/PRODUCT accepts all contexts in the intersection of the proposed and acceptable presentation contexts. There is no check for duplicate contexts. Duplicate contexts are accepted.

A.3.2.3.2.5 Transfer Syntax Selection Policies

XYZ/PRODUCT prefers its native byte ordering (Little Endian), and will prefer explicit over implicit VR.

A.4 Communication Profiles

A.4.1 Supported Communication Stacks

The XYZ/PRODUCT application provides DICOM V3.0 TCP/IP Network Communication Support as defined in Part 8 of the DICOM Standard.

A.4.2 TCP/IP Stack

XYZ/PRODUCT inherits its TC/IP stack from the Microsoft Windows NT Server (Version 4.0) operating system upon which it executes.

A.4.3 Physical Media Support

XYZ/PRODUCT supports Ethernet ISO.8802-3.

On XYZ/COMPANY supplied hardware platforms the connection type provided is 100/10BASE-T (RJ45 twisted pair).

A.5 Extensions/Specializations/Privatisations

Not applicable.

A.6 Configuration

The XYZ/PRODUCT system DICOM settings are configured by means of a DICOM-specific configuration program.

Configuration changes are effective immediately they are committed.

Configuration is intended to be performed by XYZ/COMPANY service engineers only.

A.6.1 AE Title/Presentation Address mapping

A.6.1.1 Local AE Titles and Presentation Addresses

The local Application Entity Title is configurable. The default is “XYZ/COMPANY_ XYZ/PRODUCT”

The listen port number is configurable. The default is 104.

A.6.1.2 Remote AE Titles and Presentation Addresses

All remote applications that wish to communicate with XYZ/PRODUCT must be defined at XYZ/PRODUCT DICOM configuration time.

The following information must be provided:

- the remote AE Title.
- the TCP/IP host name on which the remote application resides.
- the IP address of the remote host.

A.6.2 Configurable Parameters

A.6.2.1 Communication Parameters

- the Maximum PDU size is configurable.
- the maximum number of simultaneous pending associations is configurable.
- DICOM Upper Layer Timeouts are configurable.

A.6.2.2 XYZ/PRODUCT Attribute Mapping

- the mapping of certain XYZ/PRODUCT Prescription parameters from attributes in received RT Plan storage requests can be explicitly disabled through configuration. (See Appendix C).

A.7 Support of Extended Character Sets

None.

Annex B

Applied RT Plan IOD and Mapping to XYZ/PRODUCT Database Import of RT Plan Prescriptions

The modules selected from the RT Plan IOD of DICOM for prescription import are given in Table 4 below. If a module is not listed, none of the attributes in that module is stored by XYZ/PRODUCT.

Table 4 – Applied Modules in the RT Plan IOD for Import (SCP Role)

IE	Module	Usage
Patient	Patient	M
Study	General Study	M
Series	RT Series	M
Equipment	General Equipment	M
Plan	RT General Plan	M
	RT Prescription	U
	RT Tolerance Tables	U
	RT Patient Setup	U
	RT Fraction Scheme	U
	RT Beams	C
	Approval	U
	SOP Common	M

Table 5 to Table 16 below specify, for each of the applied modules above, the attributes stored by XYZ/PRODUCT, further details of mapping onto the XYZ/PRODUCT database, and any attribute specific constraints applicable to their use. Attributes that are completely ignored by XYZ/PRODUCT are shown shaded.

Note that XYZ/PRODUCT configuration settings may determine whether certain attributes are actually used to map to XYZ/PRODUCT parameters (see Appendix C).

Note also that XYZ/PRODUCT requires validation of the entire applied IOD, i.e. where attributes irrelevant to XYZ/PRODUCT are included in a message, they must still have values that are valid according to the DICOM standard. Storage requests containing invalid attributes will be REJECTED **(See** Table 17**, Status Code A901).**

Table 5 – RT Plan Storage SOP Class (SCP) – Patient Module

Attribute Name	Tag	VR, VM	DICOM Type	Notes/Constraints
Patient's Name	(0010,0010)	PN 1	2	Treated as Type 1 attribute. See Note I.
Patient ID	(0010, 0020)	LO 1	2	Treated as Type 1 attribute. See Note I and Note II.
Patient's Birth Date	(0010, 0030)	DA 1	2	See Note **III**.
Patient's Sex	(0010, 0040)	CS 1	2	See Note **III**.
Referenced Patient Sequence	(0008, 1120)	SQ 1	3	Ignored
>Referenced SOP Class UID	(0008, 1150)	UI 1	1C	
>Referenced SOP Instance UID	(0008, 1155)	UI 1	1C	
Patient's Birth Time	(0010, 0032)	TM 1	3	
Other Patient IDs	(0010, 1000)	LO 1-N	3	Up to 5 values stored.
Other Patient's Names	(0010, 1001)	PN 1-N	3	Up to 5 values stored.
Ethnic Group	(0010, 2160)	SH 1	3	
Patient Comments	(0010, 4000)	LT 1	3	

Note I Handling of Empty Patient Identification Attributes

The Patient ID (0010, 0020) and Patient Name (0010, 0010) attributes of the Patient Module are specified by DICOM as Type 2 and so may legally have zero length.

As a safety measure, however, XYZ/PRODUCT treats these attributes as Type 1 and will REJECT any RT Plan Storage request containing zero length values for these attributes. (See Table 17, Status Code C001).

Note II Patient ID Already Exists in XYZ/PRODUCT Database

If a patient with the Patient ID specified in the RT Plan Storage request already exists in the XYZ/PRODUCT database, no further Patient Module attributes in the request will be imported. The check for an existing Patient ID is insensitive to case or leading/trailing spaces.

XYZ/PRODUCT will REJECT any RT Plan Storage request where an existing patient prescription is currently locked for treatment or editing by another application. **(See Table 17, Status Code A701).**

Note III Matching of Birth Date, Sex Attributes for Existing Patients

If a Patient with the specified Patient ID already exists in the XYZ/PRODUCT database, and existing Date of Birth and/or Sex details are also available, then any corresponding Birth Date and/or Patient Sex attributes present in the RT Plan Storage request MUST match the respective existing data, otherwise the request will be REJECTED **(See Table 17 Status Code C002).**

Table 6 – RT Plan Storage SOP Class (SCP) – General Study Module

Attribute Name	Tag	VR, VM	DICOM Type	Notes/Constraints
Study Instance UID	(0020, 000D)	UI 1	1	Logged to Dicom Plan Information record if present. See Note V. * Up to 5 values stored
Study Date	(0008, 0020)	DA 1	2	
Study Time	(0008, 0030)	TM 1	2	
Referring Physicians Name	(0008, 0090)	PN 1	2	
Study ID	(0020, 0010)	SH 1	2	
Accession Number	(0008, 0050)	SH 1	2	
Study Description	(0008, 1030)	LO 1	3	
Physician(s) of Record	(0008, 1048)	PN 1-N	3 *	
Name of Physician(s) Reading Study	(0008, 1060)	PN 1-N	3 *	
Referenced Study Sequence	(0008, 1110)	SQ 1	3	Ignored
>Referenced SOP Class UID	(0008, 1150)	UI 1	1C	
>Referenced SOP Instance UID	(0008, 1155)	UI 1	1C	

Table 7 – RT Plan Storage SOP Class (SCP) – RT Series Module

Attribute Name	Tag	VR, VM	DICOM Type	Notes/Constraints
Modality	(0008, 0060)	CS 1	1	"RTPLAN" only. (See Table 17, Status Code A900)
Series Instance UID	(0020, 000E)	UI 1	1	Logged to Dicom Plan Information record if present. See Note V.
Series Number	(0020, 0011)	IS 1	2	
Series Description	(0008, 103E)	LO 1	3	
Referenced Study Component Sequence	(0008, 1111)	SQ 1	3	Ignored
>Referenced SOP Class UID	(0008, 1150)	UI 1	1C	
>Referenced SOP Instance UID	(0008, 1155)	UI 1	1C	

Table 8 – RT Plan Storage SOP Class (SCP) – General Equipment Module

Attribute Name	Tag	VR, VM	DICOM Type	Notes/Constraints
Manufacturer	(0008, 0070)	LO 1	2	Ignored
Institution Name	(0008, 0080)	LO 1	3	
Institution Address	(0008, 0081)	ST 1	3	
Station Name	(0008, 1010)	SH 1	3	
Institutional Department Name	(0008, 1040)	LO 1	3	
Manufacturer's Model Name	(0008, 1090)	LO 1	3	
Device Serial Number	(0018, 1000)	LO 1	3	
Software Version	(0018, 1020)	LO 1-N	3	
Spatial Resolution	(0018, 1050)	DS 1	3	
Date of Last Calibration	(0018, 1200)	DA 1-N	3	
Time of Last Calibration	(0018, 1201)	TM 1-N	3	
Pixel Padding Value	(0028, 0120)	US 1	3	

Table 9 – RT Plan Storage SOP Class (SCP) – RT General Plan Module

Attribute Name	Tag	VR, VM	DICOM Type	Notes/Constraints
RT Plan Label	(300A, 0002)	SH 1	1	Combined and used for name of new Treatment Site. See Note IV.
RT Plan Name	(300A, 0003)	LO 1	3	
RT Plan Description	(300A, 0004)	ST 1	3	Treatment Site description
Operators Name	(0008, 1070)	PN 1-N	2 *	Logged to Dicom Plan Information record if present. See Note V. * Only 1st value stored
RT Plan Date	(300A, 0006)	DA 1	2	
RT Plan Time	(300A, 0007)	TM 1	2	
Treatment Protocols	(300A, 0009)	LO 1-N	3	Ignored
Treatment Intent	(300A, 000A)	CS 1	3	
Treatment Sites	(300A, 000B)	LO 1-N	3	
RT Plan Geometry	(300A, 000C)	CS 1	1	
Referenced Structure Set Sequence	(300C, 0060)	SQ 1	1C	
>Referenced SOP Class UID	(0008, 1150)	UI 1	1C	
>Referenced SOP Instance UID	(0008, 1155)	UI 1	1C	
Referenced Dose Sequence	(300C, 0080)	SQ 1	3	
>Referenced SOP Class UID	(0008, 1150)	UI 1	1C	
>Referenced SOP Instance UID	(0008, 1155)	UI 1	1C	
Referenced RT Plan Sequence	(300C, 0002)	SQ 1	3	
>Referenced SOP Class UID	(0008, 1150)	UI 1	1C	
>Referenced SOP Instance UID	(0008, 1155)	UI 1	1C	
>RT Plan Relationship	(300A, 0055)	CS 1	1C	

Note IV Creation of Treatment Site

Each successfully imported RT Plan Storage request shall cause creation of a single new Treatment Site (i.e. course of treatment) for the specified Patient, containing a single Phase.

The RT Plan Label and RT Plan Name attributes are used as the basis for the new Treatment Site name. If necessary, the generated name will be forced to be unique for the Patient by the appending of a sequence number "-2", "-3" etc.

The Phase Name is derived from the RT Plan Label. The Phase Description will contain the RT Plan Label and Name, and the AE title of the remote application.

Note V Dicom Plan Information Record, Dicom Beam Information Record

Certain attributes are identified as being stored to the 'Dicom Plan Information Record' or 'Dicom Beam Information Record'. These are internal areas of the XYZ/PRODUCT database whose contents are not directly accessible or visible to the end user. Their purpose is primarily to facilitate compatibility with future releases of XYZ/PRODUCT applications.

Table 10 – RT Plan Storage SOP Class (SCP) – RT Prescription Module

Attribute Name	Tag	VR, VM	DICOM Type	Notes/Constraints
Prescription Description	(300A, 000E)	ST 1	3	Ignored
Dose Reference Sequence	(300A, 0010)	SQ 1	3	Used to create new Dose Monitoring Points for the new Course of Treatment.
>Dose Reference Number	(300A, 0012)	IS 1	1C	Root of new DMP Name (combined with Dose Reference Description). Number must be unique within sequence. (See Table 17, Status Code A903)
>Dose Reference Structure Type	(300A, 0014)	CS 1	1C	Ignored
>Dose Reference Description	(300A, 0016)	LO 1	3	If specified, combined with Dose Reference Number to form new DMP Name (truncated to 64 chars total).
>Referenced ROI Number	(3006, 0084)	IS 1	1C	Ignored
>Dose Reference Point Coordinates	(300A, 0018)	DS 3	1C	
>Nominal Prior Dose	(300A, 001A)	DS 1	3	DMP Adjusted Dose
>Dose Reference Type	(300A, 0020)	CS 1	1C	DMP Type
>Constraint Weight	(300A, 0021)	DS 1	3	Ignored
>Delivery Warning Dose	(300A, 0022)	DS 1	3	
>Delivery Maximum Dose	(300A, 0023)	DS 1	3	
>Target Minimum Dose	(300A, 0025)	DS 1	3	
>Target Prescription Dose	(300A, 0026)	DS 1	3	
>Target Maximum Dose	(300A, 0027)	DS 1	3	DMP Max Dose (if Dose Reference Type is 'TARGET')
>Target Underdose Volume Fraction	(300A, 0028)	DS 1	3	Ignored
>Organ at Risk Full-volume Dose	(300A, 002A)	DS 1	3	
>Organ at Risk Limit Dose	(300A, 002B)	DS 1	3	
>Organ at Risk Maximum Dose	(300A, 002C)	DS 1	3	DMP Max Dose (if Dose Reference Type is 'ORGAN_AT_RISK')
>Organ at Risk Overdose Volume Fraction	(300A, 002D)	DS 1	3	Ignored

Table 11 – RT Plan Storage SOP Class (SCP) – RT Tolerance Tables Module

Attribute Name	Tag	VR, VM	DICOM Type	Notes/Constraints
Tolerance Table Sequence	(300A, 0040)	SQ 1	3	Tolerance Tables. See Appendix C.
>Tolerance Table Number	(300A, 0042)	IS 1	1C	Number must be unique within sequence. (See Table 17, Status Code A904).
>Tolerance Table Label	(300A, 0043)	SH 1	3	If specified, must match name of an existing XYZ/PRODUCT Tolerance Table. See Note VI. (See Table 17, Status Code C018).
>Gantry Angle Tolerance	(300A, 0044)	DS 1	3	If specified, Tolerance values must match respective values in a corresponding XYZ/PRODUCT Tolerance Table. See Note VI. (See Table 17, Status Code C018).
>Beam Limiting Device Angle Tolerance	(300A, 0046)	DS 1	3	
>Beam Limiting Device Tolerance Sequence	(300A, 0048)	SQ 1	3	
>>RT Beam Limiting Device Type	(300A, 00B8)	CS 1	1C	
>>Beam Limiting Device Position Tolerance	(300A, 004A)	DS 1	1C	
>Patient Support Angle Tolerance	(300A, 004C)	DS 1	3	
>Table Top Eccentric Angle Tolerance	(300A, 004E)	DS 1	3	
>Table Top Vertical Position Tolerance	(300A, 0051)	DS 1	3	
>Table Top Longitudinal Position Tolerance	(300A, 0052)	DS 1	3	
>Table Top Lateral Position Tolerance	(300A, 0053)	DS 1	3	

Note VI Interpretation of Tolerance Table Data

XYZ/PRODUCT Tolerance Table names are global within the scope of the XYZ/PRODUCT system. Mapping from Dicom Tolerance Tables to XYZ/PRODUCT Tolerance Tables is based on the Tolerance Table Label (300A, 0043):

If the Tolerance Table Label is present but does not map onto the name of an existing XYZ/PRODUCT Tolerance Table, XYZ/PRODUCT will REJECT the RT Plan Storage request.

If the Tolerance Table Label corresponds to an existing XYZ/PRODUCT Tolerance Table, then any Parameter Tolerance values present in the RT Plan Storage request will be compared with the respective values in the XYZ/PRODUCT Table. In the case of a match, the existing Tolerance Table will be used for all Prescribed Fields created from Beams that reference this Tolerance Table. In the case of any mismatch of Parameter Tolerances, XYZ/PRODUCT will REJECT the RT Plan Storage request

If the Tolerance Table Label is not specified, the table in the RT Plan Storage request will be ignored and a status code WARNING ELEMENTS DISCARDED will be returned to the remote application **(See Table 17, Status Code B006)**. In such cases, all Prescribed Fields created from Beams that reference this unlabelled table will be created with UNPRESCRIBED Tolerance Table parameters. It will be necessary for the operator of the XYZ/PRODUCT system to specify a valid XYZ/PRODUCT Tolerance Table for these Prescribed Fields before they become valid for treatment.

Mapping of Tolerance Table data can be disabled by configuration. (See Table 18 in Appendix C).

Table 12 – RT Plan Storage SOP Class (SCP) – RT Patient Setup Module

Attribute Name	Tag	VR, VM	DICOM Type	Notes/Constraints
Patient Setup Sequence	(300A, 0180)	SQ 1	1	Setup Notes. Only created if referenced by Fraction Groups or Beams.
>Patient Setup Number	(300A, 0182)	IS 1	1	Number must be unique within sequence. (See Table 17, Status Code A905).
>Patient Position	(0018, 5100)	CS 1	1C	Setup Note Text (When referenced)
>Patient Additional Position	(300A, 0184)	LO 1	1C	
>Fixation Device Sequence	(300A, 0190)	SQ 1	3	
>>Fixation Device Type	(300A, 0192)	CS 1	1C	Setup Note Text (When referenced)
>>Fixation Device Label	(300A, 0194)	SH 1	2C	
>>Fixation Device Description	(300A, 0196)	ST 1	3	
>>Fixation Device Position	(300A, 0198)	SH 1	3	
>Shielding Device Sequence	(300A, 01A0)	SQ 1	3	
>>Shielding Device Type	(300A, 01A2)	CS 1	1C	Setup Note Text (When referenced)
>>Shielding Device Label	(300A, 01A4)	SH 1	2C	
>>Shielding Device Description	(300A, 01A6)	ST 1	3	
>>Shielding Device Position	(300A, 01A8)	SH 1	3	
>Setup Technique	(300A, 01B0)	CS 1	3	Setup Note Text (When referenced)
>Setup Technique Description	(300A, 01B2)	ST 1	3	
>Setup Device Sequence	(300A, 01B4)	SQ 1	3	
>>Setup Device Type	(300A, 01B6)	CS 1	1C	Setup Note Text (When referenced)
>>Setup Device Label	(300A, 01B8)	SH 1	2C	
>>Setup Device Description	(300A, 01BA)	ST 1	3	
>>Setup Device Parameter	(300A, 01BC)	DS 1	2C	
>>Setup Reference Description	(300A, 01D0)	ST 1	3	Ignored
>Table Top Vertical Setup Displacement	(300A, 01D2)	DS 1	3	
>Table Top Longitudinal Setup Displacement	(300A, 01D4)	DS 1	3	
>Table Top Lateral Setup Displacement	(300A, 01D6)	DS 1	3	

Table 13 – RT Plan Storage SOP Class (SCP) – RT Fraction Scheme Module

Attribute Name	Tag	VR, VM	DICOM Type	Notes/Constraints
Fraction Group Sequence	(300A, 0070)	SQ 1	1	Used to create Fractions for new Phase
>Fraction Group Number	(300A, 0071)	IS 1	1	Fraction Name. Number must be unique within sequence. (See Table 17, Status Code A906).
>Referenced Patient Setup Number	(300C, 006A)	IS 1	3	If specified, must match a Patient Setup Number (300A, 0182) included in the Patient Setup Module. Data in referenced Patient Setup will be used as Fraction Note entries for this Fraction (See Table 17, Status Code A905).
>Referenced Dose Sequence	(300C, 0080)	SQ 1	3	Ignored
>>Referenced SOP Class UID	(0008, 1150)	UI 1	1C	
>>Referenced SOP Instance UID	(0008, 1155)	UI 1	1C	
>Referenced Dose Reference Sequence	(300C, 0050)	SQ 1	3	
>>Referenced Dose Reference Number	(300C, 0051)	IS 1	1C	
>>Constraint Weight	(300A, 0021)	DS 1	3	
>>Delivery Warning Dose	(300A, 0022)	DS 1	3	
>>Delivery Maximum Dose	(300A, 0023)	DS 1	3	
>>Target Minimum Dose	(300A, 0025)	DS 1	3	
>>Target Prescription Dose	(300A, 0026)	DS 1	3	
>>Target Maximum Dose	(300A, 0027)	DS 1	3	
>>Target Underdose Volume Fraction	(300A, 0028)	DS 1	3	
>>Organ at Risk Full-volume Dose	(300A, 002A)	DS 1	3	
>>Organ at Risk Limit Dose	(300A, 002B)	DS 1	3	
>>Organ at Risk Maximum Dose	(300A, 002C)	DS 1	3	
>>Organ at Risk Overdose Volume Fraction	(300A, 002D)	DS 1	3	
>Number of Fractions Planned	(300A, 0078)	IS 1	2	Number of Fractions prescribed for this Fraction
>Number of Fractions Per Day	(300A, 0079)	IS 1	3	If specified, used to define Fractions and Fraction Sequence for the new Phase
>Repeat Fraction Cycle Length	(300A, 007A)	IS 1	3	
>Fraction Pattern	(300A, 007B)	LT 1	3	
>Number of Beams	(300A, 0080)	IS 1	1	Number of Fields in Fraction
>Referenced Beam Sequence	(300C, 0004)	SQ 1	1C	Fields included in Fraction. Fields will be created in the new Fraction in the order in which they appear in the Referenced Beam Sequence. The number of items in the Referenced Beam Sequence must match the Number of Beams attribute (300A, 0080). (See Table 17, Status Code A906).

>>Referenced Beam Number	(300C, 0006)	IS 1	1C	Must match a Beam Number (300A, 00C0) included in the Beam Sequence (300A, 00B0) in the RT Beams Module. (See Table 17, Status Code A906).
>>Beam Dose Specification Point	(300A, 0082)	DS 3	3	Ignored
>>Beam Dose	(300A, 0084)	DS 1	3	If specified, value for a Beam must be the same in all Fraction Groups. See Note VII, Note IX. (See Table 17, Status Code C017).
>>Beam Meterset	(300A, 0086)	DS 1	3	If specified, value for a Beam must be the same in all Fraction Groups. See Note VII, Note VIII, Note X. (See Table 17, Status Code C017).
>Number of Brachy Application Setups	(300A, 00A0)	IS 1	1	Must be 0. (See Table 17, Status Code C015).
>Referenced Brachy Application Setup Sequence	(300C, 000A)	SQ 1	1C	Ignored
>>Referenced Brachy Application Setup Number	(300C, 000C)	IS 1	1C	
>>Brachy Application Setup Dose Specification Point	(300A, 00A2)	DS 3	3	
>>Brachy Application Setup Dose	(300A, 00A4)	DS 1	3	

Note VII XYZ/PRODUCT-Specific Restrictions on Beam Dosimetry & Fraction Groups

In the Dicom data model the Beam Meterset (300A, 0086) is specified as an attribute of the Fraction Group within the Fraction Group Sequence (300A, 0070). This Beam Meterset value is used in conjunction with the Final Cumulative Meterset Weight (300A, 010E) and Cumulative Meterset Weight (300A, 0134) values in the RT Beams Module to derive the actual dosimetric values to be prescribed for a Beam and its Control Points.

The XYZ/PRODUCT data model allows Prescribed Fields to be grouped into one or more Fractions for treatment. In XYZ/PRODUCT, however, the Prescribed MU to be delivered for a given Field is stored as an attribute of the **Field**, not of the **Fraction** in which it is being delivered.

XYZ/PRODUCT will REJECT any RT Plan Storage request if the Beam Meterset (300A, 0086) value for any Referenced Beam Number (300C, 0006) in a Fraction Group is specified to be a different value to that specified in another Fraction Group.

I.e. if Beam Meterset is specified for a Beam, it must be specified as the same value in all Fraction Groups in which the Beam appears.

(See Table 17, Status Code C017).

Similarly, in the Dicom model, Beam Dose (300A, 0084) for a Beam is specified as an attribute of the Fraction Group in which the Beam is used. This Beam Dose is used in conjunction with the Cumulative Dose Reference Coefficient (300A, 010C) to derive the dose contribution of a Beam's Control Point to a Dose Reference.

XYZ/PRODUCT will REJECT any RT Plan Storage request if the Beam Dose (300A, 0084) value for any Referenced Beam Number (300C, 0006) in a Fraction Group is specified to be a different value to that specified in another Fraction Group.

I.e. if Beam Dose is specified for a Beam, it must be specified as the same value in all Fraction Groups in which the Beam appears.

(See Table 17, Status Code C017).

Note VIII Handling of Missing Beam Meterset Attributes

The Beam Meterset (300A 0086) attribute is specified by Dicom as Type 3, and is part of an optional IOD module, so it may legally be missing from an RT Plan Storage request.

If this attribute is not present for a particular Referenced Beam Number in any Fraction Group in which the Beam appears, then the Prescribed Field will be created in the XYZ/PRODUCT database with UNPRESCRIBED MU parameters. It will be necessary for the operator of the XYZ/PRODUCT system to enter the Prescribed MU data for the Field and its Control Points before the Field becomes valid for treatment.

Note IX Handling of Missing Beam Dose Attributes

The Beam Dose (300A 0084) attribute is specified by Dicom as Type 3, and is part of an optional IOD module, so it may legally be missing from an RT Plan Storage request.

If this attribute is not present for a particular Referenced Beam Number in any Fraction Group in which the Beam appears, AND the Beam specifies a Referenced Dose Reference Sequence (300C, 0050), then XYZ/PRODUCT will create the respective dose contributions UNPRESCRIBED. It will be necessary for the operator of the XYZ/PRODUCT system to enter the Field Dose Contribution data before the Field becomes valid for treatment.

Table 14 – RT Plan Storage SOP Class (SCP) – RT Beams Module

Attribute Name	Tag	VR, VM	DICOM Type	Notes/Constraints
Beam Sequence	(300A, 00B0)	SQ 1	1	Used to create Prescribed Fields for new Treatment Site and Phase.
>Beam Number	(300A, 00C0)	IS 1	1	Combined and used for Prescribed Field Name. Numbers must be unique within sequence. (See Table 17, Status Code A902).
>Beam Name	(300A, 00C2)	LO 1	3	
>Beam Description	(300A, 00C3)	ST 1	3	Prescribed Field Description
>Beam Type	(300A, 00C4)	CS 1	1	Must be consistent with other Beam Control Point data, i.e. STATIC Beams must prescribe no movements. (See Table 17, Status Code C010).
>Radiation Type	(300A, 00C6)	CS 1	2	"PHOTON" or "ELECTRON" only (See Table 17, Status Code C005).
>Treatment Machine Name	(300A, 00B2)	SH 1	2	Treated as Type 1. Must match an existing XYZ/PRODUCT Linac Name. (See Table 17, Status Codes C003,C004)
>Manufacturer	(0008, 0070)	LO 1	3	Logged to Dicom Beam Information record if present. See Note V.
>Institution Name	(0008, 0080)	LO 1	3	
>Institution Address	(0008, 0081)	ST 1	3	
>Institutional Department Name	(0008, 1040)	LO 1	3	
>Manufacturers Model Name	(0008, 1090)	LO 1	3	
>Device Serial Number	(0018, 1000)	LO 1	3	If specified, must match default Linac ID. (See Table 17, Status Code C004).
>Primary Dosimeter Unit	(300A, 00B3)	CS 1	3	If specified, "MU" only, else assumed to be "MU". See Note X. (See Table 17, Status Code C00A).
>Referenced Tolerance Table	(300C, 00A0)	IS 1	3	If specified, must match a Tolerance Table Number (300A, 0042) included in the Tolerance Table Module. See Note VI. (See Table 17, Status Code A904).
>Source-Axis Distance	(300A, 00B4)	DS 1	3	Ignored
>Beam Limiting Device Sequence	(300A, 00B6)	SQ 1	1	Must specify a complete set of BLD's (i.e. ASYMY and [ASYMX and/or MLCX]) (See Table 17, Status Code C007).
>>RT Beam Limiting Device Type	(300A, 00B8)	CS 1	1	"ASYMX", "ASYMY", "MLCX" only. If MLCX, must match capability of the named Treatment Machine (300A, 00B2). (See Table 17, Status Code C006).
>>Source to Beam Limiting Device Distance	(300A, 00BA)	DS 1	3	Ignored
>>Number of Leaf/Jaw Pairs	(300A, 00BC)	IS 1	1	40 or 1 only (i.e. MLC or Diaphragms) (See Table 17, Status Code C006).
>>Leaf Position Boundaries	(300A, 00BE)	DS 3-N	2C	Ignored

>Referenced Patient Setup Number	(300C, 006A)	IS 1	3	If specified, must match a Patient Setup Number (300A, 0182) included in the Patient Setup Module. (See Table 17, Status Code A905). Data in referenced Patient Setup will be used as Field Note entries for this Field.
>Referenced Reference Image Sequence	(300C, 0042)	SQ 1	3	
>>Referenced SOP Class UID	(0008, 1150)	UI 1	1C	
>>Referenced SOP Instance UID	(0008, 1155)	UI 1	1C	
>>Reference Image Number	(300A, 00C8)	IS 1	1C	
>>Start Cumulative Meterset Weight	(300C, 0008)	DS 1	3	
>>End Cumulative Meterset Weight	(300C, 0009)	DS 1	3	
>Planned Verification Image Sequence	(300A, 00CA)	SQ 1	3	
>>Start Cumulative Meterset Weight	(300C, 0008)	DS 1	3	Ignored
>>Meterset Exposure	(3002, 0032)	DS 1	3	
>>End Cumulative Meterset Weight	(300C, 0009)	DS 1	3	
>>RT Image Plane	(3002, 000C)	CS 1	3	
>>X-Ray Image receptor Angle	(3002, 000E)	DS 1	3	
>>RT Image Orientation	(3002, 0010)	DS 6	3	
>>RT Image Position	(3002, 0012)	DS 2	3	
>>RT Image SID	(3002, 0026)	DS 1	3	
>>Imaging Device-Specific Acquisition Parameters	(300A, 00CC)	LO 1-N	3	
>>Referenced Reference Image Number	(300C, 0007)	IS 1	3	
>Treatment Delivery Type	(300A, 00CE)	CS 1	3	If specified, “TREATMENT” only, else assumed to be “TREATMENT”. **(See Table 17, Status Code C016).**
>Referenced Dose Sequence	(300C, 0080)	SQ 1	3	Ignored
>>Referenced SOP Class UID	(0008, 1150)	UI 1	1C	
>>Referenced SOP Instance UID	(0008, 1155)	UI 1	1C	
>Number of Wedges	(300A, 00D0)	IS 1	1	1 or 0 only. **(See Table 17, Status Code C00B).**
>Wedge Sequence	(300A, 00D1)	SQ 1	1C	Number of items in the Wedge Sequence must match the Number of Wedges (300A, 00D0) attribute. **(See Table 17, Status Code A902).**
>>Wedge Number	(300A, 00D2)	IS 1	1C	Must be consistent with any specified Referenced Wedge Number (300C, 00C0) used in Wedge Position Sequence (300A, 0116). **(See Table 17, Status Code A902).**
>>Wedge Type	(300A, 00D3)	CS 1	2C	Treated as Type 1. “MOTORIZED” only. **(See Table 17, Status Code C00B).**

>>Wedge ID	(300A, 00D4)	SH 1	3	Ignored
>>Wedge Angle	(300A, 00D5)	IS 1	2C	
>>Wedge Factor	(300A, 00D6)	DS 1	2C	
>>Wedge Orientation	(300A, 00D8)	DS 1	2C	Must be 0 or empty. **(See Table 17, Status Code C00B).**
>>Source to Wedge Tray Distance	(300A, 00DA)	DS 1	3	Ignored

>Number of Compensators	(300A, 00E0)	IS 1	1	Must match number of items in Compensator Sequence (300A, 00E3). **(See Table 17, Status Code A902).** WARNING + Field Note entry if non-zero. See Note XI.
>Total Compensator Tray Factor	(300A, 00E2)	DS 1	3	Ignored. See Note XI
>Compensator Sequence	(300A, 00E3)	SQ 1	1C	
>>Compensator Number	(300A, 00E4)	IS 1	1C	
>>Material ID	(300A, 00E1)	SH 1	2C	
>>Compensator ID	(300A, 00E5)	SH 1	3	
>>Source to Compensator Tray Distance	(300A, 00E6)	DS 1	2C	
>>Compensator Rows	(300A, 00E7)	IS 1	1C	
>>Compensator Columns	(300A, 00E8)	IS 1	1C	
>>Compensator Pixel Spacing	(300A, 00E9)	DS 2	1C	
>>Compensator Position	(300A, 00EA)	DS 2	1C	
>>Compensator Transmission Data	(300A, 00EB)	DS 1-N	1C	
>>Compensator Thickness Data	(300A, 00EC)	DS 1-N	1C	
>Number of Boli	(300A, 00ED)	IS 1	1	Must match number of items in Referenced Bolus Sequence (300A, 00B0). **(See Table 17, Status Code A902).** WARNING + Field Note entry if non-zero. See Note XI
>Referenced Bolus Sequence	(300C, 00B0)	SQ 1	1C	Ignored. See Note XI
>>Referenced ROI Number	(3006, 0084)	IS 1	1C	
>Number of Blocks	(300A, 00F0)	IS 1	1	Must match number of items in Block Sequence (300A, 00F4). **(See Table 17, Status Code A902).** WARNING + Field Note entry if non-zero. See Note **XII**
>Total Block Tray Factor	(300A, 00F2)	DS 1	3	Ignored
>Block Sequence	(300A, 00F4)	SQ 1	1C	See Appendix C and Note **XII**.