DICOM™ Conformance Statement

Hi-Art® Treatment System v5.0
TomoTherapy® Treatment System v2.0
DICOM™ Conformance Statement

TomoTherapy® Treatment System

Version 2.0

DICOM™ Conformance Statement

Part number: 1025620

Revision: B

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TomoTherapy® user documentation applies to safe and effective use of the TomoTherapy® treatment system by educated dosimetrists, therapists, and physicists. Personnel must be trained by Accuray Incorporated before the TomoTherapy® treatment system is used for research or clinical purposes. TomoTherapy® treatment system documentation was originally drafted, approved, and supplied in English (US).

The following statements are intended to alert the user to potential conditions that could result in injury to the patient (warning) or conditions that could affect system components (caution).

Warning Warning statements describe possible conditions that can result in serious or fatal injury to the patient or facility personnel. Each warning gives the possible condition and how to avoid it.

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Intended Use Statement

The TomoTherapy® treatment system is intended to be used as an integrated system for the planning and precise delivery of radiation therapy, stereotactic radiotherapy, or stereotactic radiosurgery to tumors or other targeted tissues while minimizing the delivery of radiation to vital healthy tissue. The megavoltage x-ray radiation is delivered in a rotational, non-rotational, modulated (IMRT), or non-modulated (non-IMRT/three dimensional conformal) format in accordance with the physician prescribed and approved plan.

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Company Name: Accuray Incorporated

Product Name: TomoTherapy® Treatment System

Version: 2.0 Release

Internal document number: PN 1025620

Date: 2012-Dec-20

1 CONFORMANCE STATEMENT OVERVIEW

This document specifies the compliance to DICOM conformance requirements for the relevant networking features on the TomoTherapy® Treatment System. It requires the release version specified in this document as a minimum for this Conformance Statement to apply.

The connectivity features described in this document support information exchange between the TomoTherapy Treatment System and third-party systems for the following uses:

- **Import:** CT Image (diagnostic) and RT Structure Set objects are imported from third-party systems in order to perform TomoTherapy planning or re-planning for subsequent treatment delivery.
- **Export:** CT Image (diagnostic or CTrue Image), RT Structure Set, RT Dose, RT Beams Treatment Records, True Color SC Image of Registration, Raw Data Objects and RT Plan objects are exported to third-party systems in order to perform additional therapy-related activities on those systems, or for gathering of clinical trial data.
- **Workflow:** RT Plan, RT Beams Treatment Record, and optionally Multi-frame True Color SC Image objects (single frame only) are exported, and Unified Procedure Step (UPS) worklist queries, UPS updates, and move requests are issued to an Oncology Information System (OIS, also known as a Treatment Management System or TMS), in order to exchange planning and delivery information and facilitate scheduling and billing operations. This release implements the mechanism specified in DICOM Supplement 74 Frozen Draft (Utilization of Worklist in Radiotherapy Treatment Delivery), and uses the worklist mechanism described in DICOM Supplement 96 Frozen Draft (Unified Procedure Step). The Supplement 96 Frozen Draft Unified Procedure Step – Pull abstract syntax SOP Class is negotiated for this purpose, with the TomoTherapy Treatment System acting as a “Pull Performer” and the TMS acting as a “Worklist Manager” (see DICOM Supplement 96, Part 17). The workflow implemented in the release has been designed to comply with the Integration in the Healthcare Enterprise – Radiation Oncology (IHE-RO) Treatment Delivery Workflow Profile 2010.

The service and objects implemented to support the above uses are shown in Table 1.

Table 1. Network Services

Networking SOP Classes	User of Service (SCU)	Provider of Service (SCP)
Object Storage		
CT Image Storage	Yes	Yes
RT Structure Set Storage	Yes	Yes
RT Dose Storage	Yes	—
RT Plan Storage	Yes	Yes – see Note 2

Networking SOP Classes	User of Service (SCU)	Provider of Service (SCP)
Object Storage		
RT Beams Treatment Record Storage	Yes	—
Multi-frame True Color SC Image Storage	Yes	—
RT Beams Delivery Instruction Storage (Supplement 74 Frozen Draft SOP Class UID)	—	Yes- see Note 2
Raw Data Storage	Yes	—
Workflow Management		
Unified Procedure Step – Pull (Supplement 96 Frozen Draft SOP Class UID)	Yes	—
Study Root Query/Retrieve Information Model - MOVE	Yes	—

NOTE 1: Support for some of these services may be separately licensable options. Details about licensable options can be found in TomoTherapy Treatment System marketing and sales documentation.

NOTE 2: The TomoTherapy Treatment System supports the RT Plan Storage and RT Beams Delivery Instruction Storage SOP classes as an SCP (see Supplement 74), in order to implement the C-MOVE operations required by the IHE-RO Delivery Workflow profiles. However, plan data is managed internally by the TomoTherapy Treatment System, and the received RT Plan is used only to verify the intended plan is the same as that expected and that the plan intent is for treatment. All instructions supplied in the RT Beams Delivery Instruction are currently ignored in favor of the decisions made by the TomoTherapy Treatment System operator at the time of treatment.

NOTE 3: The TomoWorkflow SCU supplies the Supplement 74 RT Beams Delivery Instruction SOP Class UID, and the Supplement 96 Frozen Draft UPS- Pull SOP Class UID. Following full standardization of Supplement 96, the equivalent DICOM 2010 SOP Class UIDs may be supplied in future releases.

TABLE OF CONTENTS

2 INTRODUCTION

2.1 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 that are used in those Standards.

If readers are unfamiliar with DICOM terminology they should read the DICOM Standard before reading this Conformance Statement document.

2.2 Remarks

The use of this DICOM Conformance Statement, in conjunction with the DICOM 3.0 Standard, is intended to facilitate communication with TomoTherapy 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 3.0), and of this DICOM Conformance Statement when interoperability with non-TomoTherapy equipment is desired. The responsibility to analyze the applications requirements and to design a solution that integrates TomoTherapy equipment with non–TomoTherapy 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 the TomoTherapy Treatment System and non–TomoTherapy devices, before the connection is declared operational, should not be overlooked. Therefore, the user should ensure that any non–TomoTherapy provider accepts full responsibility for all validation required for their connection with the TomoTherapy Treatment System. This includes the accuracy of the image and treatment data once it has crossed the interface between the TomoTherapy Treatment System and the non–TomoTherapy device and the stability of the image for the intended applications.

  Such a validation is required before any clinical use (treatment planning and/or delivery) is performed. It applies when images or dose information acquired on non-TomoTherapy equipment are processed/displayed on a TomoTherapy workstation, and when images and plan information are exported from the TomoTherapy Treatment System to a non-TomoTherapy device.
- **Future Evolution**: Accuray understands that the DICOM Standard will evolve to meet the user's growing requirements. Accuray is actively involved in the development of the DICOM 3.0 Standard. DICOM 3.0 will incorporate new features and technologies and Accuray may follow the evolution of the Standard. Evolution of the Standard may require changes to the TomoTherapy Treatment System. In addition, Accuray reserves the right to discontinue or make changes to the support of communications features (on its products) reflected by this DICOM Conformance Statement. The user should ensure that any non–TomoTherapy provider, which connects with the TomoTherapy Treatment System, also plans for the future evolution of the DICOM Standard.

Failures to do so will likely result in the loss of function and/or connectivity as the DICOM Standard changes and the TomoTherapy Treatment System is enhanced to support these changes.

- **Interaction**: It is the sole responsibility of the non–TomoTherapy provider to ensure that communication with the interfaced equipment does not cause degradation of TomoTherapy Treatment System performance and/or function.

2.3 Definitions, Terms, and Abbreviations

AE	Application Entity
DICOM	Digital Imaging and Communications in Medicine
HIS	Hospital Information System
IHE-RO	Integration in the Healthcare Enterprise – Radiation Oncology
OIS	Oncology Information System (a.k.a. TMS)
RIS	Radiology Information System
SC	Secondary Capture
SCP	Service Class Provider
SCU	Service Class User
SOP	Service-Object Pair
TCP/IP	Transmission Control Protocol/Internet Protocol
TMS	Treatment Management System (a.k.a. OIS)
UID	Unique Identifier
UPS	Unified Procedure Step

2.4 References

- Digital Imaging and Communications in Medicine (DICOM), NEMA PS 3.1-3.18, 2009
- DICOM Supplement 74 (Frozen Draft): Utilization of Worklist in Radiotherapy Treatment Delivery
- DICOM Supplement 96 (Frozen Draft): Unified Procedure Step
- IHE-RO Treatment Delivery Workflow (TDW) Technical Framework V1.1

3 NETWORKING

3.1 Implementation Model

3.1.1 Application Data Flow

The following sections illustrate the applications' data flow models, for the Import, Export and Workflow applications.

3.1.1.1 Import Application Data Flow Diagram

This implementation model provides for import of DICOM-compatible CT Images and RT Structure Sets from an external system. See Figure 1. The Import Application is invoked by the following real-world activities:

Import: The external DICOM-compliant system, acting as a Service Class User (SCU), initiates the transfer to the TomoProvider Application Entity using DICOM Storage Service Classes. The *TomoProvider* Application Entity, which is a Service Class Provider (SCP), responds dynamically to receive the data and prepares them for storage in a format that complies with TomoTherapy protocols. No local operator action is necessary to receive data, i.e. if the incoming data is not rejected in is placed directly in the TomoTherapy Data Server.

Verification: The external system initiates a DICOM Verification (C-ECHO) request to the TomoTherapy workstation. The workstation generates a response to the external system.

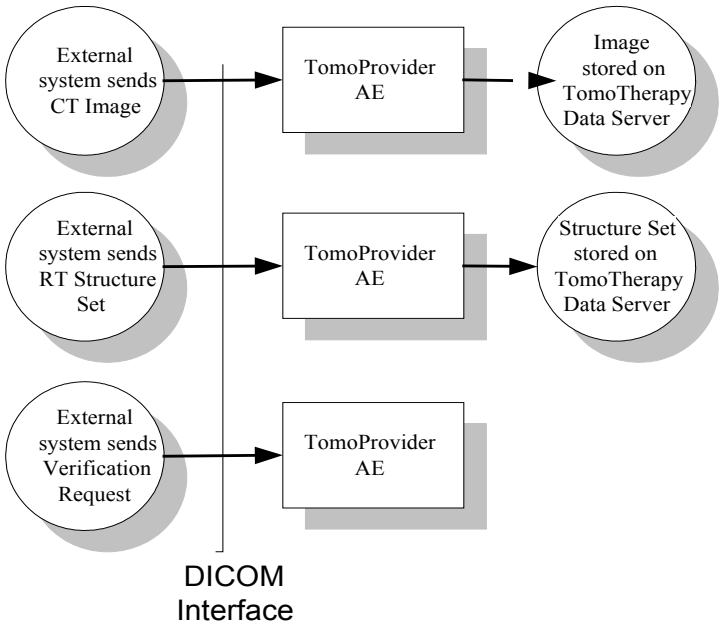


Figure 1: Import Application Data Flow Diagram

3.1.1.2 Export Application Data Flow Diagram

This implementation model provides for export of DICOM-compatible CT image and CTrue Image sets, RT Structure Set objects, RT Plan objects, RT Dose objects, RT Beams Treatment Records and Raw Data objects to an external system using the corresponding DICOM Information Object Definitions (IODs). See Figure 2. The Export Application is invoked by the following real-world activities:

Export: The user initiates a DICOM transfer to an external system from the TomoTherapy workstation. The workstation generates a request to the TomoUser Application Entity, containing information identifying the TomoTherapy database object to be transmitted to the external system. The TomoUser Application Entity, acting as a Service Class User (SCU), initiates the transfer to the external DICOM-compliant system, using the appropriate DICOM Storage Service Classes. The data are conditioned from TomoTherapy data into DICOM-compliant data at send time.

Verification: The user initiates a DICOM Verification from the TomoTherapy workstation to an external system. The workstation generates a request to the TomoUser server. This request initiates the C-ECHO on the TomoUser server to the external system.

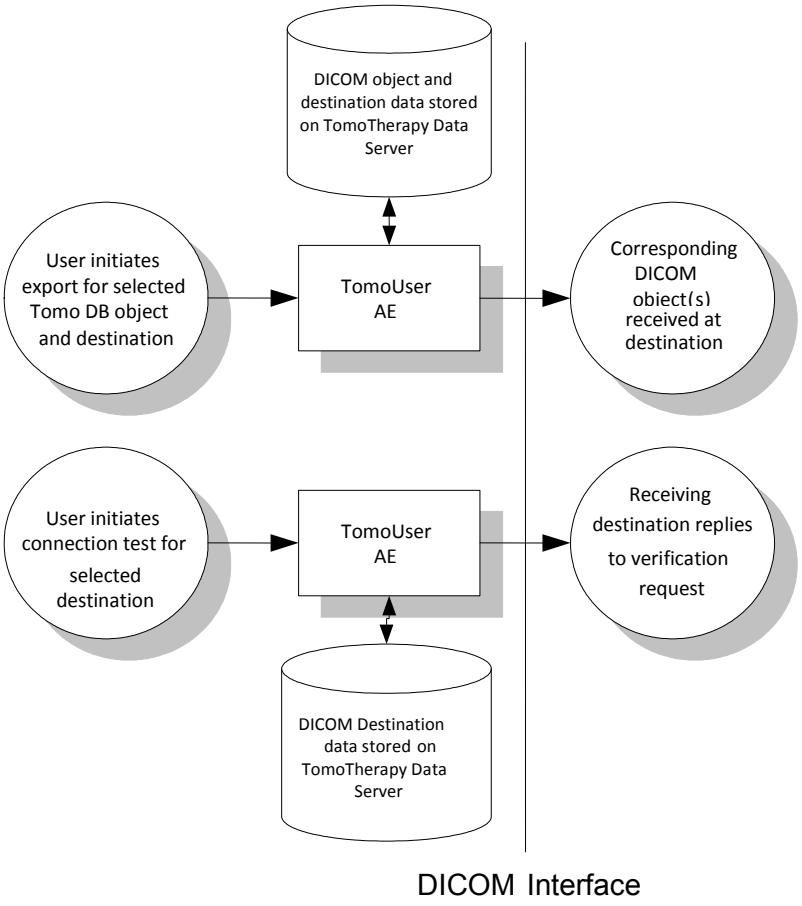


Figure 2: Export Application Flow Diagram

3.1.1.3 Workflow Application Data Flow Diagram

This implementation model provides for export of RT Plan data to a Treatment Management System (TMS), also known as an Oncology Information System (OIS). The terms TMS and OIS are used interchangeably throughout this document. The TomoTherapy workstation queries the TMS for the plan to be delivered using a Unified Procedure Step query, obtaining input data objects for verification purposes using C-MOVE, updating the TMS with treatment progress using operations on a Unified Procedure Step, and closure of the open procedure step and transmission of the treatment delivery results to the TMS by exporting an RT Beams Treatment Record object and optional Multi-frame True Color SC Image object. See Figure 3. See also DICOM Supplement 96 for informative examples of Unified Procedure Step message flow.

The Workflow Application is invoked by the following real-world activities:

1. **Plan Export to TMS**: The user initiates a DICOM RT Plan transfer to a TMS from the TomoTherapy workstation (Operator Station or Planning Station), by initiating an export using the normal export interface. The workstation generates a request to the TomoUser Application Entity, containing information identifying the TomoTherapy plan object to be transmitted to the TMS. The TomoUser Application Entity, acting as a Service Class User (SCU), initiates the transfer to the external DICOM-compliant TMS system, using the DICOM RT Plan Storage Service Class. The data are conditioned from TomoTherapy data into DICOM-compliant data at send time. The TMS subsequently uses the data from the plan to prepare a patient folder, including a delivery schedule. Note: The mechanism for communication of plan information prior to treatment delivery is outside the scope of DICOM Supplement 74: the above mechanism (RT Plan Storage) is a commonly supported and logical choice for this operation.

   NOTE: Some TMS applications may not support RT Plan Store as an SCP, or may not be able to process plans received from a TomoTherapy workstation. In this case, the Patient demographic and scheduling information can still be created on the TMS, either manually or by querying a HIS/RIS System or received acquisition image series. The RT Plan Instance UID for the plan will not be available in the TMS, and the Operator Station will use demographics (Patient Name and Patient ID) to match a received work item with data in the TomoTherapy Data Server.

2. **Worklist Query**: The user initiates a query of the plan selected on the TMS from the Operator Station. The Operator Station generates a request to the TomoWorkflow Application Entity acting as a worklist SCU, which issues a DICOM UPS Query (using the Supplement 96 Frozen Draft UPS – Pull abstract syntax) to the TMS. The TMS responds with a one or more worklist items. In one typical mode of TMS operation a single worklist item will be returned, representing the treatment selected on the TMS. In another common mode a list of potentially deliverable worklist items will be returned directly from the TMS data base, and the user on the Operator Station will select the one to be delivered.

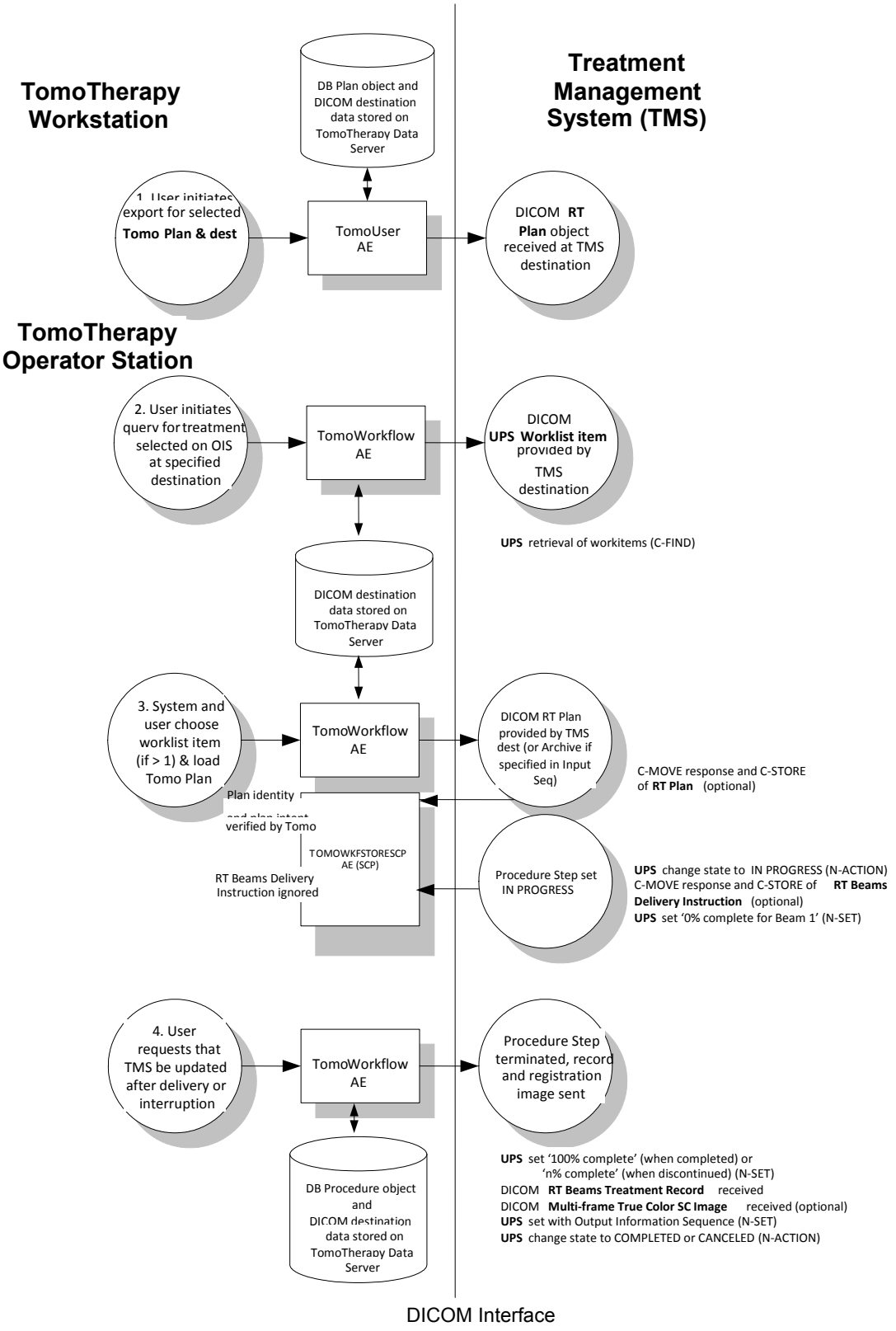


Figure 3: Workflow Application Flow Diagram

3. **Selection and Treatment Start**: If more than one worklist item is returned, the Operator Station displays a list of the returned worklist items, and the user is prompted to select one of them. Once this selection is made — or directly without human intervention if exactly one item was returned in the list — the Operator Station loads the active plan specified in the worklist item and displays summary information associated with that patient and plan. Once the user confirms the selection, the Operator Station requests the TomoWorkflow Application Entity to retrieve the RT Plan (if available) from the AE Title specified in the UPS using DICOM C-MOVE, and set the state of the Unified Procedure Step (UPS) on the TMS to IN PROGRESS. It then immediately retrieves the RT Beams Delivery Instruction (if available) from the AE Title specified in the UPS using C-MOVE, then updates the UPS with a procedure step progress of “0% complete” and referenced beam of “1”.

   If a plan UID is not supplied in the worklist item, then the Operator Station attempts to match the patient using Patient Name and Patient ID, and retrieves the active plan for that patient. If a patient match cannot be found then an error message is indicated. If more than one plan is active for a matched patient, the user is prompted to choose which plan to select.

   NOTE: TomoTherapy Treatment System supports the RT Plan Storage and RT Beams Delivery Instruction Storage networking SOP classes (see Supplement 74) when operating within the workflow scenario. When references to instances of these SOP Classes are supplied in the Input Information Sequence of the selected UPS, the TomoTherapy Treatment System attempts to retrieve them using C-MOVE, requesting that the store be performed to the Application Entity named ‘TOMOWKFSTORESCP’. If the RT Plan is available, the TomoTherapy Treatment System verifies that the RT Plan is the same instance (i.e. has the same SOP Instance UID) as the plan stored internally that was passed to the TMS in the plan export step. The treatment system also verifies that the plan is intended for treatment. In the case of the retrieved RT Beams Delivery Instruction IOD, any information supplied within such an object (e.g. which fraction to deliver or what verification images to acquire) is ignored by the TomoTherapy Treatment System.

4. **Treatment End:** When the treatment has completed normally, the Operator Station initiates signaling of the treatment delivery to the TMS, supplying information regarding the billable items (such as CTrue Image acquisition, registration, and delivery). In this signal the Operator Station also requests the TomoWorkflow Application Entity to update the UPS on the TMS with a procedure step progress of ‘100%’.

   The Operator Station then requests the TomoWorkflow Application Entity to transmit a record of the treatment to the TMS, specifying information identifying the object instance to be transmitted. If supported by the TMS archive, a single-frame instance of a Multi-frame True Color SC Image of the primary registration view at the last registration acceptance is also stored. The TomoWorkflow Application Entity, acting as a Service Class User (SCU), initiates the transfer to the external DICOM-compliant TMS system, using the DICOM RT Beams Treatment Record Storage SOP Class and optionally the Multi-frame True Color SC Image Storage SOP Class. The data are conditioned from TomoTherapy data into DICOM-compliant data at send time. The contents of the treatment record vary according to whether or not CTrue Image acquisition and registration has been performed. In addition, the information regarding performance of CTrue Image acquisition and registration is encoded in the UPS using the attribute ‘Performed Workitem Code

Sequence' and the Delivered Procedure (fraction) Number is encoded in the 'Performed Procedure Step Description'.

When storage is complete, the Operator Station updates the UPS again, this time specifying the details and location of the stored treatment record and optional registration image. It then requests the TomoWorkflow Application Entity to set the status of the UPS on the TMS to COMPLETED. The TMS can then access the treatment record and use the data contained within to update the patient folder, including information necessary for billing purposes.

If a treatment procedure does not complete normally, the user will generally deliver one or more completion procedures on the TomoTherapy Treatment System until it does, and then signal this to the TMS as described in the previous paragraph. However, if the session is terminated without the complete fraction being delivered, the user is still able to select TMS notification. The message flow is then the same as above, except that:

- The UPS will be updated on the TMS with a procedure step progress of less than 100%.
- The stored treatment record will contain information regarding the point of interruption.
- The Unified Procedure Step State will be set to CANCELED.

NOTE: If treatment or Operator Station interruption occurs, the system will attempt to resume the Workflow Management. The user will be informed of the current state of the Workflow Management and be given a choice to resume the treatment or report, or be told that the current patient procedure cannot be managed under OIS control.

NOTE: Some TMS or Archive applications may not support RT Beams Treatment Record Storage or Multi-frame True Color Secondary Capture Image Storage as a SCP, or may not be able to process treatment records or registration image captures received from a TomoTherapy workstation. In this case the attempted exports will not occur, but this will otherwise not affect the treatment end signaling process.

3.1.1.4 HIS RT Beams Record Automatic Export Data Flow Diagram

This implementation model provides for export of RT Beams Treatment Records to an HIS, RIS or other appropriate DICOM target. The term HIS is used to represent any DICOM device that can accept RT Beams Treatment Record storage. The TomoTherapy workstation communicates the end of delivery through transmission of the treatment delivery results to the recipient DICOM target by exporting an RT Beams Treatment Record object. See Figure 4.

The HIS RT Beams Automatic Export has the following aspect:

Treatment End: The Operator Station signals that the Export Application initiate the transfer to an external HIS system of a DICOM RT Beams Treatment Record Storage SOP Class. This is attempted after every delivery of any planned dose, whether interrupted or completed.

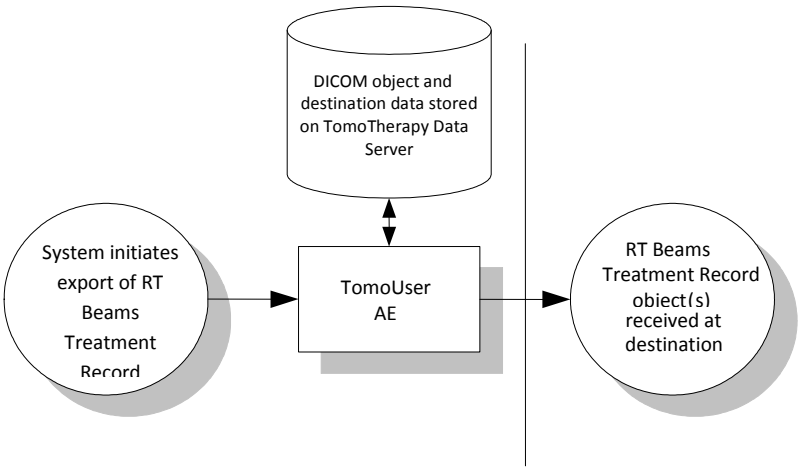


Figure 4: HIS RT Beams Record Automatic Export Flow Diagram

3.1.2 Functional Definition of AEs

3.1.2.1 Functional Definition of TomoProvider Storage SCP Application Entity

The ***TomoProvider*** Application Entity resides on the TomoTherapy Data Server machine. It starts when the station on which it resides is brought up, and runs continuously until the station is brought down. After initialization, TomoProvider waits for an association request at the port address configured for its Application Entity Title. When an external system requests an association, TomoProvider checks the presentation and application contexts to see if a valid context has been proposed. After a valid context is proposed and TomoProvider accepts the association, it waits for C-ECHO or C-STORE commands from the external system. TomoProvider maintains the association until the external system initiates the release process or initiates an abort. The following operations are supported:

- **Verification:** The connection is verified by responding to an external C-ECHO command.
- **Storage:** The appropriate C-STORE commands are executed until all objects have been received and processed, or a failure is issued.

3.1.2.2 Functional Definition of TomoUser SCU Application Entity

The ***TomoUser*** Application Entity resides on the TomoTherapy Data Server machine. It starts when the station on which it resides is brought up, and runs continuously until the station is brought down. After initialization, TomoUser waits for a user request from a TomoTherapy workstation. This request specifies the AE Title, port, and address for the association. TomoUser constructs a context and proposes it to the SCP. If accepted, it then attempts the requested operation. The following operations are supported:

- **Verification:** The connection is verified using the C-ECHO command.
- **Storage:** The appropriate C-STORE commands are executed until all objects are transmitted or a failure is received.

3.1.2.3 Functional Definition of TomoWorkflow SCU Application Entity

The ***TomoWorkflow*** Application Entity resides on the TomoTherapy Data Server machine. It starts when the station on which it resides is brought up, and runs continuously until the station is brought down. After initialization, TomoWorkflow waits for a user request from a TomoTherapy workstation. This request specifies the AE Title, port, and address for the association. TomoWorkflow constructs a context and proposes it to the SCP. If accepted, it then attempts the requested operation. The following operations are supported:

- **Worklist Query:** A Unified Procedure Step query (using the Supplement 96 Frozen Draft UPS – Pull abstract syntax) is performed using a C-FIND command and C-FIND responses are received until a final response is indicated or a failure is signaled.
- **Treatment Start:** If an RT Plan instance is specified in the Input Information Sequence of the selected UPS, then a C-MOVE is issued to have the specified AE Title store the instance to the 'TOMOWKFSTORESCP' Application Entity (see below). Then the Unified Procedure Step is modified, using an N-ACTION command to set the Unified Procedure Step State to 'IN PROGRESS'. If an RT Beams Delivery Instruction instance is specified in the Input Information Sequence of the selected UPS, then another C-MOVE is issued to have the specified AE Title store the instance to the 'TOMOWKFSTORESCP' Application Entity (see below).Then a Unified Procedure Step update is performed using an N-SET command with a procedure step progress of 0%, and referencing a Beam Number of '1'.
- **Treatment End:** A Unified Procedure Step is updated, using an N-SET command with procedure step progress of 100% for completed treatments, or less than 100% for interrupted (canceled) treatments. Then an RT Beams Treatment Record is stored using a C-STORE command, and if registration has been performed a Multi-frame True Color SC Image may also be stored (if accepted by the SCP). Another N-SET command then supplies the identity and location of the stored objects to the TMS. Finally, the state of the Unified Procedure Step is modified using an N-ACTION command with a Unified Procedure Step State of 'COMPLETED" or 'CANCELED'. In the special case of a treatment being cancelled prior to radiation starting then no RT Beams Treatment Record is sent.

3.1.2.4 Functional Definition of TOMOWKFSTORESCP SCP Application Entity

The **TOMOWKFSTORESCP** Application Entity resides on the TomoTherapy Data Server machine. It starts when the station on which it resides is brought up, and runs continuously until the station is brought down. After initialization, TOMOWKFSTORESCP waits for an association request at the port address configured for its Application Entity Title. This association will come as a result of a C-MOVE request issued by the TomoWorkflow Application Entity, to retrieve either an RT Plan instance or a RT Beams Delivery Instruction instance. Storage of the following IODs is supported:

- RT Plan Storage: The TomoTherapy Treatment System verifies that if the 'plan intent' attribute is returned by the TMS, then the given plan intent is validated to be for a patient treatment prior to being dispatched for the actual treatment.
- RT Beams Treatment Record Storage: The TomoTherapy Treatment System receives and ignores the instance.

3.1.3 Sequencing of Real-World Activities

3.1.3.1 Import Application Sequencing

The sequencing of events for the Import Application is illustrated in Figure 5. The sequencing for a verification request has been omitted from the diagram.

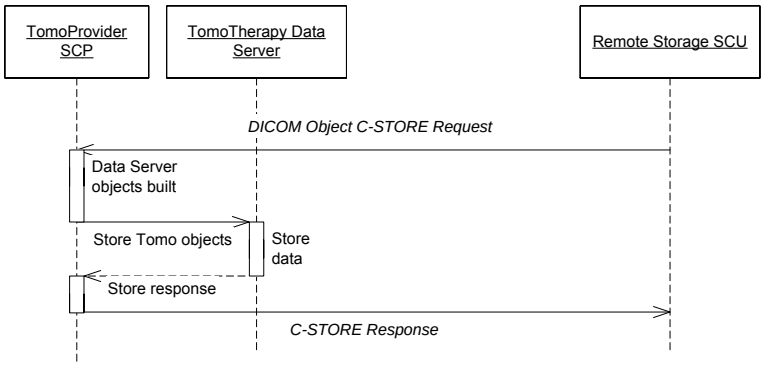


Figure 5: Import Application Sequence Diagram

Under normal workflow conditions the following sequencing constraints apply:

- If the external system acting as an SCU sends the CT Image series and associated (referencing) RT Structure Set(s) to TomoProvider in separate associations, then the CT Image must precede the RT Structure Set(s).
- For an external system acting as an SCU, all CT Image objects of interest in a given CT series must be sent to TomoProvider in a single association, i.e. a second set of images belonging to an existing series cannot be appended to the initial series.
- If multiple objects are sent to TomoProvider within the same association, the sequencing of those objects within the association is not relevant.

3.1.3.2 Export Application Sequencing

The sequencing of events for the Export Application is illustrated in Figure 6. The sequencing for a verification request is not described by this diagram.

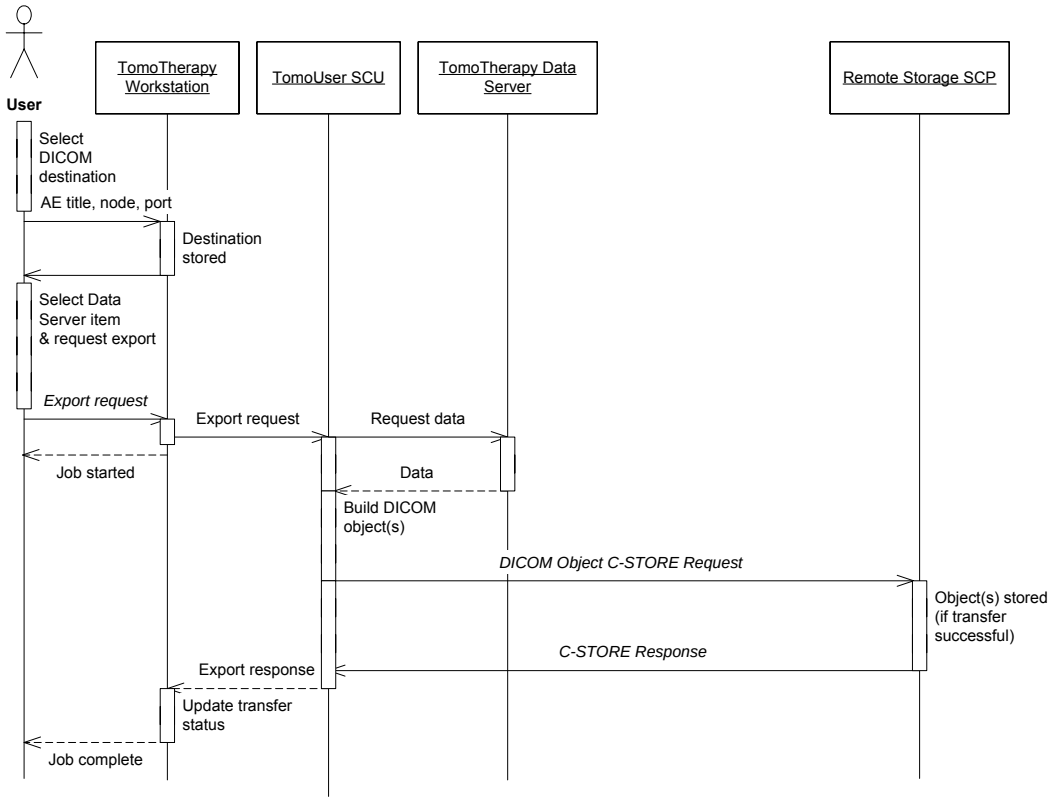


Figure 6: Export Application Sequence Diagram

Under normal workflow conditions the following sequencing constraints apply:

- TomoTherapy Data Server entities can be selected and transmitted via DICOM in any order. However, it is usual to export diagnostic CT image sets (if required) before structure set, plan and dose information.
- Diagnostic CT information or CTrue Image information can be sent at any time. Both image types use the standard CT Image IOD.
- A TomoTherapy Plan and its associated (plan-level) Structure Set are selected and exported independently. The RT Plan and RT Structure Set information cannot be sent until the corresponding TomoTherapy treatment plan has been approved (i.e. 'Final Accept' has been performed on the TomoTherapy Planning Station).
- When a disease-level (imported) structure set is selected, only an RT Structure Set object is sent. It does not require the existence of corresponding plans, approved or otherwise.
- When dose information is selected, only an RT Dose object is sent. The dose information cannot be sent until the corresponding treatment plan has been approved (i.e. 'Final Accept' has been performed on the TomoTherapy Planning Station).
- When a procedure's detector data is selected, a Raw Data object is sent. The detector data cannot be sent until the procedure finishes being delivered.

Export of a Multi-frame True Color SC Image can only be performed once an image registration has been performed on the Operator Station, at which time the 'Export Screen' option becomes available. The export destination is a configurable item (See the Section "Parameters," page 53). Note that this IOD is also exported by the Workflow application entity as part of workflow management.

3.1.3.3 Workflow Application Sequencing

Under normal workflow conditions the following event sequencing applies (numbers refer to steps illustrated in the figures).

3.1.3.3.1 Plan Export to TMS

The sequencing of events for the *Plan Export to TMS* operation on the Workflow Application is illustrated in Figure 7.

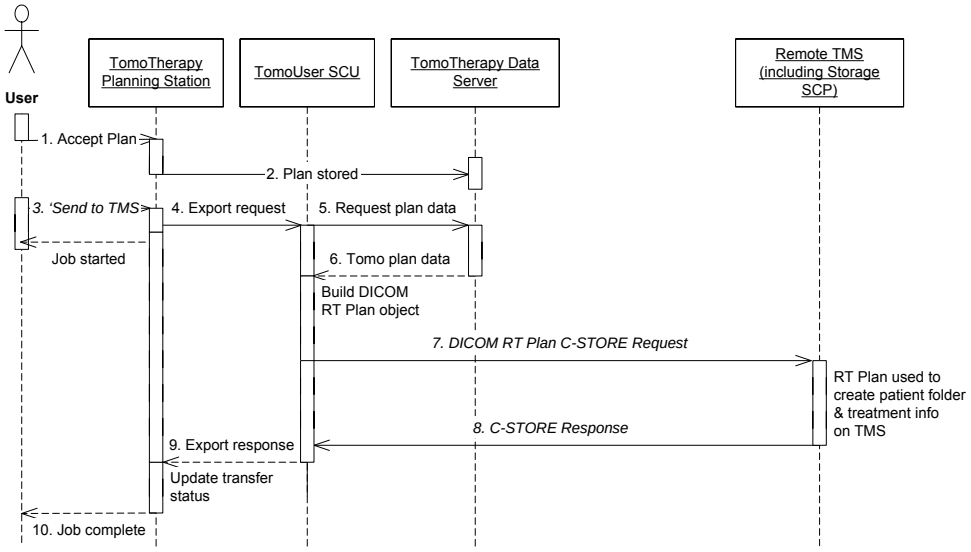


Figure 7: Workflow Plan Export Sequence Diagram

On the TomoTherapy Planning Station, the user performs a "Final Accept" on a treatment plan (1), and the plan data is stored in the Data Server (2). The user then uses the normal DICOM export interface to send the plan to the TMS DICOM target (3), and the plan data is sent (4-10). Note that the mechanism for this transfer is essentially identical to that of the Export Application, and the in fact the Export Application ('TomoUser') is used for this part of the workflow. See the Section "Export Application Sequencing," page 13, for a more detailed explanation of this mechanism.

On the TMS, the RT Plan object contents will subsequently be used to add treatment information to a patient folder that has been created already via the Hospital Information System. If such a folder does not exist, the TMS may either postpone translation of the received object until such a folder is created, or use the RT Plan demographic information to create the folder before adding the treatment information. The TMS user can then develop a treatment schedule for the patient.

Variant (not shown in figure):

- If the TMS application does not support RT Plan Store as a SCP, or is not be able to process plans received from a TomoTherapy workstation, then the Patient demographic and scheduling information can still be created on the TMS. It may be created manually or obtained from a HIS/RIS System or received acquisition image series. The RT Plan Instance UID for the plan will not be available in the TMS, and the Operator Station will need to use demographics (Patient Name and Patient ID) to match a received work item with data in the TomoTherapy Data Server.

3.1.3.3.2 Selection and Treatment Start

The sequencing of events for the *Selection and Treatment Start* operation on the Workflow Application is illustrated in Figure 8.

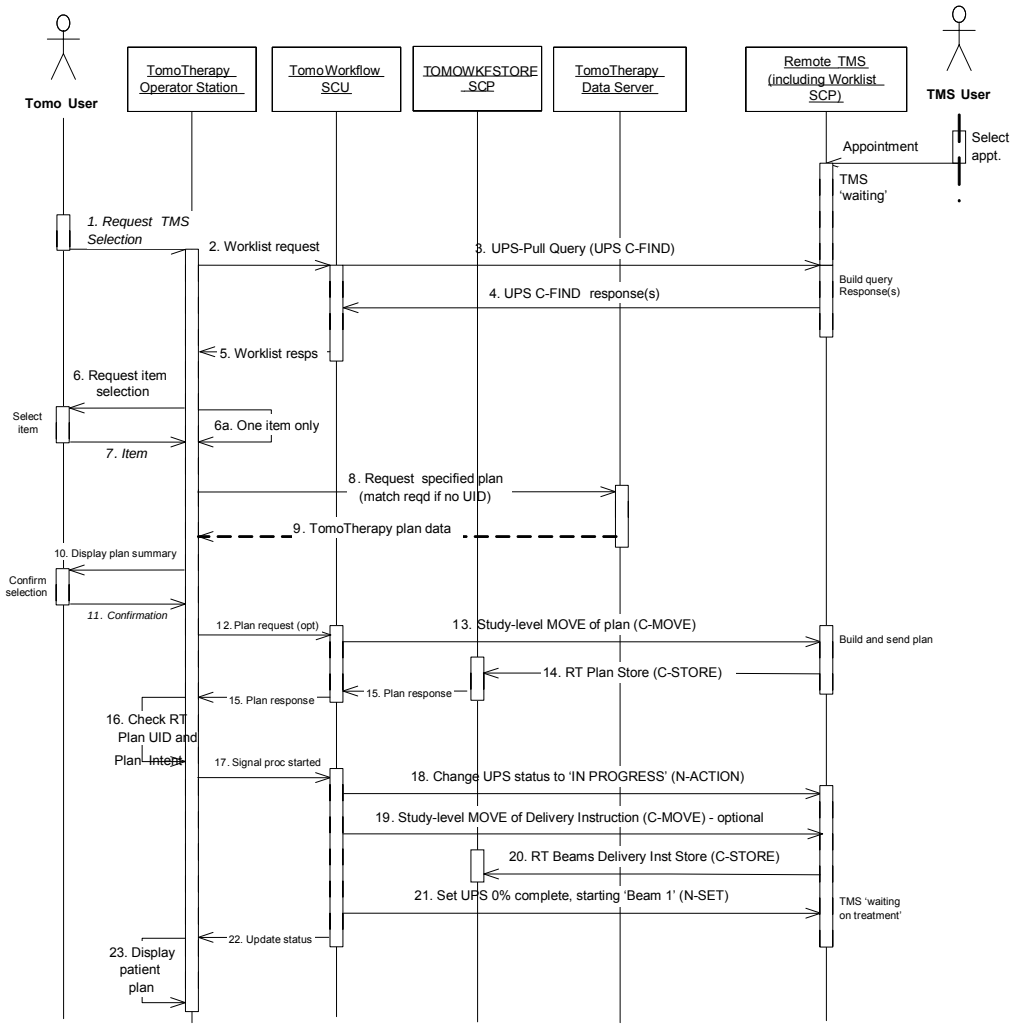


Figure 8: Workflow Selection and Treatment Start Sequence Diagram

On the TomoTherapy Operator Station, the user selects the option to retrieve the current selection from the TMS schedule (1). The Operator Station then requests the worklist from the Workflow DICOM Target that has been configured (see the Section " Remote AE Title/Presentation Address Mapping." page 51), using the TomoWorkflow SCU (2-3). See Table 23 for the attributes used as keys in this request. The

TMS then retrieves the current selection and builds and returns one or more ‘pending’ worklist responses containing the selections, followed by an empty ‘success’ worklist response (4). See the Section ”Activity — Worklist Query,” page 32, for further description of this transfer. The TomoWorkflow SCU then extracts key patient and plan identifying information from the worklist responses, and returns the data to the Operator Station (5). The Operator Station prompts the user to select one of the proposed work items (6-7), or selects the work item automatically if only one is returned (6a). It then retrieves the specified plan from the Data Server (8-9), using the RT Plan UID if supplied, otherwise matching upon the Patient Name and Patient ID fields. It displays summary plan data to the Operator Station user for confirmation (10-11). Once confirmed, if the worklist item contained an RT Plan reference then the Operator Station signals the TomoWorkflow SCU to retrieve the plan from the specified AE Title (assumed to be the TMS in steps 12-15 of the illustration), and verifies it is the correct plan and that the plan is intended for treatment (16). It then notifies the TomoWorkflow SCU that the procedure handling has started (17). This causes the UPS to be set (18), the Delivery Instruction to be retrieved from the specified AE title if available (19-20) and procedure step progress to be updated (21). Finally, when the update is complete (22) the patient is selected and displayed on the Operator Station itself (23) and treatment sequencing can begin.

Variants (not shown in figure):

- If the TMS does not respond to the Worklist Query, the request will time out and the Operator Station user will be notified. The user can then choose to try again, or alternatively select a patient manually and continue delivery.
- If the TMS responds to the Worklist Query with an error condition or no worklist items, the Operator Station user will be notified. The user can then choose to try again, or alternatively select a patient manually and continue delivery.
- If an RT Plan Instance UID is supplied in the Input Information Sequence of a worklist item, and RT Plan C-MOVE is supported by the TMS but the Operator Station cannot successfully retrieve (C-MOVE) that instance for some reason, the failure will be logged but delivery will be allowed to continue.
- If an RT Plan Instance UID is supplied in the Input Information Sequence of a worklist item, and the Operator Station cannot find the plan in the Data Server corresponding to that worklist item when it is selected by the user, the user will be notified. He or she can then choose to try again, or alternatively select a patient manually and continue delivery.
- If the Operator Station cannot find the patient corresponding to the Patient Name and Patient ID in the worklist item selected by the user, the user will be notified. He or she can then choose to try again, or alternatively select a patient manually and continue delivery.
- If the Operator Station finds the patient corresponding to the Patient Name and Patient ID in the worklist item, but that patient has more than one active plan, then the user will be requested to select which of the active plans is to be delivered.
- If an RT Beams Delivery Instruction Instance UID is supplied in the Input Information Sequence of the selected worklist item, and RT Beams Delivery Instruction C-MOVE is supported by the TMS but the Operator Station cannot successfully retrieve (C-MOVE) that instance for some reason, the failure will be logged but delivery will be allowed to continue.

- If a timeout or error condition occurs during UPS signaling to the TMS (13-14), then the Operator Station user will be notified but permitted to continue delivery for the selected patient. The TomoWorkflow SCU may nevertheless attempt to set the UPS and store the RT Beams Treatment Record at the Treatment End phase (see below). The TMS must then be capable of handling such unexpected messaging and generate an appropriate error condition for display on the Operator Station.

NOTE 1: If more than one plan for a given patient has been transmitted by the TomoTherapy Planning Station, the plans will have distinct UIDs. They can therefore be managed separately by the TMS such that when the Operator Station receives the plan selected on the TMS it will be able to verify that this plan corresponds to the active plan in the TomoTherapy Treatment System.

NOTE 2: If a plan has been cancelled on the TomoTherapy Treatment System, it must be manually removed from the set of active plans on the TMS.

NOTE 3: Although SCU support for the N-GET operation is a requirement of support for UPS – Pull, TomoTherapy applications do not issue an N-GET request since all necessary information is returned in the initial C-FIND responses returned from the TMS (SCP).

3.1.3.3.3 Treatment End

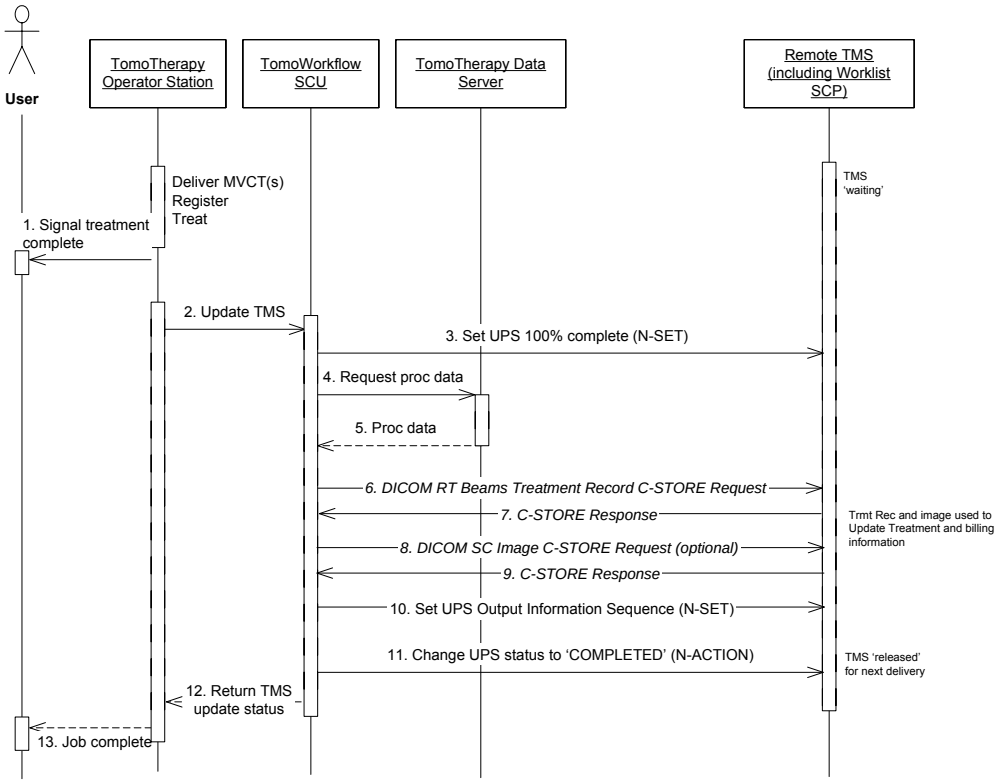
The sequencing of events for the *Treatment End* operation on the Workflow Application is illustrated in Figure 9.

After treatment is indicated as complete (1), the Operator Station requests the TomoWorkflow SCU to update the Workflow DICOM Target application entity with the result of the delivery (2). An N-SET command is used to send information regarding performance of CTrue Image acquisition, registration, and treatment delivery, encoded in the UPS using the attribute ‘Performed Workitem Code Sequence’ (3).

The procedure data is then fetched (4-5) and used to create and then store an RT Beams Treatment Record object (6-7) to the Archive DICOM Target (shown as the TMS in Figure 8) that has been configured (see the Section “AE Title/Presentation Address Mapping,” page 50). If supported by the Archive DICOM Target, a single-frame instance of a Multi-frame True Color SC Image object is constructed from temporary pixel data saved during when the last registration was accepted, and also transmitted. (8-9).

The Unified Procedure Step is then updated using N-SET with the identity and location of the stored treatment record and optional registration image (10). Using N-ACTION, the Unified Procedure Step State is set to ‘COMPLETED’ (11) in the normal case, and the TomoWorkflow SCU returns the update status to the Operator Station (12), which in turn indicates it to the user (13). Note that TomoTherapy treatments consist of a single ‘beam’ (helical), or multiple beams (TomoDirect), transmitted in a single RT Beams Treatment Record object.

Figure 9: Treatment End Sequence Diagram



Variants:

- If the treatment delivery has been started but is abandoned before completion (i.e. a completion procedure is never successfully delivered), then by manually selecting an interrupted treatment procedure, the user can send a procedure step update and treatment record indicating that a treatment was started but did not complete successfully. The options for CTrue Image delivery and registration are also displayed in this case, prior to sending the object. However, the SC Image of registration will not be transmitted. The signaling is identical to that described above except that the procedure step progress is set to less than 100% (with N-SET), and the Unified Procedure Step State is set to 'CANCELED' in the UPS (with N-ACTION). The transmitted RT Beams Treatment Record will also indicate that the treatment is not complete If the treatment delivery is cancelled prior to radiation occurring, the RT Beams Treatment Record and optional SC Image will not be stored (i.e. steps 6-9 will be absent).
- If the Operator Station user selects another patient, deselects the current patient, or selects 'cancel' prior to treatment delivery starting, no treatment record or registration image is stored and no final N-SET is issued (i.e. steps 6-10 are absent), The Operator Station asks the TomoWorkflow SCU to set the Unified Procedure Step State to 'CANCELED' (with N-ACTION), and returns the Operator Station to the idle state.
- If the TMS does not respond to the update or returns an error condition, the user can cancel (abandon) the TMS update operation and continue. If such a cancellation has occurred, the user

can then subsequently manually initiate transmittal of a procedure step update and RT Beams Treatment Record transmittal for the following procedure types:

- By selecting an interrupted treatment procedure, the user can send a procedure step update and treatment record indicating that a treatment was started but did not complete successfully.
- By selecting a completed treatment procedure, the user can send a procedure step update and treatment record indicating that a treatment completed successfully.

  NOTE: If treatment or Operator Station interruption occurs, the system will attempt to resume the Workflow Management. The user will be informed of the current state of the Workflow Management and be given a choice to resume the treatment or report, or be told that the current patient procedure cannot be managed under OIS control.

3.1.3.4 HIS RT Beams Report Automatic Export Sequencing

The sequencing of events for the HIS RT Beams Treatment Report Automatic Export is illustrated in Figure 10.

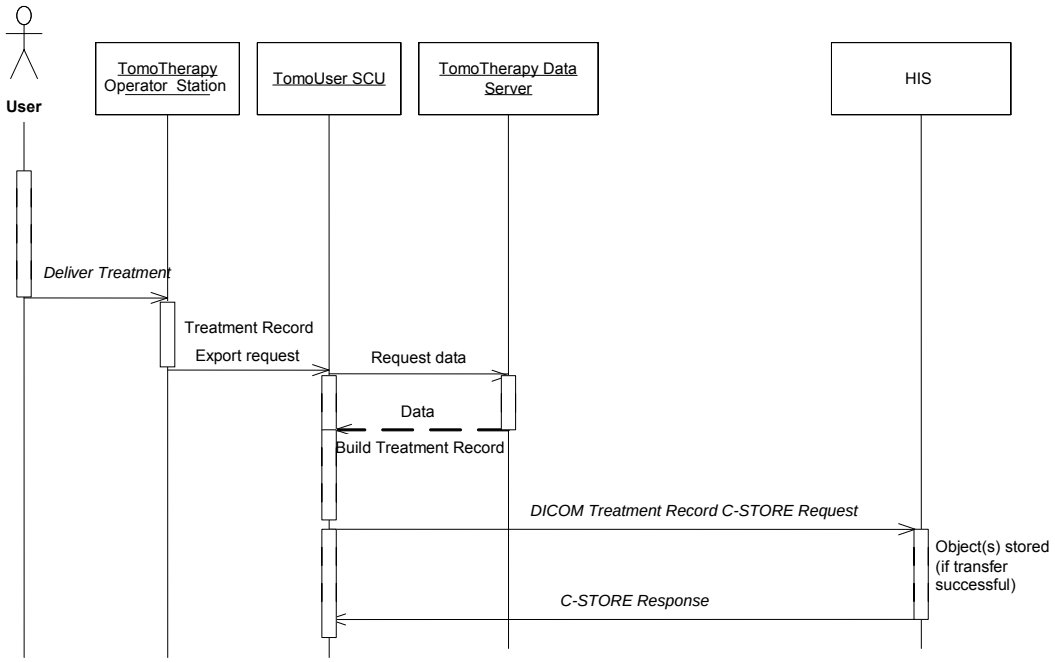


Figure 10: HIS Automatic Export of RT Beams Record Sequence Diagram

After treatment is delivered, the Operator Station requests the TomoWorkflow SCU to update the Workflow DICOM Target application entity with the result of the delivery

The procedure data is then fetched and used to create and then store an RT Beams Treatment Record object to the HIS DICOM Target (shown as the HIS in Figure 9).

3.2 AE Specifications

3.2.1 TomoProvider Storage SCP Application Entity Specification

3.2.1.1 SOP Classes

TomoProvider provides Standard Conformance to the following DICOM 3.0 SOP Classes as an SCP. TomoProvider never acts in the role of an SCU.

Table 2: SOP Classes for TomoProvider Storage

SOP Class	SOP Class UID
CT Image Storage	1.2.840.10008.5.1.4.1.1.2
RT Structure Set Storage	1.2.840.10008.5.1.4.1.1.481.3
Verification	1.2.840.10008.1.1

3.2.1.2 Association Establishment Policy

3.2.1.2.1 General

The standard application context name for DICOM 3.0 is always proposed:

Table 3: DICOM Application Context for TomoProvider Storage

Application Context Name	1.2.840.10008.3.1.1.1

TomoProvider is started as a service on the TomoTherapy Data Server approximately one minute after the Data Server initializes. After initializing, TomoProvider waits for association requests. When a successful association is made, a new thread is started to handle requests on the association. This process will receive one request at a time, process it, and send a response before reading the next request from the external system. The process will close the association if it has been idle for more than the configured time, if an unrecoverable error is reported, or if the Service Class User releases the connection.

TomoProvider does not place any restrictions on the maximum PDU size received from the sending SCU.

TomoProvider sets its maximum PDU size to 8192.

3.2.1.2.2 Number of Associations

TomoProvider places no limits on the number of concurrent associations. All transfers of a single image series must be performed using the same association.

Table 4: Number of Associations Accepted for TomoProvider Storage

Maximum number of simultaneous associations	No limit

3.2.1.2.3 Asynchronous Nature

Although there may be concurrent associations, objects are processed in a serial fashion. TomoProvider processes each object in turn and sends a response before processing the next object. Therefore, there is no asynchronous activity in this implementation.

Table 5: Asynchronous Nature as an SCP for TomoProvider Storage

Maximum number of outstanding asynchronous transactions	1

3.2.1.2.4 Implementation Identifying Information

The implementation information for this application entity is:

Table 6: DICOM Implementation Information for TomoProvider Storage

SOP Class	SOP Class UID
Implementation Class UID	1.2.826.0.1.3680043.2.200.1
Implementation Version Name	Release's software version number

3.2.1.3 Association Initiation Policy

TomoProvider does not initiate any associations.

3.2.1.4 Association Acceptance Policy

There following Real World Activities may establish an association with the TomoProvider:

- The external system requests storage for a CT Image Series and associated RT Structure Set(s) in the same association.
- The external system requests storage for a CT Image Series in one association, then RT Structure Set(s) in one or more separate associations.
- The external system requests storage for multiple related objects, one or more of which include an abstract syntax that is accepted but not stored.

TomoProvider acts the same way in making the association for each of these cases, so the association acceptance policy for all of these real world activities is grouped in "Receive Objects" below.

3.2.1.4.1 Activity — Receive Objects

3.2.1.4.1.1 Description & Sequencing of Activities

The Associated Real-World Activity is an attempt by an external system to connect to the TomoProvider for CT Image or RT Structure Set storage.

3.2.1.4.1.2 Accepted Presentation Contexts

The table below indicates which presentation contexts the TomoProvider will accept. The IODs RT Image, RT Plan, and RT Beams Treatment Record are accepted but not processed by the TomoProvider AE, i.e. the presence of these objects in an association will be ignored but will not cause the DICOM transfer to fail.

Table 7: Acceptable Presentation Contexts for Receive Objects

Presentation Context Table					
Abstract Syntax		**Transfer Syntax**		**Role**	**Ext Neg**
Name	**SOP Class UID**	**Name List**	**UID List**		
CT Image Storage	1.2.840.10008.5.1.4.1.1.2	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCP	None
RT Image Storage *	1.2.840.10008.5.1.4.1.1.481.1				
RT Dose Storage *	1.2.840.10008.5.1.4.1.1.481.2				
RT Structure Set Storage	1.2.840.10008.5.1.4.1.1.481.3				
RT Beams Treatment Record Storage *	1.2.840.10008.5.1.4.1.1.481.4				
RT Plan Storage *	1.2.840.10008.5.1.4.1.1.481.5				

NOTE 1: * denotes that object is not processed by application

NOTE 2: Support for some of these services may be separately licensable options. Details about licensable options can be found in TomoTherapy marketing and sales documentation.

3.2.1.4.1.2.1 Presentation Context Acceptance Criterion

TomoProvider will always accept a Presentation Context with the DICOM Default Transfer Syntax. Additionally, TomoProvider will accept from one to all of the above-mentioned Presentation Contexts shown in Table 7 on an association with the DICOM Default Transfer Syntax. It will also accept the Verification Presentation Context.

3.2.1.4.1.2.2 Transfer Syntax Selection Policies

TomoProvider accepts only the DICOM default transfer syntax.

3.2.1.4.1.3 Conformance for all Storage SOP Classes

TomoProvider will return one of the following error statuses when the C-STORE command is not successful.

Table 8: Error Statuses (all Storage SOP Classes)

Status Code	Meaning	Remedy
0110	Processing failure	Examine reason code, fix problem, and retransmit.
0118	Unknown SOP Class	A command with an unknown SOP class was received; examine operation attempted on SCU and retry as appropriate.
0120	A required field was not present	Review attribute field in error response to identify missing attribute. Correct problem and retry.
0210	Duplicate instance	Image/RT Structure Set already received successfully; no action required.
0211	Unrecognized operation	An invalid data command, SOP Instance, or other corruption was detected; retransmit.
0213	Resource limitation	Memory problem in server; database table full; identify particular problem and see appropriate documentation for resolution.
C001	Cannot understand	The given combination of elements, and/or its conjunction with the referenced CT image does not satisfy the required conditions; identify particular problem and see appropriate documentation for resolution.

3.2.1.4.1.4 SOP Specific Conformance for CT Image Storage and RT Structure Set Storage Classes

TomoProvider provides Level 0 Conformance to the C-STORE operations (local). Each SOP Class saves a particular subset of attributes (identified in Annex 7.1.2) from the transmission. All other attributes are discarded. When the C-STORE operation is successful, the CT Image or RT Structure Set is normally written to the Data Server. In the event that data is not written to the Data Server, the reason for failure will be identified in the Tomo Event Log facility as described in Section 3.4.1.2.

The data received by TomoProvider is accessible through the workstation software included with the TomoTherapy Treatment System. TomoProvider does not delete any data that it stores. Planning Station and Operator Station users determine its persistence duration.

Additional SOP-specific error codes are identified in the following table:

Table 9: Error Statuses (CT Image Storage and RT Structure Set Storage SOP Classes)

Status Code	Meaning	Remedy
0111	Duplicate instance	Image/RT Structure Set already received successfully; no action required
0210	Duplicate invocation	Image/RT Structure Set already received successfully; no action required.

3.2.1.4.1.5 SOP Specific Conformance for Verification Class

TomoProvider provides standard conformance to the DICOM Verification Class as a Service Class Provider.

3.2.2 TomoUser SCU Application Entity Specification

3.2.2.1 SOP Classes

TomoUser provides Standard Conformance to the following DICOM 3.0 SOP Classes as an SCU. TomoUser never acts in the role of an SCP.

Table 10: SOP Classes for TomoUser

SOP Class	SOP Class UID	SCU	SCP
CT Image Storage (for diagnostic images and CTrue Images)	1.2.840.10008.5.1.4.1.1.2	Yes	No
RT Structure Set Storage	1.2.840.10008.5.1.4.1.1.481.3	Yes	No
RT Dose Storage	1.2.840.10008.5.1.4.1.1.481.2	Yes	No
RT Plan Storage	1.2.840.10008.5.1.4.1.1.481.5	Yes	No
RT Beams Treatment Record Storage	1.2.840.10008.5.1.4.1.1.481.4	Yes	No
Multi-frame True Color SC Image Storage	1.2.840.10008.5.1.4.1.1.7.4	Yes	No
Raw Data Storage	1.2.840.10008.5.1.4.1.1.66	Yes	No
Verification	1.2.840.10008.1.1	Yes	No

NOTE: Support for some of these services may be separately licensable options. Details about licensable options can be found in TomoTherapy marketing and sales documentation.

3.2.2.2 Association Establishment Policy

3.2.2.2.1 General

The standard application context name for DICOM 3.0 is always proposed:

Table 11: DICOM Application Context for TomoUser

Application Context Name	1.2.840.10008.3.1.1.1

TomoUser operates as an SCU server; available at all times to service Workstation User requests. A user initiates a DICOM export activity. The workstation software constructs a request with references to any user data and transmits it to the TomoUser server.

The TomoUser server dynamically updates the workstation with the status of any outstanding requests. If TomoUser completes the transaction successfully, the Export icon is dismissed from the desktop. If the TomoUser server completes the transaction unsuccessfully, the Export icon is available to the user to report the full history of the specific request. For the automated RT Beams Record Export, no visual cue is shown for the success or failure of the export.

TomoUser does not place any restrictions on the maximum PDU size received from the receiving SCP.

TomoUser sets its maximum PDU size to the size configured for the particular DICOM destination involved in the association.

3.2.2.2.2 Number of Associations

The Export Application initiates only one Storage association at a time. Subsequent requests are queued pending completion of the current operation.

Table 12: Number of Associations Proposed for TomoUser Storage

Maximum number of simultaneous associations	1

3.2.2.2.3 Asynchronous Nature

TomoUser does not support asynchronous communication (multiple outstanding transactions over a single Association).

Table 13: Asynchronous Nature as an SCU for TomoUser Storage

Maximum number of outstanding asynchronous transactions	1

3.2.2.2.4 Implementation Identifying Information

The implementation information for this application entity is:

Table 14: DICOM Implementation Information for TomoUser Storage

SOP Class	SOP Class UID
Implementation Class UID	1.2.826.0.1.3680043.2.200.1

Implementation Version Name	Release's software version number

3.2.2.3 Association Initiation Policy

TomoUser initiates an association upon receiving a request from the Workstation software. The initiation occurs based on one of the following real-world activities:

Workstation user tests an external destination (using the verification SOP Class). This activity is not described in the following sections.

Following plan approval, the workstation user accepts the proposition that a plan be sent to the Treatment Management System (TMS), and an RT Plan object is sent.

Workstation user pushes one or more of the supported entities (CT Image, RT Structure Set, RT Dose, RT Plan, RT Beams Treatment Record, Raw Data) to an external destination using the object export interface.

Operator Station user pushes a Multi-frame True Color SC Image instance to the configured location following an image registration, using the 'Export Screen' function.

3.2.2.3.1 Activity — Send Objects

3.2.2.3.1.1 Description & Sequencing of Activities

The Associated Real-World Activity is an attempt by a TomoTherapy application to connect to the TomoUser AE to initiate storage of a supported object at an external storage SCP. This includes sending an RT Plan to the TMS as described in Section 3.1.3.3.1.

3.2.2.3.1.2 Proposed Presentation Contexts

The table below indicates the presentation contexts that TomoUser may propose to the storage SCP.

Table 15: Proposed Presentation Contexts for Send Objects

Presentation Context Table					
Abstract Syntax		**Transfer Syntax**		**Role**	**Ext Neg**
Name	**SOP Class UID**	**Name List**	**UID List**		
CT Image Storage	1.2.840.10008.5.1.4.1.1.2	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None
RT Dose Storage	1.2.840.10008.5.1.4.1.1.481.2				
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				
Raw Data Storage	1.2.840.10008.5.1.4.1.1.66				

Presentation Context Table					
Abstract Syntax		**Transfer Syntax**		**Role**	**Ext Neg**
Name	**SOP Class UID**	**Name List**	**UID List**		
Multi-frame True Color SC Image Storage	1.2.840.10008.5.1.4.1.1.7.4				
RT Beams Treatment Record Storage	1.2.840.10008.5.1.4.1.1.481.4				

3.2.2.3.1.3 SOP Specific Conformance for All SOP Classes

TomoUser provides Level 0 Conformance as an SCU. The following table describes processing of status codes received from a Storage SCP.

Table 16: Warning and Error Statuses

Status Code	Meaning	TomoUser Response
0106	Error: invalid attribute	Association released. Error reported.
0107	Warning: bad attribute	
0110	Processing failure	
0111	Duplicate instance	
0112	Error: no object instance	
0115	Error: invalid argument	
0116	Warning: value out of range	
0118	Error: no such SOP class	
0119	Error: class instance conflict	
0120	Error: missing attribute	
0122	Error: SOP unsupported	
0210	Error: duplicate request	

Status Code	Meaning	TomoUser Response
0211	Error: unrecognized operation	
0213	Error: resource limitation	
A700	Refused: out of resources	
A900	Error: data set mismatch	
B000	Warning: data element coercion	
B006	Warning: elements discarded	
B007	Warning: data set mismatch	
C001 and all others	Error: cannot understand	

3.2.2.3.1.4 SOP Specific Conformance for Verification Class

TomoUser provides standard conformance to the DICOM Verification Class as a Service Class User.

3.2.3 TomoWorkflow SCU Application Entity Specification

3.2.3.1 SOP Classes

TomoWorkflow provides Standard Conformance to the following DICOM 3.0 SOP Classes as an SCU. TomoWorkflow never acts in the role of an SCP.

Table 17: SOP Classes for TomoWorkflow

SOP Class	SOP Class UID	SCU	SCP
Multi-frame True Color SC Image Storage (for registration screen captures, single frame)	1.2.840.10008.5.1.4.1.1.7.4	Yes	No
Unified Procedure Step – Pull (Supplement 96 Frozen Draft SOP Class UID)	1.2.840.10008.5.1.4.34.4.3	Yes	No
Study Root Query/Retrieve Information Model - MOVE	1.2.840.10008.5.1.4.1.2.2.2	Yes	No

NOTE 1: Support for some of these services may be separately licensable options. Details about licensable options can be found in TomoTherapy marketing and sales documentation.

NOTE 2: TomoWorkflow SCU uses the C-FIND, N-SET, and N-ACTION DIMSE services for the UPS – Pull SOP Class.

NOTE 3: The TomoWorkflow SCU supplies the Supplement 96 Frozen Draft UPS- Pull SOP Class UID. Following full standardization of Supplement 96, the equivalent DICOM 2010 UPS- Pull SOP Class UID may be supplied in future releases.

3.2.3.2 Association Establishment Policy

3.2.3.2.1 General

The standard application context name for DICOM 3.0 is always proposed:

Table 18: DICOM Application Context for TomoWorkflow

Application Context Name	1.2.840.10008.3.1.1.1

TomoWorkflow operates as an SCU server; available at all times to service Workstation User requests. A user initiates a worklist query activity on the Operator Station. The workstation software constructs a query request and transmits it to the TomoWorkflow server. The Operator Station waits for the query responses, and then displays the information corresponding to the worklist items returned. If only one workitem is returned, this display step is omitted. If the request returns an error or times out, an error message is displayed on the Operator Station.

When the user selects the work item to be delivered, the Operator Station validates that the selection represents a valid plan (if a Plan UID is not supplied, this may involve matching the Patient and prompting for selection of the appropriate active plan). The Operator Station then requests the TomoWorkflow SCU to retrieve the specified plan (if available), notify the TMS that the procedure step is active on the Delivery System, retrieve the specified Delivery Instruction (if available), and finally notify the TMS that the treatment has started. When the treatment delivery is either completed normally or interrupted without subsequent completion, the Operator Station then requests information from the user regarding the workflow steps that are to be communicated, and asks the TomoWorkflow SCU to communicate this to the TMS. In this step, a treatment record and potentially a registration image may also be sent using DICOM storage functionality.

TomoWorkflow does not place any restrictions on the maximum PDU size received from the receiving SCP.

TomoWorkflow sets its maximum PDU size to the size configured for the particular DICOM destination involved in the association.

3.2.3.2.2 Number of Associations

The Workflow Application may initiate one Unified Procedure Step – Pull Query association, Study Root MOVE association, RT Beams Treatment Record Storage association, or Multi-frame True Color SC Image Storage association at a time. It does not issue a subsequent request until the current one is processed.

Table 19: Number of Associations Proposed for TomoWorkflow AE

Maximum number of simultaneous associations	1

3.2.3.2.3 Asynchronous Nature

Operation is synchronous with respect to the Operator Station, i.e. the Operator Station application awaits the return of the call to the TomoWorkflow SCU before continuing.

TomoWorkflow does not support asynchronous communication (multiple outstanding transactions over a single Association).

Table 20: Asynchronous Nature as an SCU for TomoWorkflow AE

Maximum number of outstanding asynchronous transactions	1

3.2.3.2.4 Implementation Identifying Information

The implementation information for this application entity is:

Table 21: DICOM Implementation Information for TomoWorkflow AE

SOP Class	SOP Class UID
Implementation Class UID	1.2.826.0.1.3680043.2.200.1
Implementation Version Name	Release's software version number

3.2.3.3 Association Initiation Policy

TomoWorkflow initiates an association upon receiving a request from the Operator Station software. The initiation occurs based on one of the following real-world activities:

Operator Station user requests a worklist from the configured Treatment Management System (TMS).

Operator Station user selects and approves the details of a worklist item and requests that the TMS be notified that treatment has started.

Operator Station user completes or abandons treatment and the TMS is notified and an RT Beams Treatment Record and optional Multi-frame True Color SC Image are sent.

3.2.3.3.1 Activity — Worklist Query

3.2.3.3.1.1 Description & Sequencing of Activities

The Associated Real-World Activity is an attempt by a TomoTherapy Operator Station to connect to the TomoWorkflow AE to initiate a query of a patient list on an external Treatment Management System (TMS) SCP. See Figure 11 (two items returned in this example).

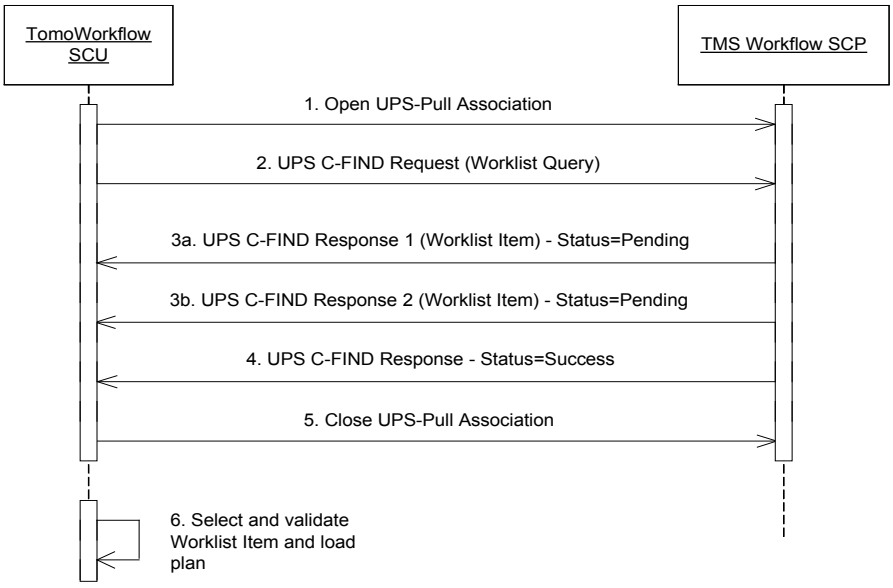


Figure 11: Worklist Query Sequence Diagram

TomoWorkflow will first initiate a UPS – Pull association with the configured TMS (1), and issue a UPS – Pull C-FIND request for Unified Procedure Steps (2). It will then wait for a worklist response. TomoWorkflow expects zero or more C-FIND Responses each containing a worklist item, with Status set to PENDING (3a-3b), followed by a C-FIND Response containing no worklist item, with Status set to SUCCESS (4). TomoWorkflow will then close the association (5).

If one or more items have been returned, the Operator Station will then display the items as described for the activity *Selection and Treatment Start*.

3.2.3.3.1.2 Proposed Presentation Contexts

The table below indicates the presentation contexts TomoWorkflow may propose to the worklist SCP. Note that the TomoWorkflow SCU currently supplies the Supplement 96 Frozen Draft UPS-Pull SOP Class UID.

Table 22: Proposed Presentation Contexts for Worklist Query

Presentation Context Table					
Abstract Syntax		**Transfer Syntax**		**Role**	**Ext Neg**
Name	**SOP Class UID**	**Name List**	**UID List**		
Unified Procedure Step – Pull (Supplement 96 Frozen Draft SOP Class UID)	1.2.840.10008.5.1.4.34.4.3	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None

3.2.3.3.1.3 SOP Specific Conformance for UPS – Pull

3.2.3.3.1.3.1 C-FIND Request Conformance

0 provides a description of the TomoWorkflow UPS C-FIND Request Identifier. Unexpected attributes returned in a C-FIND response are ignored.

Note that the UPS-Pull SOP Class is negotiated as the abstract transfer syntax, but the UPS-Push SOP Class is used as the Affected SOP Class UID in all subsequent N-ACTION and N-SET DIMSE messaging (see DICOM Supplement 96, Part 4, Section F.X.4). The UPS-Pull SOP Class is however specified as the Affected SOP Class UID in the UPS-Pull C-FIND messaging using for querying the TMS. The UPS-Push SOP Class UID supplied is the Supplement 96 Frozen Draft UPS-Push SOP Class UID.

0 shows the Worklist Request attributes used by the TomoTherapy application. The table should be read as follows:

Module Name: The name of the associated module for supported worklist attributes.

Attribute Name: Attributes supported to build a TomoWorkflow Worklist Request Identifier.

Tag: DICOM tag for this attribute.

VR: DICOM VR for this attribute.

M: Matching keys for (automatic) Worklist Update. An "S" will indicate that TomoWorkflow will supply an attribute value for Single Value Matching, and an “R” will indicate Range Matching.

R: Return keys. An "x" will indicate that TomoWorkflow will supply this attribute as Return Key with zero length for Universal Matching. TomoWorkflow will NOT support retired date format (yyyy.mm.dd) for "Patient’s Birth Date" in the response identifiers.

D: Displayed keys. An “x” indicates that this worklist attribute is displayed to the user during the plan confirmation dialog on the Operator Station.

The TomoTherapy implementation requires that TMS implementations return at a minimum those attributes with an ‘**x**’ indicated in bold. Supply of the additional attributes marked ‘x’ is also highly recommended.

The query configuration always proposed by TomoWorkflow is the following:

Unified Procedure Step State (0074,1000) with a value of ‘SCHEDULED’.

Code Value in Scheduled Station Name Code Sequence corresponding to the Station Name (0008,1010) attribute of the RT Plan object received when creating the patient folder on the TMS. For TomoTherapy plans this is equal to the 'Machine Name' on which the treatment was planned. Note that for TomoTherapy applications, the Code Value is BOTH the machine-readable unique identifier for the machine, and the human-readable display value for the machine name.
Scheduled Procedure Step Start Date and Time (0040,4005) shall be supplied with a range corresponding to the current day. For example, "20070128000000.0000-20070128235959.9999" would be supplied for any query performed on January 28, 2007.
Code Value in Scheduled Workitem Code Sequence of '121726' (RT Treatment with Internal Verification'), and Coding Scheme Designator of 'DCM'.

Table 23: UPS C-FIND Request Identifier

Module Name Attribute Name	Tag	VR	M	R	D
SOP Common					
SOP Class UID	(0008,0016)	UI		**x**	
SOP Instance UID	(0008,0018)	UI		**x**	
Unified Procedure Step Progress Information					
Unified Procedure Step State	(0074,1000)	CS	**S**		
Unified Procedure Step Scheduled Proc. Information					
Procedure Step Label	(0074,1204)	LO		**x**	x
Scheduled Station Name Code Sequence	(0040,4025)	SQ			
>Code Value	(0008,0100)	SH	**S**		
>Coding Scheme Designator	(0008,0102)	SH		**x**	
>Code Meaning	(0008,0104)	LO		**x**	x
Scheduled Procedure Step Start Date and Time	(0040,4005)	DT	**R**		x
Scheduled Workitem Code Sequence	(0040,4018)	SQ			
>Code Value	(0008,0100)	SH	**S**		
>Coding Scheme Designator	(0008,0102)	SH	**S**		
>Code Meaning	(0008,0104)	SH		x	**x**
Scheduled Processing Parameters Sequence	(0074,1210)	SQ		**x**	x
Input Information Sequence	(0040,4021)	SQ		**x**	
Study Instance UID	(0020,000D)	UI		**x**	
Unified Procedure Step Relationship					
Patient's Name	(0010,0010)	PN		**x**	x
Patient ID	(0010,0020)	LO		**x**	x
Patient's Birth Date	(0010,0030)	DA		**x**	x
Patient's Sex	(0010,0040)	CS		**x**	x
Admission ID	(0038,0010)	LO		**x**	x
Other Patient IDs Sequence	(0010,1002)	SQ		x	x

Module Name Attribute Name	Tag	VR	M	R	D
Admitting Diagnoses Description	(0008,1080)	LO		x	x
Admitting Diagnoses Code Sequence	(0008,1084)	SQ		x	x
Patient Medical					
Medical Alerts	(0010,2000)	LO		x	x
Special Needs	(0038,0050)	LO		x	x

The behavior of TomoWorkflow during communication failure is summarized in Table 24: UPS C-FIND Communication Failure Behavior.

Table 24: UPS C-FIND Communication Failure Behavior

Exception	Behavior
Timeout	The Association is aborted using A-ABORT and the worklist query is marked as failed. The status meaning is logged and reported to the user on the Operator Station. Any additional error information in the Response is logged.
Association aborted by SCP or network layers	The worklist query is marked as failed. The status meaning is logged and reported to the user on the Operator Station. Any additional error information in the Response is logged.

3.2.3.3.1.3.2 C-FIND Response Conformance

The C-FIND Response Identifier issued by a TMS (SCP) shall conform to the following constraints: Code Value and Coding Scheme Designator in Scheduled Workitem Code Sequence shall correspond to 'RT Treatment with Internal Verification' (see Supplement 74). This is implemented using a DICOM Context ID (Coding Scheme Designator 'DCM', code value '121726'), as specified in DICOM Supplement 74.

The TMS (SCP) should normally provide in the C-FIND response a reference to the RT Plan being delivered. In this case the Study Instance UID and Series Instance UID in the Input Information Sequence are ignored, and the match with TomoTherapy Data Server contents is made using referenced RT Plan SOP Instance UID only. If no RT Plan Instance UID is supplied, then the Operator Station attempts to match the returned work item with a plan in the Data Server using the Patient Name and Patient ID fields.

The TMS (SCP) should provide the desired Study Instance UID for any created composite SOP Instances being delivered in the return value for the top-level attribute Study Instance UID. Under normal workflow control (i.e. when there is no breakdown in the workflow process), the TomoTherapy application expects this Study Instance UID to be the Study Instance UID of the original plan, and will create output SOP Instances (such as the treatment record) that are in the same Study as the delivered RT Plan. If the TMS (SCP) does not know the required Study Instance UID, then it shall supply a null (empty) response, and the TomoTherapy application will also then use the same Study Instance UID as the delivered RT Plan when creating new objects.

0 summarizes the behavior of TomoWorkflow when encountering status codes in a UPS C-FIND response.

Table 25: UPS C-FIND Response Status Handling Behavior

Service Status	Further Meaning	Error Code(s)	Behavior
Success	Matching is complete	0000	The SCP has completed the matches. The returned worklist items are then displayed to the Operator Station user so that one of the items can be selected.
Failure	Refused: Out of Resources	A700	The Association is aborted using A-ABORT and the worklist query is marked as failed. The status meaning is logged and reported to the user on the Operator Station. Any additional error information in the Response is logged.
	Identifier does not match SOP Class	A900	
	Refused: Not Authorized	C305	
	Unable to Process	C000 – CFFF	
Cancel	Matching terminated due to Cancel request	FE00	The status never occurs, since the Operator Station application cannot cancel a worklist request.
Pending	Matches are continuing	FF00	The worklist item is processed by storing the returned parameters, ready for selection and processing when a response with status Success is received.
	Matches are continuing – Warning that one or more Optional Keys were not supported	FF01	
*	*	Any other status code.	The Association is aborted using A-ABORT and the worklist is marked as failed. The status meaning is logged and reported to the user on the Operator Station. Any additional error information in the Response is logged.

3.2.3.3.2 Activity — Selection and Treatment Start

3.2.3.3.2.1 Description & Sequencing of Activities

The associated Real-World Activity is an attempt by a TomoTherapy Operator Station to connect to the TomoWorkflow AE to retrieve objects for verification and initiate updates of the UPS State on the TMS. These updates are associated with starting a treatment delivery. See Figure 12.

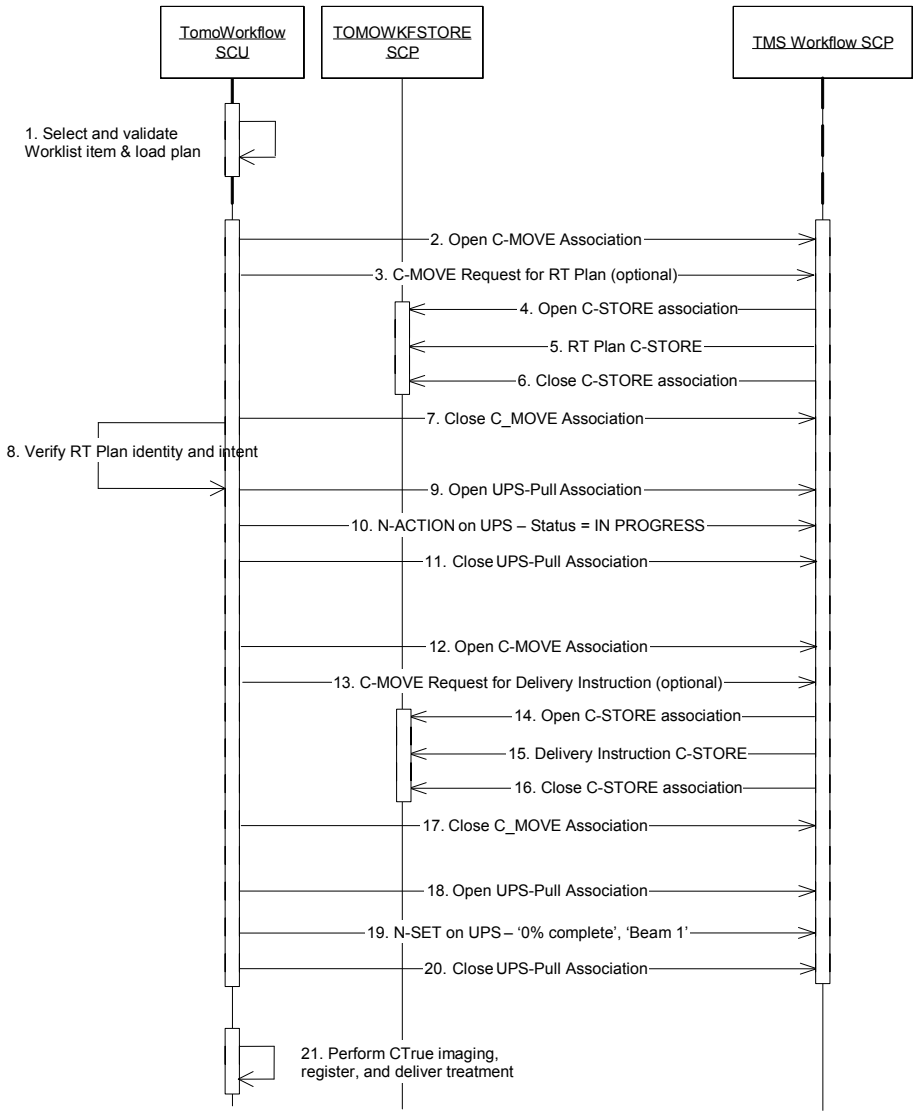


Figure 12: Selection and Treatment Start Sequence Diagram

The Operator Station begins by displaying the returned TMS worklist items in human-readable form, and prompts the user to choose one of the items (1). Once this is done, or if there was only a single item returned in the worklist, it then attempts to match the selected item with a plan in the TomoTherapy Data Server using the supplied RT Plan UID as the primary key. If exactly one match is successful, the Operator Station will display demographic patient details and plan details for the selected item, and ask the user to confirm that this is the plan to be treated. If the user accepts, the Operator Station then

retrieves the RT Plan object (2-7) from the specified AE Title and verifies its identity (8). The Operator Station then loads the (internal) plan ready for treatment delivery.

If a Plan UID is not supplied, then the Operator Station attempts a match based upon the Patient Name and Patient ID. If a match is found, the active plan is loaded (or a user selection is prompted if multiple active plans are present).

The Operator Station then asks TomoWorkflow to initiate an association with the configured TMS (9), signals an N-ACTION request to the TMS to set the state of the selected UPS to 'IN PROGRESS' (10), and closes the association (11).

The Operator Station then attempts to retrieve the Delivery Instruction object from the specified AE Title (12-17). The Remote AE used to do this may differ from the TMS Workflow SCP (although these two AEs are shown as one and the same in the diagram).

If the N-ACTION was successful, the Operator Station then asks TomoWorkflow to initiate another association with the configured TMS (18), signal an N-SET request to the TMS to set the UPS progress to 0% and the 'Referenced Beam Number' to '1' (19), and close the association (20).

Finally, the Operator Station is ready for the user to begin verification imaging, registration, and treatment delivery (21).

3.2.3.3.2.2 Proposed Presentation Contexts

The table below indicates which presentation contexts TomoWorkflow may propose to the Worklist SCP.

Table 26: Proposed Presentation Contexts for Selection and Treatment Start

Presentation Context Table					
Abstract Syntax		**Transfer Syntax**		**Role**	**Ext Neg**
Name	**SOP Class UID**	**Name List**	**UID List**		
Unified Procedure Step – Pull (Supplement 96 Frozen Draft SOP Class UID)	1.2.840.10008.5.1.4.34.4.3	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None

3.2.3.3.2.3 SOP Specific Conformance for UPS – Pull

3.2.3.3.2.3.1 General Conformance

The behavior of TomoWorkflow during communication failure is summarized in Table 27.

Table 27: Selection and Treatment Start Communication Failure Behavior

Exception	Behavior
Timeout	The Association is aborted using A-ABORT. The status meaning is logged and reported to the user on the Operator Station. Any additional error information in the Response is logged. Operator Station continues as described in 'Failure' rows of above tables.
Association aborted by SCP or network layers	The status meaning is logged and reported to the user on the Operator Station. Any additional error information in the Response is logged. Operator Station continues as described in 'Failure' rows of the following sections.

3.2.3.3.2.3.2 N-ACTION Request Conformance

In the Treatment Start UPS N-ACTION Request, TomoWorkflow shall supply in the Requested SOP Instance UID the SOP Instance UID specified in the selected worklist item. The N-ACTION request identifier information supplied by TomoWorkflow is shown in Table 28.

Table 28: Treatment Start N-ACTION Request Identifier

Action Type Name	Action Type ID	Attribute	Tag	VR	N-ACTION
Request UPS State Modification	1	Unified Procedure Step State	(0074,1000)	CS	'IN PROGRESS'

3.2.3.3.2.3.3 N-ACTION Response Conformance

In the UPS N-ACTION Response, the TMS (SCP) shall return the Transaction UID to be used in subsequent workflow messaging.

Table 29 summarizes the behavior of TomoWorkflow when encountering status codes in a UPS N-ACTION response.

Table 29: UPS N-ACTION Response Status Handling Behavior

Service Status	Further Meaning	Error Code(s)	Behavior
Success	Status modified	0000	Success – no further action
Failure	UPS may no longer be updated	C300	Error code and description displayed to Operator Station user. Subsequent N-SET of UPS not performed.
	Correct Transaction UID not provided	C301	

Service Status	Further Meaning	Error Code(s)	Behavior
	UPS already 'IN PROGRESS'	C302	Treatment can continue.
	UPS may only become SCHEDULED via N-CREATE	C303	
	UPS has not met final state requirements	C304	
	Specified SOP Instance is not a UPS Instance managed by this SCP	C307	
	Refused: Not Authorized	C305	

3.2.3.3.2.3.4 N-SET Request Conformance

In the UPS N-SET Request, TomoWorkflow shall supply the SOP Instance UID specified in the selected worklist item. The N-SET request identifier information supplied by TomoWorkflow is shown in Table 30. Attributes not shown in the table will not be sent by TomoWorkflow.

Note that the UPS-Pull SOP Class is negotiated as the abstract transfer syntax, but the UPS-Push SOP Class is used as the Affected SOP Class UID in all subsequent N-ACTION and N-SET DIMSE messaging (see DICOM Supplement 96, Part 4, Section F.X.4). The UPS-Pull SOP Class is however specified as the Affected SOP Class UID in the UPS-Pull C-FIND messaging using for querying the TMS.

Table 30: Treatment Start UPS N-SET Request Identifier

Attribute Name	Tag	VR	N-SET
Transaction UID	(0008,1195)	UI	Transaction UID of initial UPS N-ACTION response
Unified Procedure Step Progress Information Module			
UPS Progress Information Sequence	(0074,1002)	SQ	Always provided
>Unified Procedure Step Progress	(0074,1004)	DS	0.0
Unified Procedure Step Performed Procedure Information Module			
UPS Performed Procedure Sequence	(0074,1216)	SQ	Always provided

Attribute Name	Tag	VR	N-SET
>Performed Station Name Code Sequence	(0040,4028)	SQ	Always provided
>>Code Value	(0008,0100)	SH	Equal to Station Name (0008,1010) attribute of RT Plan object
>>Coding Scheme Designator	(0008,0102)	SH	'99_TOMO_STN_NAME'
>>Code Meaning	(0008,0104)	LO	'Performed Station Name'
>Performed Processing Parameters Sequence	(0074,1212)	SQ	Always provided
>>Value Type	(0040,A040)	CS	'TEXT'
>>Concept Name Code Sequence	(0008,0100)	SQ	Always provided
>>>Code Value	(0008,0100)	SH	'121700'
>>>Coding Scheme Designator	(0008,0102)	SH	'DCM'
>>>Code Meaning	(0008,0104)	LO	'Referenced Beam Number in Progress'
>>Text Value	(0040,A160)	UT	'1'
>Output Information Sequence	(0040,4033)	SQ	Empty
>Non-DICOM Output Code Sequence	(0040,4032)	SQ	Empty

3.2.3.3.2.3.5 N-SET Response Conformance

Table 31 summarizes the behavior of TomoWorkflow when encountering status codes in a UPS N-SET response.

Table 31: UPS N-SET Response Status Handling Behavior

Service Status	Further Meaning	Error Code(s)	Behavior
Success	Attribute(s) modified	0000	Success – no further action
Warning	Requested optional attributes are not supported	0001	Warning code and description written to log file. Treatment can continue.
	Coerced invalid values to valid values	B304	
Failure	Refused: The UPS is not in 'IN PROGRESS' state	C310	Error code and description displayed to Operator Station user. Treatment can continue.
	Refused: The correct Transaction UID was not provided	C301	
	Refused: The UPS may no longer be updated	C300	
	Specified SOP Instance UID is not a UPS Instance managed by this SCP	C307	
	Refused: Not Authorized	C305	

3.2.3.3.3 Activity —Treatment End

3.2.3.3.3.1 Description & Sequencing of Activities

3.2.3.3.3.1.1 Normal Completion and Interruption During Radiation

The associated Real-World Activity is an attempt by a TomoTherapy Operator Station to connect to the TomoWorkflow AE to initiate updates of the UPS Status on the TMS. These updates are associated with notification that a treatment delivery has ended normally, or has been interrupted during radiation. See Figure 13.

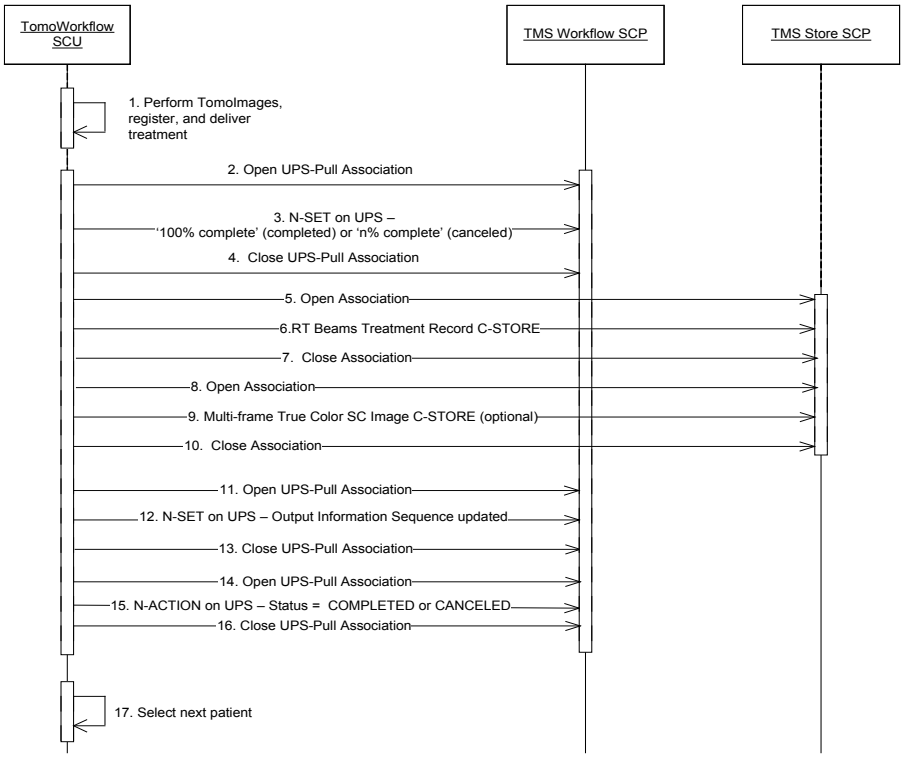


Figure 13: Treatment End Sequence Diagram

This scenario begins when the Operator Station successfully completes a treatment procedure, or the user has selected a previously delivered procedure and activated a right-button mouse option to update the TMS. In either case, a panel appears asking the user to indicate the activities (CTrue Image acquisition, registration, and/or treatment delivery) that were performed, and if a registration screen capture image should be sent. The following communications then occur:

The Operator Station then asks TomoWorkflow to initiate an association with the configured TMS Workflow SCP (2), and signal an N-SET request to the TMS to set the UPS progress to 100% (3). The association is then closed (4).

Irrespective of whether notification completes successfully, the Operator Station then asks TomoWorkflow to initiate an association with the configured TMS Store SCP (5), and perform an RT Beams Treatment Record Store (6). The association is then closed (7).

If transfer of the registration screen capture is supported by the TMS Store SCP, the Operator Station also asks TomoWorkflow to initiate another association with the configured TMS Store SCP (8), and store a single frame instance of the Multi-frame True Color SC Image object to the same Application Entity (9). The association is then closed (10).

If the first N-SET above completed successfully, the Operator Station then asks TomoWorkflow to initiate an association with the configured TMS Workflow SCP (11), signal an N-SET request to transmit the identity and location of the stored treatment record and optional registration image (12), and close the association (13). Finally, the Operator Station then asks TomoWorkflow to initiate another association with the configured TMS Workflow SCP (14), send N-ACTION request to the

TMS to set the UPS State to either ‘COMPLETED’ if the procedure completed successfully, or ‘CANCELED’ if the procedure did not complete successfully (15), and close the association (16).

Variant:

If the TMS Workflow SCP responds to the initial N-SET request (step 2) with an error condition, then the Operator Station attempts to send the treatment record and registration image objects in any case by performing steps 5-7 of Figure 11 to send the treatment record and optionally the (single frame) Multi-frame True Color SC Image of the registration screen (steps 8-10). However, the following N-SET and N-ACTION (steps 11-16) are NOT performed. This scenario is likely to occur, for example, when the TMS has been restarted or treatment has been recorded manually, i.e. the workflow context has been lost on the TMS.

The Operator Station is then ready for the user to begin selection and treatment of another patient (17).

3.2.3.3.3.1.2 Interruption Prior to Radiation

If attempted delivery of the treatment is interrupted prior to the start of radiation, then message sequencing is different from the previous case. All messages prior to the N-ACTION message are not transmitted (i.e. Steps 2-13 in Figure 11 are omitted), since N-SET Final State requirements have already been satisfied by the initial N-SET, and there is no treatment record to be stored. The ‘Cancel’ N-ACTION message (steps 14-16) is transmitted as usual.

3.2.3.3.3.2 Proposed Presentation Contexts

Table 32 indicates which presentation contexts TomoWorkflow may propose for worklist operations.

Table 32: Proposed Presentation Contexts for Treatment End – Worklist Operations

Presentation Context Table					
Abstract Syntax		**Transfer Syntax**		**Role**	**Ext Neg**
Name	**SOP Class UID**	**Name List**	**UID List**		
Unified Procedure Step – Pull (Supplement 96 Frozen Draft SOP Class UID)	1.2.840.10008.5.1.4.34.4.3	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None

Table 33 indicates which presentation contexts TomoWorkflow may propose for storage operations.

Table 33: Proposed Presentation Contexts for Treatment End – Storage Operations

Presentation Context Table					
Abstract Syntax		**Transfer Syntax**		**Role**	**Ext Neg**
Name	**SOP Class UID**	**Name List**	**UID List**		
RT Beams Treatment Record Storage	1.2.840.10008.5.1.4.1.1.481.4	DICOM Implicit VR Little Endian	1.2.840.10008.1.2	SCU	None
Multi-frame True Color SC Image Storage	1.2.840.10008.5.1.4.1.1.7.4				

3.2.3.3.3.3 SOP Specific Conformance for UPS – Pull

3.2.3.3.3.3.1 General Conformance

The behavior of TomoWorkflow during communication failure is summarized in Table 34.

Table 34: Treatment End Communication Failure Behavior

Exception	Behavior
Timeout	The Association is aborted using A-ABORT. The status meaning is logged and reported to the user on the Operator Station. Any additional error information in the Response is logged. Operator Station continues as described in 'Failure' rows of above tables.
Association aborted by SCP or network layers	The status meaning is logged and reported to the user on the Operator Station. Any additional error information in the Response is logged. Operator Station continues as described in 'Failure' rows of above tables.

3.2.3.3.3.3.2 N-SET Request Conformance

In the Progress UPS N-SET Request (line 3 in Figure 11), TomoWorkflow shall supply the SOP Instance UID specified in the selected worklist item. The N-SET request identifier information supplied by TomoWorkflow is shown in Table 35. Attributes not shown in the table will not be sent by TomoWorkflow.

Note that the UPS-Pull SOP Class is negotiated as the abstract transfer syntax, but the UPS-Push SOP Class is used as the Affected SOP Class UID in all subsequent N-ACTION and N-SET DIMSE messaging (see DICOM Supplement 96, Part 4, Section F.X.4). The UPS-Pull SOP Class is however

specified as the Affected SOP Class UID in the UPS-Pull C-FIND messaging using for querying the TMS.

Table 35: Progress UPS N-SET Request Identifier

Attribute Name	Tag	VR	N-SET
Transaction UID	(0008,1195)	UI	Transaction UID of initial UPS N-ACTION response
Unified Procedure Step Progress Information Module			
UPS Progress Information Sequence	(0074,1002)	SQ	Always provided
>Unified Procedure Step Progress	(0074,1004)	DS	100.0 for normally completed procedures, or some value between '0.0' and '100.0' for interrupted procedures.

In the Final UPS N-SET Request (line 12 in Figure 11), TomoWorkflow shall supply in the Requested SOP Instance UID the SOP Instance UID specified in the selected worklist item. The N-SET request identifier information supplied by TomoWorkflow is shown in Table 36. Attributes not shown in the table will not be sent by TomoWorkflow.

Note that the Performed Procedure Step Description is used to encode the 'Delivered Procedure Number'. This allows TMS implementations to update the delivered procedure on the TMS without needing to retrieve and open the treatment record.

The generated RT Beams Treatment Record and optional Multi-frame True Color SC Image objects will use the same Patient and Study level attributes as those specified for the RT Plan object received by the TMS when creating the patient folder.

Table 36: Final UPS N-SET Request Identifier

Attribute Name	Tag	VR	N-SET
Transaction UID	(0008,1195)	UI	Transaction UID of initial UPS N-ACTION response
Unified Procedure Step Performed Procedure Information Module			
UPS Performed Procedure Sequence	(0074,1216)	SQ	Always provided
>Performed Station Name Code Sequence	(0040,4028)	SQ	Always provided

Attribute Name	Tag	VR	N-SET
>>Code Value	(0008,0100)	SH	Equal to Station Name (0008,1010) attribute of RT Plan object
>>Coding Scheme Designator	(0008,0102)	SH	'99_TOMO_STN_NAME'
>>Code Meaning	(0008,0104)	LO	'Performed Station Name'
>Performed Procedure Step Start Date	(0040,0244)	DT	Always provided
>Performed Procedure Step Start Time	(0040,0245)	TM	Always provided
>Performed Procedure Step Description	(0040,0254)	LO	Always provided. Contains TomoTherapy Fraction Number of Delivered Procedure, e.g. '5' for fraction 5.
>Performed Workitem Code Sequence	(0040,4019)	SQ	Always provided. Contains up to 3 items (imaging, registration, treatment)
>>Code Value	(0008,0100)	SH	Always provided, value one of 121708, 121714, 121726. See Supplement 74 for meaning.
>>Coding Scheme Designator	(0008,0102)	SH	'DCM'
>>Code Meaning	(0008,0104)	LO	Always provided. See Supplement 74 for wording.
>Performed Procedure Step End Date	(0040,0250)	DT	Always provided
>Performed Procedure Step End Time	(0040,0251)	TM	Always provided
>Output Information Sequence	(0040,4033)	SQ	Always provided: 1st item: RT Beams Treatment Record, if successfully stored 2nd item (only if registration performed): Multi-frame True Color SC Image, if successfully stored

Attribute Name	Tag	VR	N-SET
>>Study Instance UID	(0020,000D)	UI	Always provided
>>Referenced Series Sequence	(0008,1115)	SQ	Always provided
>>>Series Instance UID	(0020,000E)	UI	Always provided
>>>Retrieve AE Title	(0008,0054)	AE	Always provided
>>>Referenced SOP Sequence	(0008,1199)	SQ	Always provided
>>>>Referenced SOP Class UID	(0008,1150)	UI	Always provided
>>>>Referenced SOP Instance UID	(0008,1155)	UI	Always provided
>Non-DICOM Output Code Sequence	(0040,4032)	SQ	Empty

3.2.3.3.3.3.3 N-SET Response Conformance

Table 37 summarizes the behavior of TomoWorkflow when encountering status codes in a Treatment End UPS N-SET response.

Table 37: Treatment End N-SET Response Status Handling Behavior

Service Status	Further Meaning	Error Code(s)	Behavior
Success	Attribute(s) modified	0000	Success – no further action
Warning	Requested optional attributes are not supported	0001	Warning code and description written to log file. Application then continues normally.
	Coerced invalid values to valid values	B304	
Failure	Refused: The UPS is not in 'IN PROGRESS' state	C310	Error code and description displayed to Operator Station user. User is asked if treatment record should be sent, and RT Beams Treatment Record C-STORE is performed if requested. Subsequent N-ACTION of UPS not performed.
	Refused: The correct Transaction UID was not provided	C301	
	Refused: The UPS may no longer be updated	C300	
	Specified SOP Instance UID is not a UPS Instance managed by this SCP	C307	

Service Status	Further Meaning	Error Code(s)	Behavior
	Refused: Not Authorized	C305	

3.2.3.3.3.3.4 N-ACTION Request Conformance

In the Final UPS N-ACTION Request, TomoWorkflow shall supply the SOP Instance UID specified in the selected worklist item. The N-ACTION request identifier information supplied by TomoWorkflow is shown in Table 38.

Table 38: Final N-ACTION Request Identifier

Action Type Name	Action Type ID	Attribute	Tag	VR	N-ACTION
Request UPS State Modification	1	Unified Procedure Step State	(0074,1000)	CS	'COMPLETED' or 'CANCELED'
		Transaction UID	(0008,1195)	UI	Transaction UID of initial UPS N-ACTION response

3.2.3.3.3.3.5 N-ACTION Response Conformance

Table 39 summarizes the behavior of TomoWorkflow when encountering status codes in a UPS N-ACTION response.

Table 39: Final N-ACTION Response Status Handling Behavior

Service Status	Further Meaning	Error Code(s)	Behavior
Success	Status modified	0000	Success – no further action
Failure	Refused: The UPS is not in 'IN PROGRESS' state	C310	Error code and description displayed to Operator Station user.
	Refused: The correct Transaction UID was not provided	C301	
	Refused: The UPS may no longer be updated	C300	
	Specified SOP Instance UID is not a UPS Instance managed by this SCP	C307	

Service Status	Further Meaning	Error Code(s)	Behavior
	Refused: Not Authorized	C305	

3.2.3.3.3.4 SOP Specific Conformance for Storage

There are no SOP-specific conformance requirements for RT Beams Treatment Record Storage or Multi-frame True Color SC Image Storage.

3.3 Network Interfaces

3.3.1 Physical Network Interface

TomoProvider, TomoUser, and TomoWorkflow are indifferent to the physical medium over which TCP/IP executes. This behavior is inherited from the Windows 2000 or Windows XP system upon which they reside. In TomoTherapy applications the physical medium will be 100BaseT or faster.

3.3.2 Additional Protocols

No additional protocols.

3.4 Configuration

3.4.1 AE Title/Presentation Address Mapping

3.4.1.1 Local AE Titles

The default AE Title for the SCP Application Entity is ‘TomoProvider’.

The AE Title for the SCU Export Application Entity is ‘TomoUser’. The AE Title is not configurable.

The default AE Title for the SCU Workflow Application Entity is ‘TomoWorkflow’.

The default AE Title for the Workflow Store SCP Application Entity (used as the C-MOVE target) is ‘TOMOWKFSTORESCP’

Table 40: AE Title Configuration Table

Application Entity	Default AE Title	Default TCP/IP Port
Storage SCP	TomoProvider	104
Export SCU	TomoUser	Not applicable
Worklist SCU	TomoWorkflow	Not applicable
Worklist Storage SCP	TOMOWKFSTORESCP	11112

The `Dicom.properties` file in the `$CONFIG` directory provides address mapping information. A mapping is permitted between the TomoProvider, its AE Title, and its port. At installation, these are defined in the `Dicom.properties` file specified above as:

```
ProviderAETitle = TomoProvider
```

```
Port = 104
```

They may be changed as required by site needs.

The `Dicom.properties` file also provides a mapping is permitted between the Worklist Storage SCP used as the C-MOVE target, its AE Title, and its port. At installation, these are defined in the `Dicom.properties` file specified above as:

```
WorkflowStoreSCPAETitle = TOMOWKFSTORESCP
```

```
WorkflowStoreSCPPort = 11112
```

They may be changed as required by site needs.

3.4.1.2 Remote AE Title/Presentation Address Mapping

Configuration of DICOM remote AE destinations is made using the “DICOM Destination Maintenance Utility” in the “DICOM options…” selection of the TomoTherapy application tools menu. This option is available on the TomoTherapy Operator Station (installed outside the treatment bunker) ,on the TomoTherapy Planning Station (typically located in the treatment planning room), and on other TomoTherapy workstations. Privileged access may be required to select this option.

Users with appropriate permissions may configure the following fields for every remote DICOM Application Entity with which the TomoUser communicates:

- Name used for selection (a descriptive name for the destination you are creating or editing)
- Application Entity Title (the AE title for the destination you are creating or editing). This information is available from the DICOM Conformance Statement of the remote equipment.
- Machine name or IP Address (the network location for the destination you are creating or editing)

- IP port (the IP Port used by the destination you are creating or editing). This information is available from the DICOM Conformance Statement of the remote equipment.
- Connection timeout (seconds) (the length of time the TomoTherapy service will attempt to connect to the remote destination). Range 0-300 seconds, default 30 seconds.
- Maximum packet size (the maximum data size of each data packet that the TomoTherapy Treatment System will export). Default 8k; most treatment planning systems accept 8k or 32k – this information is available from the DICOM Conformance Statement of the remote equipment.
- Whether this AE represents the Treatment Management System (TMS) in the user's environment. Only one DICOM AE may be identified in this way.

Options are available in the user interface to add, delete or change these configuration parameters.

Workflow DICOM Target: The remote AE destination representing the Workflow Manager SCP in the TMS is defined by selecting this option in one of the DICOM Targets defined using the Destination Maintenance Utility. This Application Entity is then used by the Operator Station as the destination for Worklist queries to the TMS, and UPS set and update operations. If a destination with this setting is not defined, the Operator Station shall not query the TMS for the patient to be treated, nor manage the state of the UPS.

Archive DICOM Target: The remote AE destination representing the archive SCP in the TMS is defined by selecting this option in one of the DICOM Targets defined using the Destination Maintenance Utility. This Application Entity is then used by the Operator Station as the destination for DICOM Storage of RT Beams Treatment Record objects and Multi-frame True Color SC Image objects. If a destination with this setting is not defined, the Operator Station shall not send treatment record and SC information to the TMS.

AutomaticTreatment Record DICOM Target: The remote AE destination representing the target to receive automatic export of the RT Beams Treatment Record is defined by selecting this option in one of the DICOM Targets on the Automatic Export tab, under the Destination Maintenance Utility. This Application Entity is then used by the Operator Station as the destination for automatic export of the RT Beams Treatment Record after every patient treatment. If a destination with this setting is not defined, the Operator Station shall not export Treatment Records automatically.

NOTE: If other DICOM targets are required by the TMS, such as those for the C-Move of the Plan or Delivery Instruction, these must be defined on the TomoTherapy Treatment System as valid DICOM destinations.

NOTE: For diagnostic purposes, the last transmitted object of a transmitted series is always stored in DICOM Part 10 format. Its default location is defined in `LogFile.properties`. The file name is `dicom.out`.

NOTE: Logs of the activities of the TomoProvider ("EDI') server are kept in the directory `c:\tomo\logs`.

NOTE: Logs of the activities of the TomoUser ('EXP') server are kept in the directory `c:\tomo\logs`.

NOTE: Logs of the activities of the TomoWorkflow ('WFL') server are kept in the directory `c:\tomo\logs`.

3.4.2 Parameters

Table 41: Configuration Parameters Table

Parameter	Configurable (Yes/No)	Default Value
TomoProvider SCP		
`DebugPath` (path for location of debugging files)	Yes	c:/tomo/logs (configurable in $CONFIG/Dicom.properties on TomoTherapy Data Server)
`DebugLevel` (level of debugging information generated): -1 = no debugging info generated 0 = DICOM debug file generated	Yes	-1 (configurable in $CONFIG/Dicom.properties on TomoTherapy Data Server)
SCP Local AE Title	Yes	TomoProvider (configurable in $CONFIG/Dicom.properties on TomoTherapy Data Server)
`Port` (SCP listening port)	Yes	104 (configurable in $CONFIG/Dicom.properties on TomoTherapy Data Server)
SCP Maximum PDU Size sent	No	8192
SCP Maximum PDU Size received	No	No limit
SCP Number of Associations	No	No limit
`VerticalDeviation`: The maximum tolerated variation (in cm) in vertical image position across the slices of an imported CT data set, as defined in the attribute Image Position (Patient) (0020,0032).	Yes	0.01
`SocketTimeout`: The SCP Remote Connection Timeout.	Yes	60 (configurable in $CONFIG/Dicom.properties on TomoTherapy Data Server)

Parameter	Configurable (Yes/No)	Default Value
TomoWorkflow SCU		
`WorkflowDebugPath` (path for location of debugging files)	Yes	c:/tomo/logs (configurable in $CONFIG/Dicom.properties on Data Server)
`WorkflowDebugLevel` (level of debugging information generated): -1 = no debugging info generated 0 = DICOM debug file generated	Yes	-1 (configurable in $CONFIG/Dicom.properties on Data Server)
SCU Local AE Title	Yes	TomoWorkflow (configurable in $CONFIG/Dicom.properties on Data Server)
`WorkflowStoreSCPAETitle` (Workflow Store SCP AE Title)	Yes	TOMOWKFSTORESCP (configurable in $CONFIG/Dicom.properties on Data Server)
`WorkflowStoreSCPPort` (Workflow Store SCP IP Port)	Yes	11112 (configurable in $CONFIG/Dicom.properties on Data Server)
TomoUser SCU and TomoWorkflow SCU		
SCU Maximum PDU Size received	No	No limit
SCU Maximum PDU Size sent	Yes	8192 (configurable from DICOM Destination Maintenance Utility)
SCU Remote AE Title	Yes	No default (configurable from DICOM Destination Maintenance Utility)
SCU Remote IP address/machine name	Yes	No default (configurable from DICOM Destination Maintenance Utility)
SCU Remote IP Port	Yes	104 (configurable from DICOM Destination Maintenance Utility)

Parameter	Configurable (Yes/No)	Default Value
SCU Remote Connection Timeout	Yes	30 seconds (configurable from DICOM Destination Maintenance Utility)
TomoTherapy Planning Station and Operator Station		
Archive DICOM Target name used for RT Plan store (PS), RT Beams Treatment Record store and Multi-frame True Color Secondary Capture Image store (OS)	Yes	No default (configurable from DICOM Destination Maintenance Utility by selecting the option from one of the DICOM Target AEs)
TMS (workflow) DICOM Target name used for UPS workflow instructions.	Yes	No default (configurable from DICOM Destination Maintenance Utility by defining the DICOM Target AE of the TMS)
Multi-frame True Color Secondary Capture Image storage DICOM Target name, used for ‘Operator Station registration ‘Export Screen’ functionality	Yes	No default (configurable from ‘Configure Registration Image’ Utility in workstation tools menu by selecting the DICOM option and target AE Title)

4 MEDIA INTERCHANGE

TomoTherapy applications do not support DICOM Media Interchange.

5 SUPPORT OF CHARACTER SETS

TomoProvider supports SOP Instances containing either the DICOM default character set (ISO 646) or the DICOM Latin-1 character set (ISO_IR 100) as defined in PS 3.5 (see also PS 3.3, Section C.12.1.1.2). TomoUser and TomoWorkflow create instances containing the DICOM Latin-1 character set (ISO_IR 100).

6 SECURITY

TomoTherapy applications do not support DICOM Security Profiles.

7 ANNEXES

7.1 IOD Contents

7.1.1 Created SOP Instances

Table 42: Abbreviations Used for Presence of Values

Abbreviation	Meaning
VNAP	Value Not Always Present (attribute sent zero length if no value is present)
ANAP	Attribute Not Always Present
ALWAYS	Always present with a value
SNAP	Sequence Not Always Present
EMPTY	Attribute is sent without a value
ABSENT	Attribute never present

Note: All attributes are generated automatically.

7.1.1.1 Common Modules

The following tables outline attribute mappings for modules where those mappings are common to two or more supported storage IODs.

Table 43: Patient Module

Attribute Name	Element Tag	Type	Usage notes
Patient's Name	(0010,0010)	2	ALWAYS: The selected patient's name
Patient ID	(0010,0020)	2	ALWAYS: The selected patient's MRN (medical record number)
Patient's Birth Date	(0010,0030)	2	VNAP: The selected patient's birth date
Patient's Sex	(0010,0040)	2	VNAP: For the selected patient: 'M' if Male, 'F' if Female, 'O' if Other, not valued if unknown
Patient's Birth Time	(0010,0032)	3	ANAP: The selected patient's time of birth

Attribute Name	Element Tag	Type	Usage notes
Other Patient IDs	(0010,1000)	3	ANAP: The selected patient's other IDs
Other Patient Names	(0010,1001)	3	ANAP: The selected patient's other names
Ethnic Group	(0010,2160)	3	ANAP: The selected patient's ethnic group
Patient Comments	(0010,4000)	3	ANAP: Patient comments that may be associated with the patient record

Table 44: General Study Module

Attribute Name	Element Tag	Type	Usage notes
Study Instance UID	(0020,000D)	1	ALWAYS: The Study Instance UID for the original study CT images. For RT Beams Treatment Record, will be overridden by the Study Instance UID received from the OIS, if supplied.
Study Date	(0008,0020)	2	ALWAYS (except RT Beams Treatment Record): The date of creation for the original study CT images (EMPTY for RT Beams Treatment Record)
Study Time	(0008,0030)	2	ALWAYS (except RT Beams Treatment Record): The time of creation for the original study CT images (EMPTY for RT Beams Treatment Record)
Referring Physician's Name	(0008,0090)	2	ANAP: The referring physician for the original study CT images (EMPTY for RT Beams Treatment Record)
Study ID	(0020,0010)	2	ALWAYS (except RT Beams Treatment Record): TomoTherapy Disease Name (EMPTY for RT Beams Treatment Record)
Accession Number	(0008,0050)	2	ANAP: The accession number for the original study CT images (EMPTY for RT Beams Treatment Record)

Attribute Name	Element Tag	Type	Usage notes
Study Description	(0008,1030)	3	ALWAYS (except RT Beams Treatment Record): The study description for the original study CT images, otherwise 'TomoTherapy Patient Disease' if absent
Physician(s) of Record	(0008,1048)	3	ANAP: The attending oncologist for the original study CT images
No other fields sent from the General Study Module			

Table 45: Patient Study Module

Attribute Name	Element Tag	Type	Usage notes
Admitting Diagnoses Description	(0008,1080)	3	ANAP: The admitting diagnoses description for the original study CT images
Patient's Age	(0010,1010)	3	ANAP: The patient's age for the original study CT images
Patient's Size	(0010,1020)	3	ANAP: The patient's height in meters for the original study CT images
Patient's Weight	(0010,1030)	3	ANAP: The patient's weight in kg for the original study CT images.
Additional Patient's History	(0010,21B0)	3	ANAP: Additional patient's history for the original study CT images
No other fields sent from the Patient Study Module			

Table 46: General Equipment Module

Attribute Name	Element Tag	Type	Usage notes
Manufacturer	(0008,0070)	2	ALWAYS: Manufacturer of equipment that created object. Value 'TomoTherapy Incorporated' for all exported objects.

Attribute Name	Element Tag	Type	Usage notes
Institution Name	(0008,0080)	3	ANAP: Name of institution that created object. Institution where Accuray equipment is installed. Supplied by all exported objects if Institution Name is configured on Data Server.
Station Name	(0008,1010)	3	ANAP: The name of the treatment system (‘machine name’) that created object. Used by TMS to support subsequent worklist queries. Present for RT Doses, RT Plans, RT Beams Treatment Records, and Multi-frame True Color SC Images, and CTrue Images, absent for exported kVCT images and RT Structure Sets.
Manufacturer’s Model Name	(0008,1090)	3	ALWAYS: The machine model type associated with the equipment that created object.
Device Serial Number	(0018,1000)	3	ANAP: The device serial number associated with the equipment that created object. Value of treatment system serial number, if available in database. See Station Name for objects that may supply this attribute.
Software Versions	(0018,1020)	3	ALWAYS: The device software versions associated with the equipment that created object. Value of treatment system software version for all exported objects. Multiplicity is always 1.
No other fields sent from the General Equipment Module			

7.1.1.2 CT Image Storage Class

The following tables identify the entities for each IOD module for a CT Image Store Request operation. The table indicates which IOD Entities have fields that will be retrieved from the TomoTherapy Data Server to construct the object(s) for the C-STORE operation.

Note that all type 3 fields are populated if the field value is non-blank. If it is blank, it will not be sent.

Table 47: CT Image IOD Entities

Entity Name	Module Name	Usage	Reference
Patient	Patient	M	Table 43
	Clinical Trial Subject	U	Not used
Study	General Study	M	Table 44
	Patient Study	U	Table 45
	Clinical Trial Study	U	Not used
Series	General Series	M	Table 48
	Clinical Trial Series	U	Not used
Frame of Reference	Frame of Reference	M	Table 49
Equipment	General Equipment	M	Table 46
Image	General Image	M	Table 50
	Image Plane	M	Table 51
	Image Pixel	M	Table 52
	Contrast/bolus	C	Table 53
	Device	U	Not used
	Specimen	U	Not used
	CT Image	M	Table 54
	Overlay Plane	U	Not used
	VOI LUT	U	Not used
	SOP Common	M	Table 55

Table 48: General Series Module

Attribute Name	Element Tag	Type	Usage notes
Modality	(0008,0060)	1	ALWAYS: Value ‘CT’
Series Instance UID	(0020,000E)	1	ALWAYS: The TomoTherapy UID from the image set database object being transmitted
Series Number	(0020,0011)	2	ALWAYS: Value equal to the Series Date month and day values (with any leading zero removed), concatenated with the Series Time hour, minute, and whole-number second portions, e.g. ‘1231235959’.
Laterality	(0020,0060)	2C	ABSENT
Series Date	(0008,0021)	3	ALWAYS: The date the image was created in the TomoTherapy database
Series Time	(0008,0031)	3	ALWAYS: The time the image was created in the TomoTherapy database
Series Description	(0008,103E)	3	ALWAYS: Value ‘kVCT Image Set’ for kV images, ‘CTrue Image Set’ for CTrue Images.
Patient Position	(0018,5100)	2C	ALWAYS: The patient position for the image being transmitted: Value one of ‘HFS’, ‘FFS’, ‘HFP’, or ‘FFP’.
No other fields sent from the General Series Module			

Table 49: Frame of Reference Module

Attribute Name	Element Tag	Type	Usage notes
Frame of Reference UID	(0020,0052)	1	ALWAYS: For planning data sets, equal to the original Frame of Reference UID from the images transmitted to the TomoTherapy System. For CTrue Image data sets, equal to the TomoTherapy UID from the image set being transmitted suffixed with '.1.1'.
Position Reference Indicator	(0020,1040)	2	ANAP: The Position Reference Indicator associated with the original study images
No other fields sent from the Frame of Reference Module			

Table 50: General Image Module

Attribute Name	Element Tag	Type	Usage notes
Instance Number	(0020,0013)	2	ALWAYS: TomoTherapy Image slice number for this slice, starting at 1.
Image Type	(0008,0008)	1	See CT Image Module
Acquisition Date	(0008,0022)	3	ALWAYS: Creation date of the image
Acquisition Time	(0008,0032)	3	ALWAYS: Creation time of the image
Derivation Description	(0008,2111)	3	ANAP: For resampled kVCT image sets, value "Resampled kVCT data set". Absent for all other objects.
Images in Acquisition	(0020,1002)	3	ALWAYS: Total number of slices in the image series
No other fields sent from the General Image Module			

Table 51: Image Plane Module

Attribute Name	Element Tag	Type	Usage notes
Pixel Spacing	(0028,0030)	1	ALWAYS: The pixel-to-pixel spacing from the CT image converted to mm. X and Y dimensions are provided.
Image Orientation (Patient)	(0020,0037)	1	ALWAYS: –1.0 (FFS, HFP) or 1.0 (HFS, FFP) 0.0 0.0 0.0 –1.0 (HFP, FFP) or 1.0 (HFS, FFS) 0.0
Image Position (Patient)	(0020,0032)	1	ALWAYS: The coordinates in patient space for the center of the first pixel sent in the array data, converted to mm
Slice Thickness	(0018,0050)	2	ALWAYS: The slice thickness from the CT image converted to mm
Slice Location	(0020,1041)	3	ALWAYS: The longitudinal location of the slice in TomoTherapy machine coordinates, converted to mm. This is equivalent to the position along the IEC Yt or Yf axis, but where the location origin coincides with the origin of the DICOM Patient Coordinate System. Note that slice location is of opposite sign to the contour z (DICOM) coordinates for HFS and HFP patients.
No other fields sent from the Image Plane Module			

Table 52: Image Pixel Module

Attribute Name	Element Tag	Type	Usage notes
Samples per Pixel	(0028,0002)	1	See CT Image Module
Photometric Interpretation	(0028,0004)	1	See CT Image Module
Rows	(0028,0010)	1	ALWAYS: The number of rows in the image
Columns	(0028,0011)	1	ALWAYS: The number of columns in the image
Bits Allocated	(0028,0100)	1	See CT Image Module
Bits Stored	(0028,0101)	1	See CT Image Module
High Bit	(0028,0102)	1	See CT Image Module
Pixel Representation	(0028,0103)	1	ALWAYS: Value 0 (unsigned data)
Pixel Data	(7FE0,0010)	1	ALWAYS: The 16-bit array data for the given slice
No other fields sent from the Image Pixel Module. Duplicate field definitions in the CT Image Module are described in the CT Image Module.			

Table 53: Contrast/bolus Module

Attribute Name	Element Tag	Type	Usage notes
Contrast/Bolus Agent	(0018,0010)	2	EMPTY
No other fields sent from the Contrast/bolus Module			

Table 54: CT Image Module

Attribute Name	Element Tag	Type	Usage notes
Image Type	(0008,0008)	1	ALWAYS: 1st value: ‘ORIGINAL’ 2nd value: ‘PRIMARY’ if CTrue Image, ‘SECONDARY’ otherwise 3rd value: ‘AXIAL’

Attribute Name	Element Tag	Type	Usage notes
Samples per Pixel	(0028,0002)	1	ALWAYS: Value 1
Photometric Interpretation	(0028,0004)	1	ALWAYS: Value ‘MONOCHROME2’
Bits Allocated	(0028,0100)	1	ALWAYS: Value 16
Bits Stored	(0028,0101)	1	ALWAYS: Value 16
High Bit	(0028,0102)	1	ALWAYS: Value 15
Rescale Intercept	(0028,1052)	1	ALWAYS: Value -1024
Rescale Slope	(0028,1053)	1	ALWAYS: Value 1.0
KVP	(0018,0060)	2	VNAP: Value 6000.0 for CTrue Image data. EMPTY for kVCT images.
Acquisition Number	(0020, 0012)	2	EMPTY
No other fields sent from the CT Image Module. Duplicate field definitions from the Image Pixel Module are described in this module.			

Table 55: SOP Common Module

Attribute Name	Element Tag	Type	Usage notes
SOP Class UID	(0008,0016)	1	ALWAYS: Value = ‘1.2.840.10008.5.1.4.1.1.2’
SOP Instance UID	(0008,0018)	1	ALWAYS: The TomoTherapy UID from the image set database object being transmitted suffixed with ‘.’ and the slice number.
Specific Character Set	(0008,0005)	1C	ALWAYS: Value ‘ISO_IR 100’
Instance Creation Date	(0008,0012)	3	ALWAYS: Date of actual object construction (object send time)
Instance Creation Time	(0008,0013)	3	ALWAYS: Time of actual object construction (object send time)
No other fields sent from the SOP Common Module			

7.1.1.3 RT Dose Storage Class

The following tables identify the entities for each IOD module for a RT Dose Store Request operation. The table indicates which IOD Entities have fields that will be retrieved from the TomoTherapy Data Server to construct the object(s) for the C-STORE operation.

Note that all type 3 fields are populated if the field value is non-blank. If it is blank, it will not be sent.

Table 56: RT Dose IOD Entities

Entity Name	Module Name	Usage	Reference
Patient	Patient	M	Table 43
	Clinical Trial Subject	U	Not used
Study	General Study	M	Table 44
	Patient Study	U	Table 45
	Clinical Trial Study	U	Not used
Series	RT Series	M	Table 57
	Clinical Trial Series	U	Not used
Frame of Reference	Frame of Reference	M	Table 58
Equipment	General Equipment	M	Table 46
Dose	General Image	C	Table 59
	Image Plane	C	Table 60
	Image Pixel	C	Table 61
	Multi-Frame	C	Table 62
	Overlay Plane	U	Not used
	Multi-Frame Overlay	U	Not used
	Modality LUT	U	Not used
	RT Dose	M	Table 63
	RT DVH	U	Table 64 (absent for Tomo QA plan doses)

Entity Name	Module Name	Usage	Reference
	Structure Set	C	Not used
	ROI Contour	C	Not used
	RT Dose ROI	C	Not used
	SOP Common	M	Table 65
	Frame Extraction	C	Not used

Table 57: RT Series Module

Attribute Name	Element Tag	Type	Usage notes
Modality	(0008,0060)	1	ALWAYS: Value ‘RTDOSE’
Series Instance UID	(0020,000E)	1	ALWAYS: The TomoTherapy UID from the dose image being transmitted, suffixed with ‘.1’
Series Number	(0020,0011)	2	ALWAYS: Value equal to the month and day values of the database creation date (with any leading zero removed), concatenated with the hour, minute, and whole-number second values of the database creation time, e.g. ‘1231235959’.
Series Description	(0008,103E)	3	ALWAYS: Value one of ‘TomoTherapy Planned Dose’, ‘TomoTherapy Reconstructed Dose’, ‘TomoTherapy Cumulative Dose’, or ‘TomoTherapy Delivery QA Dose’. Some of these types may not be supported by the current release.
No other fields sent from the RT Series Module			

Table 58: Frame of Reference Module

Attribute Name	Element Tag	Type	Usage notes
Frame of Reference UID	(0020,0052)	1	ALWAYS: For plan-based doses, value is the same Frame of Reference UID (0020,0052) as that found in the CT data set upon which is based the structure set and plan used to calculate the RT Dose object values. For doses referenced to CTrue images, value is the TomoTherapy image set UID suffixed with ".1.1".
Position Reference Indicator	(0020,1040)	2	EMPTY
No other fields sent from the Frame of Reference Module			

Table 59: General Image Module

Attribute Name	Element Tag	Type	Usage notes
Instance Number	(0020,0013)	2	See RT Dose Module
Image Type	(0008,0008)	3	ALWAYS: 1st value: ORIGINAL 2nd value: PRIMARY 3rd value: AXIAL
Acquisition Date	(0008,0022)	3	ALWAYS: Creation date of the image
Acquisition Time	(0008,0032)	3	ALWAYS: Creation time of the image
Referenced Image Sequence	(0008,1140)	3	ALWAYS: This sequence references the CT image set upon which the plan referenced by this dose is based. Number of items = number of slices in CT image set. See Table 68, Note 1.
>Referenced SOP Class UID	(0008,1150)	1	ALWAYS: Value = '1.2.840.10008.5.1.4.1.1.2'

Attribute Name	Element Tag	Type	Usage notes
>Referenced SOP Instance UID	(0008,1160)	1	ALWAYS: The TomoTherapy UID from the CT image set database object, suffixed with '.' and the slice number.
Images in Acquisition	(0020,1002)	3	ALWAYS: Value 1
No other fields sent from the General Image Module			

Table 60: Image Plane Module

Attribute Name	Element Tag	Type	Usage notes
Pixel Spacing	(0028,0030)	1	ALWAYS: The pixel-to-pixel spacing from the dose image, converted to mm. X and Y dimensions are provided.
Image Orientation (Patient)	(0020,0037)	1	ALWAYS: Values: –1.0 (FFS, HFP) or 1.0 (HFS, FFP) 0.0 0.0 0.0 –1.0 (HFP, FFP) or 1.0 (HFS, FFS) 0.0
Image Position (Patient)	(0020,0032)	1	ALWAYS: The coordinates in patient space for the center of the first pixel sent in the array data, converted to mm. This pixel lies in the first pixel plane transmitted. This pixel plane will be in the same location as the first slice of the underlying CT data referenced in the Referenced Image Sequence (0008,1140).
Slice Thickness	(0018,0050)	2	ALWAYS: The slice thickness from the dose image, converted to mm

Attribute Name	Element Tag	Type	Usage notes
Slice Location	(0020,1041)	3	ALWAYS: The longitudinal location of the first slice sent in TomoTherapy machine coordinates, converted to mm. This is equivalent to the position along the IEC Yt or Yf axis, but where the location origin coincides with the origin of the DICOM Patient Coordinate System. Note that slice location is of opposite sign to the contour z (DICOM) coordinates for HFS and HFP patients.
No other fields sent from the Image Plane Module			

Table 61: Image Pixel Module

Attribute Name	Element Tag	Type	Usage notes
Samples per Pixel	(0028,0002)	1	See RT Dose Module
Photometric Interpretation	(0028,0004)	1	See RT Dose Module
Rows	(0028,0010)	1	ALWAYS: The number of rows in the image
Columns	(0028,0011)	1	ALWAYS: The number of columns in the image
Bits Allocated	(0028,0100)	1	See RT Dose Module
Bits Stored	(0028,0101)	1	See RT Dose Module
High Bit	(0028,0102)	1	See RT Dose Module
Pixel Representation	(0028,0103)	1	See RT Dose Module
Pixel Data	(7FE0,0010)	1	ALWAYS: The array data for the 3D dose array. This data will contain the same number of pixels as the entire series of underlying CT data referenced in the Referenced Image Sequence (0008,1140).
No other fields sent from the Image Pixel Module			

Table 62: Multi-Frame Module

Attribute Name	Element Tag	Type	Usage notes
Number of Frames	(0028,0008)	1	ALWAYS: The number of axial slices in the 3D dose grid. This will equal the number of CT images referenced in the Referenced Image Sequence (0008,1140).
Frame Increment Pointer	(0028,0009)	1	ALWAYS: Value (3004,000C) (Grid Frame Offset Vector).

Table 63: RT Dose Module

Attribute Name	Element Tag	Type	Usage notes
Samples per Pixel	(0028,0002)	1C	ALWAYS: Value 1
Photometric Interpretation	(0028,0004)	1C	ALWAYS: Value 'MONOCHROME2'
Bits Allocated	(0028,0100)	1C	ALWAYS: Value 16
Bits Stored	(0028,0101)	1C	ALWAYS: Value 16
High Bit	(0028,0102)	1C	ALWAYS: Value 15
Pixel Representation	(0028,0103)	1C	ALWAYS: Value 0 (unsigned data)
Dose Units	(3004,0002)	1	ALWAYS: Value 'GY'
Dose Type	(3004,0004)	1	ALWAYS: Value 'PHYSICAL'
Instance Number	(0020,0013)	3	ALWAYS: Value 2
Dose Comment	(3004,0006)	3	ALWAYS: Plan Label of referenced plan object in TomoTherapy database.
Dose Summation Type	(3004,000A)	1	ALWAYS: Value 'PLAN' (for planned and delivery QA doses).
Referenced RT Plan Sequence	(300C,0002)	1C	ALWAYS : Number of items = 1
>Referenced SOP Class UID	(0008,1150)	1C	ALWAYS: Value '1.2.840.10008.5.1.4.1.1.481.5'

Attribute Name	Element Tag	Type	Usage notes
>Referenced SOP Instance UID	(0008,1155)	1C	ALWAYS: The UID of the RT Plan for which this dose has been calculated
Grid Frame Offset Vector	(3004,000C)	1C	ALWAYS: An array of values equal in size to the number of axial slices transmitted in the dose image. First array value = 0.0 (1st slice), second array value = location of 2nd slice relative to 1st slice (in mm), third array value = location of 3rd slice relative to 1st slice (in mm), and so on. Coordinates are in the coordinate system defined by DICOM 2009 Part 3, Section C.8.8.3.2 clause A, i.e. the z-coordinate will be opposite in sign for FFS and FFP data sets since they have a vector(cross) product with negative z.
Dose Grid Scaling	(3004,000E)	1	ALWAYS: Multiplier to be applied to dose grid data in Pixel Data to yield values in GY.
Tissue Heterogeneity Correction	(3004,0014)	3	ALWAYS: Value 'ROI_OVERRIDE' (indicates dose calculated taking into account tissue heterogeneity, with density assignments overriding pixel values if present).
No other fields sent from the RT Dose Module			

Table 64: RT DVH Module

Attribute Name	Element Tag	Type	Usage notes
Referenced Structure Set Sequence	(300C,0060)	1	ALWAYS: Number of items = 1
>Referenced SOP Class UID	(0008,1150)	1	ALWAYS: Value '1.2.840.10008.5.1.4.1.1.481.3'
>Referenced SOP Instance UID	(0008,1155)	1	ALWAYS: SOP Instance UID of RT Structure Set upon which dose is based (i.e. the structure set associated with the plan for which the dose is calculated).
DVH Sequence	(3004,0050)	1	ALWAYS: Number of items = number of ROIs in related structure set that have non-zero DVH data
>DVH Referenced ROI Sequence	(3004,0060)	1	ALWAYS: Number of items = 1
>>Referenced ROI Number	(3006,0084)	1	ALWAYS: ROI Number of ROI in referenced structure set
>>DVH ROI Contribution Type	(3004,0062)	1	ALWAYS: Value 'INCLUDED'. Portions of other ROIs located within the contour of the current ROI are included in DVH information for the current ROI. Note that this represents a change from HA3.1 and earlier, where other overlapping regions were excluded from the reported DVH region.
>DVH Type	(3004,0001)	1	ALWAYS" Value 'DIFFERENTIAL'
>Dose Units	(3004,0002)	1	ALWAYS: Value 'GY'
>Dose Type	(3004,0004)	1	ALWAYS: Value 'PHYSICAL'
>DVH Dose Scaling	(3004,0052)	1	ALWAYS: Value 1.0

Attribute Name	Element Tag	Type	Usage notes
>DVH Volume Units	(3004,0054)	1	ALWAYS: Value ‘CM3’
>DVH Number of Bins	(3004,0056)	1	ALWAYS: Number of bins for DVH curve for current ROI. For DVH curves stored in the database with a non-zero start bin index, the number of bins will be one more than the number of bins in the database, with a ‘wide’ zero-dose bin added at the start of the sequence.
>DVH Data	(3004,0058)	1	ALWAYS: Differential DVH width/volume pairs D_n,V_n. Typically there are several hundred data points for each DVH curve.
No other fields sent from the RT DVH Module			

Table 65: SOP Common Module

Attribute Name	Element Tag	Type	Usage notes
SOP Class UID	(0008,0016)	1	ALWAYS: Value ‘1.2.840.10008.5.1.4.1.1.481.2’
SOP Instance UID	(0008,0018)	1	ALWAYS: The TomoTherapy UID from the dose image being transmitted
Specific Character Set	(0008,0005)	1C	ALWAYS: Value ‘ISO_IR 100’
Instance Creation Date	(0008,0012)	3	ALWAYS: Date of actual object construction (object send time)
Instance Creation Time	(0008,0013)	3	ALWAYS: Time of actual object construction (object send time)
No other fields sent from the SOP Common Module			

7.1.1.4 RT Structure Set Storage Class

The following tables identify the entities for each IOD module for a RT Structure Set Store Request operation. The table indicates which IOD Entities have fields that will be retrieved from the TomoTherapy Data Server to construct the object(s) for the C-STORE operation.

Note that all type 3 fields are populated if the field value is non-blank. If it is blank, it will not be sent.

Table 66: RT Structure Set IOD Entities

Entity Name	Module Name	Usage	Reference
Patient	Patient	M	Table 43
	Clinical Trial Subject	U	Not used
Study	General Study	M	Table 44
	Patient Study	U	Not used
	Clinical Trial Study	U	Not used
Series	RT Series	M	Table 67
	Clinical Trial Series	U	Not used
Equipment	General Equipment	M	Table 46
Structure Set	Structure Set	M	Table 68
	ROI Contour	M	Table 69
	RT ROI Observations	M	Table 70
	Approval	U	Not used
	Audio	U	Not used
	SOP Common	M	Table 71

Table 67: RT Series Module

Attribute Name	Element Tag	Type	Usage notes
Modality	(0008,0060)	1	ALWAYS: Value ‘RTSTRUCT’
Series Instance UID	(0020,000E)	1	ALWAYS: The TomoTherapy UID from the structure set being transmitted, suffixed with ‘.1’
Series Number	(0020,0011)	2	ALWAYS: Value equal to the month and day values of the database creation date (with any leading zero removed), concatenated with the hour, minute, and whole-number second values of the database creation time, e.g. ‘1231235959’, plus 1 (to differentiate between RT Plan created at same instant).
Series Description	(0008,103E)	3	ALWAYS: Value ‘TomoTherapy Structure Set’
No other fields sent from the RT Series Module			

Table 68: Structure Set Module

Attribute Name	Element Tag	Type	Usage notes
Structure Set Label	(3006,0002)	1	ALWAYS: For disease-level structure sets, the Structure Set Label will reflect any changes to the Structure Set Label made in the planning station, otherwise, it will contain the Label from the originally imported Structure Set. For plan-level structure sets, this value will reflect any changes to the plan-level structure set label, otherwise it will contain the Plan Label for the associated RT Plan (e.g. ‘Plan_01’).

Attribute Name	Element Tag	Type	Usage notes
Structure Set Name	(3006,0004)	3	Disease-level structure sets: ANAP: the modified Structure Set description from within the TomoTherapy system, or if not modified, the Structure Set Name from the originally imported Structure Set, if present. Plan-level structure sets: ALWAYS: The modified description from within the TomoTherapy system, or if not modified, the Plan Label for the associated RT Plan (e.g. ‘Plan_01’).
Structure Set Description	(3006,0006)	3	Disease-level structure sets: ABSENT. Plan-level structure sets: ALWAYS: The Plan Label for the associated RT Plan (e.g. ‘Plan_01’).
Instance Number	(0020,0013)	3	ALWAYS: Value 3
Structure Set Date	(3006,0008)	2	ALWAYS: Date at which structure set was last modified
Structure Set Time	(3006,0009)	2	ALWAYS: Time at which structure set was last modified
Referenced Frame of Reference Sequence	(3006,0010)	3	ALWAYS: Number of items = 1
>Frame of Reference UID	(0020,0052)	1C	ALWAYS: Equal to Frame of Reference UID in CT Image Series referenced by this structure set.
>RT Referenced Study Sequence	(3006,0012)	3	ALWAYS: Number of items = 1
>>Referenced SOP Class UID	(0008,1150)	1	ALWAYS: Value ‘1.2.840.10008.3.1.2.3.1’ (Detached Study Management SOP Class)

Attribute Name	Element Tag	Type	Usage notes
>>Referenced SOP Instance UID	(0008,1155)	1	ALWAYS: Study Instance UID of CT data set upon which structure set is based
>>RT Referenced Series Sequence	(3006,0014)	1C	ALWAYS: Number of items = 1. See Note 1.
>>>Series Instance UID	(0020,000E)	1C	ALWAYS: Series Instance UID of CT data set upon which structure set is based, also corresponding to TomoTherapy UID of associated image CT data set in TomoTherapy database.
>>>Contour Image Sequence	(3006,0016)	1C	ALWAYS: Number of items = number of axial images (slices) in CT data set upon which structure set is based.
>>>>Referenced SOP Class UID	(0008,1150)	1C	ALWAYS: Value '1.2.840.10008.5.1.4.1.1.2' (CT Image Storage SOP Class)
>>>>Referenced SOP Instance UID	(0008,1155)	1C	ALWAYS: SOP Instance UID of one of the images upon which structure set is based, also corresponding to TomoTherapy UID of CT data set in TomoTherapy database suffixed with '.' followed by the image number. All series images will be referenced here (even if one or more images contain no contours).
Structure Set ROI Sequence	(3006,0020)	3	ALWAYS: Number of items = number of ROIs in TomoTherapy structure set, including any points of interest (POIs) defined on the TomoTherapy system. See Note 2

Attribute Name	Element Tag	Type	Usage notes
>ROI Number	(3006,0022)	1C	ALWAYS: Sequential index starting at 1, with ROIs listed first, then POIs. These indices are not necessarily the same as the TomoTherapy ROI (structure) Number.
>Referenced Frame of Reference UID	(3006,0024)	1C	ALWAYS: Value encoded in Frame of Reference UID (0020,0052) in unique item of Referenced Frame of Reference Sequence in this module.
>ROI Name	(3006,0026)	2C	ALWAYS: TomoTherapy ROI name for regions or POI name for points
>ROI Generation Algorithm	(3006,0036)	2C	ALWAYS: Value = 'MANUAL'
No other fields sent from the Structure Set Module			

NOTE 1: After the TomoTherapy System has received them, kVCT image sets may be modified for planning purposes, in particular for couch removal and density override. TomoTherapy RT Structure Set and RT Dose objects reference an image set according to the following rules:

If an image containing one or more density overrides (a 'final modified associated image') is present, the TomoTherapy System references that image set, otherwise

If a couch removal image (a 'modified associated image') is present, the TomoTherapy System references that image set, otherwise

The TomoTherapy System references the image set originally generated by resampling the imported diagnostic image set (an 'associated image').

When exporting RT Structure Set data, it is important to ensure that the correct kVCT image set is selected in the export dialog, so that the RT Structure Set UID link will reference an existing image set when processed by the receiving application. In general this will be the 'KVCT – Patient Plan' image set located under the Structure Set that is itself stored under the plan. If another image set is selected, in general it will however have the same Frame of Reference, providing third-party systems the potential to display the selected series with the plan and structure set.

NOTE 2: If there is an ROI in the structure set with no contour points, it will not be exported and is not included in the Structure Set ROI Sequence nor the ROI Contour Sequence.

Table 69: ROI Contour Module

Attribute Name	Element Tag	Type	Usage notes
ROI Contour Sequence	(3006,0039)	1	ALWAYS: Number of items = sum of number of regions and number of points in TomoTherapy structure set
>Referenced ROI Number	(3006,0084)	1	ALWAYS: Corresponding ROI Number in Structure Set Module
>ROI Display Color	(3006,002A)	3	ALWAYS: RGB representation of color assigned to region or point
>Contour Sequence	(3006,0040)	3	ALWAYS: Number of items = number of contours in region, or one (1) for points
>>Contour Image Sequence	(3006,0016)	3	ANAP: Always present with number of items = 1 for regions. Present with number of items = 1 for a point if it lies on a slice, otherwise absent.
>>>Referenced SOP Class UID	(0008,1150)	1C	ALWAYS (if sequence present): Value '1.2.840.10008.5.1.4.1.1.2' (CT Image Storage SOP Class)
>>>Referenced SOP Instance UID	(0008,1155)	1C	ALWAYS (if sequence present): SOP Instance UID of the image upon which contour is based, also corresponding to TomoTherapy UID of CT data set in TomoTherapy database suffixed with '.' followed by the image number.
>>Contour Geometric Type	(3006,0042)	1C	ALWAYS: Value 'CLOSED_PLANAR' (for regions) or 'POINT' (for points)
>>Contour Slab Thickness	(3006,0044)	3	ANAP: For regions, value equal to inter-slice spacing of CT data set. Attribute absent for points.

Attribute Name	Element Tag	Type	Usage notes
>>Contour Offset Vector	(3006,0045)	3	ANAP: For regions, value (0.0, 0.0, 0.0). Attribute absent for points.
>>Number of Contour Points	(3006,0046)	3	ALWAYS: Number of points (triplets) in contour data. Always 1 for points.
>>Contour Data	(3006,0050)	1C	ALWAYS: Sequence of (x,y,z) triplets defining contour or point in patient-based coordinate system
No other fields sent from the ROI Contour Module			

Table 70: RT ROI Observations Module

Attribute Name	Element Tag	Type	Usage notes
RT ROI Observations Sequence	(3006,0080)	1	ALWAYS: Number of items = sum of number of regions and number of points in TomoTherapy structure set
>Observation Number	(3006,0082)	1	ALWAYS: Corresponding ROI Number in Structure Set Module
>Referenced ROI Number	(3006,0084)	1	ALWAYS: Corresponding ROI Number in Structure Set Module
>RT ROI Interpreted Type	(3006,00A4)	2	VNAP: ROIs: Original RT ROI Interpreted Type of imported ROIs. An ROI with a name equal to “couch” (case-insensitive) will be assigned an RT ROI Interpreted Type of ‘SUPPORT’. Points: A point will be assigned a value of ‘MARKER’ for fiducial points, ‘ISOCENTER’ if the ROI Name (3006,0026) contains the string ‘isocenter’ or isocentre’ (ignoring case), or ‘DOSE_REGION’ otherwise.

Attribute Name	Element Tag	Type	Usage notes
			If the interpreted type for the ROI or point is not known, an observation will still be included with this attribute not valued (EMPTY).
>ROI Interpreter	(3006,00A6)	2	EMPTY
>ROI Physical Properties Sequence	(3006,00B0)	3	ANAP: Sequence will be present if ROI is a region and has a density override
>>ROI Physical Property	(3006,00B2)	1C	ANAP: Present if ROI is a region and has a density override, Value 'REL_ELEC_DENSITY'.
>>ROI Physical Property Value	(3006,00B4)	1C	ANAP: Present if ROI is a region and has a density override. Value equal to assigned relative electron density.
No other fields sent from the RT ROI Observations Module			

Table 71: SOP Common Module

Attribute Name	Element Tag	Type	Usage notes
SOP Class UID	(0008,0016)	1	ALWAYS: Value '1.2.840.10008.5.1.4.1.1.481.3'
SOP Instance UID	(0008,0018)	1	ALWAYS: The TomoTherapy UID from the structure set being transmitted
Specific Character Set	(0008,0005)	1C	ALWAYS: Value 'ISO_IR 100'
Instance Creation Date	(0008,0012)	3	ALWAYS: Date of actual object construction (object send time)
Instance Creation Time	(0008,0013)	3	ALWAYS: Time of actual object construction (object send time)
No other fields sent from the SOP Common Module			

7.1.1.5 RT Plan Storage Class

The following tables identify the entities for each IOD module for a RT Plan Store Request operation. The table indicates which IOD Entities have fields that will be retrieved from the TomoTherapy Data Server to construct the object(s) for the C-STORE operation.

Note that all type 3 fields are populated if the field value is non-blank. If it is blank, it will not be sent.

Table 72: RT Plan IOD Entities

Entity Name	Module Name	Usage	Reference
Patient	Patient	M	Table 43
	Clinical Trial Subject	U	Not used
Study	General Study	M	Table 44
	Patient Study	U	Not used
	Clinical Trial Study	U	Not used
Series	RT Series	M	Table 73
	Clinical Trial Series	U	Not used
Frame of Reference	Frame of Reference	U	Table 74
Equipment	General Equipment	M	Table 46
Plan	RT General Plan	M	Table 75
	RT Prescription	U	Table 76 (absent for Tomo QA plans)
	RT Tolerance Tables	U	Not used
	RT Patient Setup	U	Table 78
	RT Fraction Scheme	U	Table 79
	RT Beams	C	Table 80
	RT Brachy Application Setups	C	Not used
	Approval	U	Table 81
	SOP Common	M	Table 82

Table 73: RT Series Module

Attribute Name	Element Tag	Type	Usage notes

Modality	(0008,0060)	1	ALWAYS: Value ‘RTPLAN’
Series Instance UID	(0020,000E)	1	ALWAYS: The TomoTherapy UID from the plan being transmitted.
Series Number	(0020,0011)	2	ALWAYS: Value equal to the month and day values of the database creation date (with any leading zero removed), concatenated with the hour, minute, and whole-number second values of the database creation time, e.g. ‘1231235959’.
Series Description	(0008,103E)	3	ALWAYS: Value ‘TomoTherapy Plan’
No other fields sent from the RT Series Module			

Table 74: Frame of Reference Module

Attribute Name	Element Tag	Type	Usage notes
Frame of Reference UID	(0020,0052)	1	ALWAYS: Value is the same Frame of Reference UID (0020,0052) as that found in the CT data set upon which the plan is based.
Position Reference Indicator	(0020,1040)	2	EMPTY
No other fields sent from the Frame of Reference Module			

Table 75: RT General Plan Module

Attribute Name	Element Tag	Type	Usage notes
RT Plan Label	(300A,0002)	1	ALWAYS: TomoTherapy plan label (e.g. 'Plan_01')
RT Plan Name	(300A,0003)	3	ALWAYS: TomoTherapy plan label (e.g. 'Plan_01')
RT Plan Description	(300A,0004)	3	ALWAYS: TomoTherapy plan label (e.g. 'Plan_01')
Instance Number	(0020,0013)	3	ALWAYS: Value 5
Operators' Name	(0008,1070)	2	ALWAYS: TomoTherapy user
RT Plan Date	(300A,0006)	2	ALWAYS: Date at which user approved the plan
RT Plan Time	(300A,0007)	2	ALWAYS: Time at which user approved the plan
Plan Intent	(300A,000A)	3	ANAP: Value "VERIFICATION" for QA plans, otherwise absent
Treatment Sites	(300A,000B)	3	ANAP: List of treatment sites, if known
RT Plan Geometry	(300A,000C)	1	ALWAYS: Value 'PATIENT'

Attribute Name	Element Tag	Type	Usage notes
Referenced Structure Set Sequence	(300C,0060)	1C	ALWAYS: Number of items = 1
>Referenced SOP Class UID	(0008,1150)	1C	ALWAYS: Value ‘1.2.840.10008.5.1.4.1.1.481.3’
>Referenced SOP Instance UID	(0008,1155)	1C	ALWAYS: The TomoTherapy UID from the structure set upon which the plan is based
Referenced Dose Sequence	(300C,0080)	3	ANAP: Present if a dose has been computed for this plan (Number of items = 1)
>Referenced SOP Class UID	(0008,1150)	1C	ALWAYS: Value ‘1.2.840.10008.5.1.4.1.1.481.2’
>Referenced SOP Instance UID	(0008,1155)	1C	ALWAYS: The TomoTherapy UID of the computed dose
Referenced RT Plan Sequence	(300C,0002)	3	ANAP: Present if for QA plans. Number of items = 1
>Referenced SOP Class UID	(0008,1150)	1C	ALWAYS: Value ‘1.2.840.10008.5.1.4.1.1.481.5’
>Referenced SOP Instance UID	(0008,1155)	1C	ALWAYS: The UID of the RT Plan for the machine for which this instance of the QA plan is based.
>RT Plan Relationship	(300A,0055)	1C	ALWAYS: Value ‘VERIFIED_PLAN’
No other fields sent from the RT General Plan Module			

Table 76: RT Prescription Module

Attribute Name	Element Tag	Type	Usage notes
Prescription Description	(300A,000E)	3	English-language description of prescription, e.g. “60.0% of the NasoPh-PTV volume receives at least 65.0 Gy”
Dose Reference Sequence	(300A,0010)	3	ALWAYS: Number of items = total number of target and sensitive structure constraints that were used in the optimization, i.e. had the “Use” box checked, including those having directional or complete blocking.
>Dose Reference Number	(300A,0012)	1C	ALWAYS: Sequential number (starting at 1) identifying this dose reference. No semantics are associated with this value.
>Dose Reference Structure Type	(300A,0014)	1C	ALWAYS: Value ‘VOLUME’
>Dose Reference Description	(300A,0016)	3	ALWAYS: Value is one of: “Target” “Sensitive Structure”
>Referenced ROI Number	(3006,0084)	1C	ALWAYS: ROI Number of target or sensitive structure in Structure Set Module of referenced structure set
>Dose Reference Type	(300A,0020)	1C	ALWAYS: Value ‘TARGET’ for tumor constraint, or ‘ORGAN_AT_RISK’ for sensitive structure constraint. Obtained from use in optimization process, not original ROI Interpreted Type.
>Constraint Weight	(300A,0021)	3	ALWAYS: Overall Importance of Target or sensitive structure
>Target Minimum Dose	(300A,0025)	3	ANAP: Minimum Dose to Tumor. See Table 77 for usage.

Attribute Name	Element Tag	Type	Usage notes
>Target Prescription Dose	(300A,0026)	3	ANAP: DVH Dose to Tumor. See Table 77 for usage.
>Target Maximum Dose	(300A,0027)	3	ANAP: Maximum Dose to Tumor. See Table 77 for usage.
>Target Underdose Volume Fraction	(300A,0028)	3	ANAP: Fraction of tumor permitted to receive less than the prescribed dose. See Table 77 for usage. Value is 1.0 – (volume percentage DVH Dose to Tumor divided by 100).
>Organ at Risk Full-volume Dose	(300A,002A)	3	ANAP: Maximum Dose to Sensitive Structure. See Table 77 for usage.
>Organ at Risk Maximum Dose	(300A,002C)	3	ANAP: DVH Dose to Sensitive Structure. See Table 77 for usage.
>Organ at Risk Overdose Volume Fraction	(300A,002D)	3	ANAP: DVH Volume percentage to Sensitive Structure, divided by 100.0. See Table 77 for usage.
>Private Creator	(300D,0010)	3	ALWAYS: Value ‘TOMO_HA_01’
>Tomo Structure Blocking	(300D,1010)	3	ALWAYS: Indicates whether structure is blocked from receiving radiation. Value is one of: ‘NONE’ (no structure blocking) ‘UPSTREAM_PRIMARY’ (primary fluence reaching structure before reaching the target is blocked) ‘ALL_PRIMARY’ (all primary fluence is prevented from traversing the structure) TOMOTHERAPY PRIVATE ATTRIBUTE.

Attribute Name	Element Tag	Type	Usage notes
>Tomo Overlap Precedence	(300D,1012)	3	ALWAYS: Integer (1-n) used to resolve ownership of voxels from two ROIs that overlap (i.e. voxels that belong to more than one structure). In this case, voxels belong to the structure with the smallest precedence value (greatest precedence). TOMOTHERAPY PRIVATE ATTRIBUTE.
>Tomo Target Minimum Dose Penalty	(300D,1016)	3	Optimization penalty applied to not achieving Target Minimum Dose. TOMOTHERAPY PRIVATE ATTRIBUTE.
>Tomo Target Maximum Dose Penalty	(300D,1017)	3	Optimization penalty applied to exceeding Target Maximum Dose. TOMOTHERAPY PRIVATE ATTRIBUTE.
>Tomo Organ at Risk Maximum Dose Penalty	(300D,1018)	3	Optimization penalty applied to not achieving Organ At Risk Maximum Dose. This is known as the “DVH Point Penalty” in TomoTherapy applications. TOMOTHERAPY PRIVATE ATTRIBUTE.
>Tomo Organ at Risk Full-volume Dose Penalty	(300D,1019)	3	Optimization penalty applied to exceeding Organ At Risk Full-volume Dose. This is known as the sensitive structure “Max Dose Penalty” in TomoTherapy applications. TOMOTHERAPY PRIVATE ATTRIBUTE.

Attribute Name	Element Tag	Type	Usage notes
>Tomo Primary Prescription Type	(300D,101B)	3	ANAP: Present if the Dose Reference is used for the primary prescription, absent otherwise. Defined Terms: 'TO_VOLUME' 'MAX_TO_TUMOR' 'MIN_TO_TUMOR' 'MEDIAN_TO_TUMOR'
Private Creator	(300D,0010)	3	ALWAYS: Value 'TOMO_HA_01'
Tomo Modulation Factor	(300D,1014)	3	ALWAYS: Actual (calculated, not requested) Modulation Factor of plan. TOMOTHERAPY PRIVATE ATTRIBUTE.
No other fields sent from the RT Prescription Module			

Mapping from TomoTherapy Constraints to DICOM

The following table indicates the DICOM constraint-related attributes that appear in the RT Plan object as a function of the constraint type.

Table 77: TomoTherapy Constraint to DICOM Mapping

Tomo Prescription/Constraint Type	DICOM attributes Used
Tumor Minimum Dose Constraint	Tomo Target Minimum Dose Penalty Target Minimum Dose
Tumor DVH Constraint	Target Prescription Dose Target Underdose Volume Fraction
Tumor Maximum Dose Constraint	Tomo Target Maximum Dose Penalty Target Maximum Dose
Sensitive Structure DVH Point	Tomo Organ At Risk Maximum Dose Penalty Organ at Risk Maximum Dose Organ At Risk Overdose Volume Fraction

Sensitive Structure Maximum Dose Point	Tomo Organ At Risk Full-volume Dose Penalty Organ at Risk Full-volume Dose

Table 78: RT Patient Setup Module

Attribute Name	Element Tag	Type	Usage notes
Patient Setup Sequence	(300A,0180)	1	ALWAYS: Number of items = 1
>Patient Setup Number	(300A,0182)	1	ALWAYS: Value 1
>Patient Position	(0018,5100)	1C	ALWAYS: The Patient Position described in the referenced CT Image objects (TomoTherapy applications do not permit "flipping" of scans for planning purposes)
>Setup Technique	(300A,01B0)	3	ALWAYS: Value 'ISOCENTRIC'
>Setup Device Sequence	(300A,01B4)	3	ALWAYS: Number of Items = 3
>>Setup Device Type	(300A,01B6)	1	ALWAYS: Value 'LASER_POINTER'
>>Setup Device Label	(300A,01B8)	1	ALWAYS: 1st item: 'RED IEC X' 2nd item: 'RED IEC Y' 3rd item: 'RED IEC Z'
>>Setup Device Parameter	(300A,01BC)	1	ALWAYS (see Note 1): 1st item: IEC X red laser position in DICOM Patient Coordinate System 2nd item: IEC Y red laser position in DICOM Patient Coordinate System 3rd item: 'IEC Z red laser position in DICOM Patient Coordinate System
No other fields sent from the RT Patient Setup Module			

NOTE 1: The coordinates of the red lasers are transmitted in the DICOM Patient Coordinate System to allow receiving applications to overlay their position on patient anatomy. These values are different in sign and magnitude from the red laser offsets displayed on the Operator Station during treatment delivery.

Table 79: RT Fraction Scheme Module

Attribute Name	Element Tag	Type	Usage notes
Fraction Group Sequence	(300A,0070)	1	ALWAYS: Number of items = number of groups of differently weighted fractions (i.e. one Fraction Group per fraction weight)
>Fraction Group Number	(300A,0171)	1	ALWAYS: Item values monotonically increasing by 1, starting at 1.
>Referenced Dose Reference Sequence	(300C,0050)	3	ALWAYS: Number of items = 1
>>Referenced Dose Reference Number	(300C,0051)	3	ALWAYS: Dose Reference Number of Target in RT Prescription Module.
>>Target Minimum Dose	(300A,0025)	3	ANAP: Dose in Gray that this Fraction Group contributes to Target in related RT Structure Set. Present if prescription type is minimum dose to tumor.
>>Target Prescription Dose	(300A,0026)	3	ANAP: Dose in Gray that this Fraction Group contributes to Target in related RT Structure Set. Present if prescription type is dose to volume or median dose to tumor.
>>Target Maximum Dose	(300A,0027)	3	ANAP: Dose in Gray that this Fraction Group contributes to Target in related RT Structure Set. Present if prescription type is maximum dose to tumor.
>>Target Underdose Volume Fraction	(300A,0028)	3	ANAP: Value 50.0. Present if prescription type is median dose to tumor.
>Number of Fractions Planned	(300A,0078)	2	ALWAYS: Number of fractions (procedures) planned for delivery for this Fraction Group. DQA plans use the associated patient plan.

Attribute Name	Element Tag	Type	Usage notes
>Number of Beams	(300A,0080)	1	ALWAYS: Helical Plans: 1 Fixed Angle plans: Number of fixed beams used for delivery of this Fraction Group. For DQA plans, this is the number of beams for the patient plan being validated.
>Referenced Beam Sequence	(300C,0004)	1C	ALWAYS: Number of items = value of Number of Beams (300A,0080)
>>Referenced Beam Number	(300C,0006)	1C	ALWAYS: Beam Number (300A,00C0) of Beam contribution recorded in this item, as defined in the Beam Sequence (300A,00B0).
>>Beam Meterset	(300A,0086)	3	ALWAYS: Scheduled beam delivery time in minutes (excludes beam warmup time), For DQA plans, this is the Beam Meterset for this beam in the patient plan being validated.
>Number of Brachy Application Setups	(300A,00A0)	1	ALWAYS: Value 0
No other fields sent from the RT Fraction Scheme Module			

Table 80: RT Beams Module

Attribute Name	Element Tag	Type	Usage notes
Tomo Plan Geometry	(300D,10A4)	3	ALWAYS: Geometry of beams in TomoTherapy plan. Defined Terms: HELICAL = Helical TomoTherapy plan FIXED_ANGLE = Fixed-angle TomoTherapy plan

Attribute Name	Element Tag	Type	Usage notes
Tomo Reference Isocenter	(300D,10A9)	3	ALWAYS: Location of TomoTherapy reference planning isocenter in DICOM PATIENT coordinate system. See Note 1.
Beam Sequence	(300A,00B0)	1	ALWAYS: For helical plans: Number of items = number of Fraction Groups (one beam encoded for each Fraction Group) For fixed angle plans: Number of items = total number of distinct fixed angle beams used across all Fraction Groups (i.e. for each Fraction Group all beams used in that group are encoded separately from other Fraction Groups).
>Beam Number	(300A,00C0)	1	ALWAYS: For helical plans: Value from 1 to number of Fraction Groups For fixed angle plans: Value from 1 to Number of distinct fixed angle beams in plan
>Beam Name	(300A,00C2)	3	ALWAYS: For helical beams: Value ‘Helical TomoTherapy Beam’ For fixed angle beams: Name of specific fixed angle beam.
>Beam Description	(300A,00C3)	3	ALWAYS: For helical beams: English-language description of delivery beam pitch and field size For fixed angle beams: ‘TomoTherapy fixed-angle beam:’ followed by beam angle in degrees.
>Beam Type	(300A,00C4)	1	ALWAYS: Value ‘DYNAMIC’
>Radiation Type	(300A,00C6)	2	ALWAYS: Value ‘PHOTON’

Attribute Name	Element Tag	Type	Usage notes
>Treatment Machine Name	(300A,00B2)	2	ALWAYS: Name of associated treatment machine
>Private Creator	(300D,0010)	3	ALWAYS: Value 'TOMO_HA_01'
>Tomo Gantry Period	(300D,1040)	3	ALWAYS (Helical Plans only): Nominal gantry rotation period (in seconds). TOMOTHERAPY PRIVATE ATTRIBUTE.
>Tomo Couch Speed	(300D,1080)	3	ALWAYS: Planned couch speed in mm/sec. TOMOTHERAPY PRIVATE ATTRIBUTE.
>Tomo Treatment Pitch	(300D,1060)	3	ALWAYS for helical beams only: Distance in mm that treatment couch progresses in one gantry rotation divided by the total opening of the Y jaw pair in mm (the 'field width'). TOMOTHERAPY PRIVATE ATTRIBUTE.
>Manufacturer	(0008,0070)	3	ALWAYS: Value 'TomoTherapy Incorporated'
>Manufacturer's Model Name	(0008,1090)	3	ALWAYS
>Device Serial Number	(0018,1000)	3	ALWAYS: Serial number of the treatment machine for which this instance is being transmitted, if the machine is available in the database.
>Primary Dosimeter Unit	(300A,00B3)	3	ALWAYS: Value 'MINUTE'
>Source-Axis Distance	(300A,00B4)	3	ALWAYS: SAD of TomoTherapy machine
> Beam Limiting Device Sequence	(300A,00B6)	1	ALWAYS: Number of items = 2. Note that only the aperture collimator, and not the collimator leaves, is represented in this object.
>>RT Beam Limiting Device Type	(300A,00B8)	1	ALWAYS: 1st item: Value 'X' (collimator slit length) 2nd item: Value 'ASYMY' (jaw width)

Attribute Name	Element Tag	Type	Usage notes
>>Number of Leaf/Jaw Pairs	(300A,00BC)	1	ALWAYS: 1st item: Value 1 2nd item: Value 1
>Referenced Patient Setup Number	(300C,006A)	3	ALWAYS: Value 1
>Treatment Delivery Type	(300A,00CE)	3	ALWAYS: Value 'TREATMENT'
>Number of Wedges	(300A,00D0)	1	ALWAYS: Value 0
>Number of Compensators	(300A,00E0)	1	ALWAYS: Value 0
>Number of Boli	(300A,00ED)	1	ALWAYS: Value 0
>Number of Blocks	(300A,00F0)	1	ALWAYS: Value 0
>Final Cumulative Meterset Weight	(300A,010E)	2C	ALWAYS: Value 1.0
>Number of Control Points	(300A,0110)	1	ALWAYS: Number of (sinogram) projections in beam delivering radiation + 1
>Control Point Sequence	(300A,0111)	1	ALWAYS: Number of items = Number of (sinogram) projections in beam delivering radiation + 1
>>Control Point Index	(300A,0112)	1C	ALWAYS (all control points): Sequential index of control point, starting at 0
>>Cumulative Meterset Weight	(300A,0134)	2C	ALWAYS (all control points): Projection index normalized over range 0.0 to 1.0
>>Nominal Beam Energy	(300A,0114)	3	ALWAYS (first control point only): Value 6.0
>>Beam Limiting Device Position Sequence	(300A,011A)	1C	SNAP (first control point , and only on further control points if the value changes from previous control point.): Number of items = 2. Note that only the aperture collimator, and not the collimator leaves, is represented in this object.
>>>RT Beam Limiting Device	(300A,00B8)	1C	ALWAYS:

Attribute Name	Element Tag	Type	Usage notes
Type			1st item: Value 'X' (collimator slit length) 2nd item: Value 'ASYMY' (jaw width)
>>>Leaf/Jaw Positions	(300A,011C)	1C	ALWAYS: 1st item: 2 values -200.0, 200.0 2nd item: 2 values, Y1 (front) and Y2 (back) jaw position at isocenter, in mm.
>>Gantry Angle	(300A,011E)	1C	ALWAYS: For helical beams: Tomo helical angle converted to range 0-359.9 degrees. For fixed angle beams: First Control Point only. Gantry angle in range 0-359.9 degrees.
>>Gantry Rotation Direction	(300A,011F)	1C	ALWAYS (first control point only): For helical beams: Value 'CW' For fixed-angle beams: Value 'NONE'
>>Beam Limiting Device Angle	(300A,0120)	1C	ALWAYS (first control point only): Value 0.0
>>Beam Limiting Device Rotation Direction	(300A,0121)	1C	ALWAYS (first control point only): Value 'NONE'
>>Patient Support Angle	(300A,0122)	1C	ALWAYS (first control point only): Value 0.0
>>Patient Support Angle Rotation Direction	(300A,0123)	1C	ALWAYS (first control point only): Value 'NONE'
>>Table Top Eccentric Angle	(300A,0125)	1C	ALWAYS (first control point only): Value 0.0
>>Table Top Eccentric Rotation Direction	(300A,0126)	1C	ALWAYS (first control point only): Value 'NONE'
>>Table Top Vertical Position	(300A,0128)	2C	EMPTY (first control point only, absent for all others)
>>Table Top Longitudinal Position	(300A,0129)	2C	EMPTY (first control point only, absent for all others)
>>Table Top Lateral Position	(300A,012A)	2C	EMPTY (first control point only, absent for

Attribute Name	Element Tag	Type	Usage notes
			all others)

Attribute Name	Element Tag	Type	Usage notes
>>Isocenter Position	(300A,012C)	2C	ALWAYS (all control points): The location of the machine isocenter at the current control point, in the DICOM patient coordinate system.
>>Private Creator	(300D,0010)	3	ALWAYS: Value 'TOMO_HA_01'
>>Tomo Projection Sinogram Data	(300D,10A7)	3	Projection sinogram values for all 64 leaves of projection starting at the current control point. EMPTY if all 64 leaves have a sinogram value of zero. EMPTY for last control point.
No other fields sent from the RT Beams Module			

Table 81: Approval Module

Attribute Name	Element Tag	Type	Usage notes
Approval Status	(300E,0002)	1	ALWAYS: Value 'APPROVED'
Review Date	(300E,0004)	2C	ALWAYS: Date of the approval
Review Time	(300E,0005)	2C	ALWAYS: Time of the approval
Reviewer Name	(300E,0008)	2C	ALWAYS: Name of the approver
No other fields sent from the Approval Module			

Table 82: SOP Common Module

Attribute Name	Element Tag	Type	Usage notes
SOP Class UID	(0008,0016)	1	ALWAYS: Value '1.2.840.10008.5.1.4.1.1.481.5'
SOP Instance UID	(0008,0018)	1	ALWAYS
Specific Character Set	(0008,0005)	1C	ALWAYS: Value 'ISO_IR 100'
Instance Creation Date	(0008,0012)	3	ALWAYS: Date of actual object construction (object send time)

Instance Creation Time	(0008,0013)	3	ALWAYS: Time of actual object construction (object send time)
No other fields sent from the SOP Common Module			

7.1.1.6 Raw Data Storage Class

This section describes the implementation of the Information Object named 'Tomotherapy Private RT Raw Data IOD'. The following tables identify the entities for each IOD module for the Raw Data Storage Request operation.

The implementation is described to the extent that client vendor's applications can utilize these objects.

Note: this section identifies data that is otherwise not described in this document. The content is not guaranteed and is subject to change without notice.

Table 83: TomoTherapy Treatment Raw Data Record IOD Entities

Entity Name	Module Name	Usage	Reference
Patient	Patient	M	Table 43
	Clinical Trial Subject	U	Not used
Study	General Study	M	Table 44
	Patient Study	U	Table 45
	Clinical Trial Study	U	Not used
Series	General Series	M	Table 84
	Clinical Trial Series	U	Not used
Equipment	General Equipment	M	Table 46

Raw Data	Frame of Reference	U	Not used
	Synchronization	C	Not used
	Specimen	U	Not used
	Raw Data	M	Table 85
	Acquisition Context	M	Table 89
	SOP Common	M	Table 90

Table 84: General Series

Attribute Name	Element Tag	Type	Usage notes
Modality	(0008,0060)	1	ALWAYS: Value ‘CT’ if procedure type is a scan; value ‘RTRECORD’ if procedure type is a treatment delivery.
Series Instance UID	(0020,000E)	1	ALWAYS: The identifying procedure UID.
Series Number	(0020,0011)	2	ALWAYS: Value equal to the Series Date month and day values (with any leading zero removed), concatenated with the Series Time hour, minute, and whole-number second portions, e.g. ‘1231235959’.
Laterality	(0020,0060)	2C	ABSENT
Series Description	(0008,103E)	3	ALWAYS: ‘Detector Data’
Patient Position	(0018,5100)	2C	ABSENT
No other fields sent from the General Series Module			

Table 85: Raw Data Module

Attribute Name	Element Tag	Type	Usage notes
Instance Number	(0020,0013)	2	ALWAYS: 1
Content Date	(0008,0023)	1	ALWAYS: the date the detector data was created
Content Time	(0008,0033)	1	ALWAYS: the time the detector data was created
Creator-Version UID	(0008,9123)	1	ALWAYS: an identifier that uniquely specifies the software version and detector model combination.

Referenced Instance Sequence	(0008,114A)	3	SNAP: a sequence that establishes a correlation between the RT plan which was used to develop the delivery that was performed to produce this raw data object
>Referenced SOP Class UID	(0008,1150)	1C	ALWAYS: 1.2.840.10008.5.1.4.1.1.481.5
>Referenced SOP Instance UID	(0008,1155)	1	ALWAYS: the unique identifier associated with RT Plan that was used to create the procedure that was delivered.
>Purpose of Reference Code Sequence	(0040,A170)	1	The single reference purpose
>>Code Value	(0008, 0100)	1	ALWAYS: '111401'
>>Coding Scheme Designator	(0008,0102)	1	ALWAYS: 'DCM'
>>Code Meaning	(0008,0104)	1	ALWAYS: if Modality is RTRECORD, then 'Patient fraction fulfullment'. If Modality is CT then 'Imaging scan'.

Table 86: Tomo Procedure Identification Module

Attribute Name	Element Tag	Type	Usage notes
Private Creator ID	(300D,0020)	1	ALWAYS: TOMO_DD_01
Procedure Number	(300D,2010)	2	VNAP
Procedure Type	(300D,2011)	1	ALWAYS: either 'IMAGE' or 'TREATMENT'
Procedure Purpose	(300D,2012)	1	ALWAYS: one of 'DQA', 'DQA_STATIC', 'PATIENT', 'PATIENT_QA' or 'MACHINE_QA' (stretch goal)

Table 87: Tomo Detector Data Module

Attribute Name	Element Tag	Type	Usage notes
Private Creator ID	(300D,0020)	1	ALWAYS: TOMO_DD_01
Detector channel count	(300D,2020)	1	ALWAYS: number of detector array elements composing a frame
Dataset length	(300D,2021)	1	ALWAYS: the number of detector channel frames
Active Projection Beam Sequence	(300D,2026)	3	ANAP: Provides the beam control point to detector data sample association
>Referenced Beam Number	(300C,0006)	1	ALWAYS: the beam number
>Referenced Start Control Point Index	(300C,00F4)	1	ALWAYS: identifies the control point within the Beam referenced by the Referenced Beam Number for start of the capture sequence for the first data frame
>Start Trim	(0008,2142)	1	ALWAYS: identifies the first frame corresponding to the first control point of the referenced beam
>Referenced Stop Control Point Index	(300C,00F6)	1	ALWAYS: identifies the control point within the Beam referenced by the Referenced Beam Number for the start of the capture sequence for the last data frame
>Stop Trim	(0008,2143)	1	ALWAYS: identifies the last frame corresponding to the Referenced Stop Control Point Index (300C,00F6) of the Referenced Beam Number (300C,0006)
Bits Allocated	(0028,0100)	1	ALWAYS: 32 indicating the number of bits per detector data element
Detector data scaling factor	(300D,2022)	1	ALWAYS: the scaling factor for the

			contained data
Pixel Data	(7FE0,0010	1	ALWAYS: the detector data, row order by sample set, column order by channel ascending
Compression Type	(300D,2024)	1	ALWAYS: one of 'PROJECTION'[1] or 'COMPRESSION'
Compression Factor	(300D,2025)	1C	VNAP: conditional if (300D,2024) is of value 'COMPRESSION'

Table 88: Tomo Detector Characteristics Module

Attribute Name	Element Tag	Type	Usage notes
Private Creator ID	(300D,0020)	1	ALWAYS: TOMO_DD_01
Detector unit of measure	(300D,2030)	1	ALWAYS: 'CM'
Detector element width	(300D,2031)	2	VNAP: the physical width measured at the center of an individual detector element in the direction parallel to the plane of rotation
Curvature radius	(300D,2032)	2	VNAP: the radius to the center of the arc associated with the detector
Surface to Axis Distance	(300D,2033)	2	VNAP: the distance from the peripheral edges of the detector to the beamline
Surface to Center Distance	(300D,2034)	2	VNAP: the distance from the surface of the detector to its center
Channel range	(300D,2035)	2	VNAP: the zero-based beginning and ending channel value indicies that identify where the fluence is expected to travel based on MLC consraints

[1] The time between two contiguous control points from the RT Plan's Beams module is the length of a projection.

Table 89: Acquisition Context Module

Attribute Name	Element Tag	Type	Usage notes
Acquisition Context Sequence	(0040,0555)	2	An empty sequence is always sent.

Table 90: SOP Common Module

Attribute Name	Element Tag	Type	Usage notes
SOP Class UID	(0008,0016)	1	ALWAYS: Value '1.2.840.10008.5.1.4.1.1.66'
SOP Instance UID	(0008,0018)	1	ALWAYS: An identifier uniquely associated with the transmitted raw data set
Specific Character Set	(0008,0005)	1C	ALWAYS: Value 'ISO_IR 100'
Instance Creation Date	(0008,0012)	3	ALWAYS: Date of actual object construction (object send time)
Instance Creation Time	(0008,0013)	3	ALWAYS: Time of actual object construction (object send time)
No other fields sent from the SOP Common Module			

7.1.1.7 RT Beams Treatment Record Storage Class

The following tables identify the entities for each IOD module for a RT Beams Treatment Record Store Request operation. The table indicates which IOD Entities have fields that will be retrieved from the TomoTherapy Data Server to construct the object(s) for the C-STORE operation.

Note that all type 3 fields are populated if the field value is non-blank. If it is blank, it will not be sent.

Table 91: RT Beams Treatment Record IOD Entities

Entity Name	Module Name	Usage	Reference
Patient	Patient	M	Table 43
	Clinical Trial Subject	U	Not used
Study	General Study	M	Table 44

Entity Name	Module Name	Usage	Reference
	Patient Study	U	Not used
	Clinical Trial Study	U	Not used
Series	RT Series	M	Table 92
	Clinical Trial Series	U	Not used
Equipment	General Equipment	M	Table 46
Plan	RT General Treatment Record	M	Table 93
	RT Patient Setup	U	Table 94
	RT Treatment Machine Record	M	Table 95
	Measured Dose Reference Record	U	Not used
	Calculated Dose Reference Record	U	Not used
	RT Beams Session Record	M	Table 96
	RT Treatment Summary Record	U	Not used
	Curve	U	Not used
	SOP Common	M	Table 97

Table 92: RT Series Module

Attribute Name	Element Tag	Type	Usage notes
Modality	(0008,0060)	1	ALWAYS: Value ‘RTRECORD’
Series Instance UID	(0020,000E)	1	ALWAYS: The TomoTherapy UID from the delivered procedure being transmitted, suffixed with ‘.2’. Each RT Beams Treatment Record object related to a particular plan will appear in its own series.
Series Number	(0020,0011)	2	ALWAYS: Value equal to the month and day values of the database creation date from the delivered procedure being

Attribute Name	Element Tag	Type	Usage notes
			transmitted (with any leading zero removed), concatenated with the hour, minute, and whole-number second values of the database creation time, e.g. '1231235959'.
Series Description	(0008,103E)	3	ALWAYS: For deliveries of patient plans, value 'TomoTherapy Treatment Record'. For deliveries of DQA plans, value 'TomoTherapy Verification Record'
Referenced Performed Procedure Step Sequence	(0008,1111)	3	ANAP: Present (one item) if procedure was performed under workflow management.
>Referenced SOP Class UID	(0008,1150)	1	ALWAYS: Value '1.2.840.10008.5.1.4.34.4.1' (Supplement 96 Frozen Draft UPS Push SOP Class)
>Referenced SOP Instance UID	(0008,1155)	1	ALWAYS: The UPS SOP Instance under which the procedure was performed.
No other fields sent from the RT Series Module			

Table 93: RT General Treatment Record Module

Attribute Name	Element Tag	Type	Usage notes
Instance Number	(0020,0013)	1	ALWAYS: Value is the number of the initial planned procedure for that fraction. For example, TomoTherapy deliveries of treatment procedures 4, 4.1, and 4.2 would all have an Instance Number of 4. If a treatment was never attempted with the current fraction, a value of 0 is sent.
Treatment Date	(3008,0250)	2	ANAP: The date on which the most recent performed fraction delivery was started. Absent if a treatment was never attempted

Attribute Name	Element Tag	Type	Usage notes
			with the current fraction.
Treatment Time	(3008,0251)	2	ANAP: The time at which the most recent performed fraction delivery or CTrue Image was started. Absent if a treatment was never attempted with the current fraction.
Referenced RT Plan Sequence	(300C,0002)	1C	ALWAYS: Number of items = 1
>Referenced SOP Class UID	(0008,1150)	1C	ALWAYS: Value '1.2.840.10008.5.1.4.1.1.481.5'
>Referenced SOP Instance UID	(0008,1155)	1C	ALWAYS: The TomoTherapy UID from the plan upon which the procedure is based
No other fields sent from the RT General Treatment Record Module			

Table 94: RT Patient Setup Module

Attribute Name	Element Tag	Type	Usage notes
Patient Setup Sequence	(300A,0180)	1	ALWAYS: Number of items = 1
>Patient Setup Number	(300A,0182)	1	ALWAYS: Value 1
>Patient Position	(0018,5100)	1C	ALWAYS: The Patient Position described in the referenced CT Image objects (TomoTherapy applications do not permit "flipping" of scans for planning purposes)
>Setup Technique	(300A,01B0)	3	ALWAYS: Value 'ISOCENTRIC'
No other fields sent from the RT Patient Setup Module			

Table 95: RT Treatment Machine Record Module

Attribute Name	Element Tag	Type	Usage notes
Treatment Machine Sequence	(300A,0206)	1	ALWAYS: Number of items =1
>Treatment Machine Name	(300A,00B2)	2	ALWAYS: Name of TomoTherapy machine used for treatment
>Manufacturer	(0008,0070)	2	ALWAYS: Value 'TomoTherapy

Attribute Name	Element Tag	Type	Usage notes
			Incorporated’
>Institution Name	(0008,0080)	2	VNAP: Name of institution where TomoTherapy machine is installed, if available
>Manufacturer’s Model Name	(0008,1090)	3	ALWAYS
>Device Serial Number	(0018,1000)	2	VNAP: The TomoTherapy machine serial number if available
>Private Creator	(300D,0010)	2	ALWAYS: Value ‘TOMO_HA_01’
>Tomo Machine UID	(300D,1050)	3	ALWAYS: TomoTherapy UID of treatment machine used for delivery. TOMOTHERAPY PRIVATE ATTRIBUTE.
No other fields sent from the RT Treatment Machine Record Module			

Table 96: RT Beams Session Record Module

Attribute Name	Element Tag	Type	Usage notes
Operator Name	(0008,1070)	2	ALWAYS: Name of TomoTherapy user who was logged in at Operator Station when fraction was delivered
Referenced Fraction Group Number	(300C,0022)	3	ALWAYS: Value Fraction Group Number of Fraction Group in RT Plan’s Fraction Group Sequence that was delivered by this procedure.
Number of Fractions Planned	(300A,0078)	2	ALWAYS: Number of fractions planned for current fraction group when end-of-planning process was initiated
Primary Dosimeter Unit	(300A,00B3)	1	ALWAYS: Value ‘MINUTE’
Private Creator	(300D,0010)	3	ALWAYS: Value ‘TOMO_HA_01’

Attribute Name	Element Tag	Type	Usage notes
Tomo Performed Work Items	(300D,1090)	3	ANAP: Present if exported under OIS Connectivity, absent otherwise -List of 3 items representing tasks performed in delivering or attempting to deliver the procedure. 1st value: TOMOIMAGE if one or more CTrue Images were performed, else NO_TOMOIMAGE 2nd value: REGISTRATION if a registration was performed for at least one of the CTrue Images, else NO_REGISTRATION 3rd value: TREATMENT if a treatment was delivered, else NO_TREATMENT
Treatment Session Beam Sequence	(3008,0020)	1	ALWAYS: Helical: Number of items = 1 Fixed Angle: If exported under OIS Connectivity-Number of items between 1 (if treatment interrupted on first beam) to the total number of beams in the Fraction (if fraction did not interrupt, or interrupted on last beam) Fixed Angle: If exported separate from OIS Connectivity – total number of beams in the delivery
>Referenced Beam Number	(300C,0006)	3	ALWAYS: Value of Referenced Beam Number in Referenced Fraction Group of RT Plan.
>Beam Name	(300A,00C2)	3	ALWAYS: Helical: Value ‘Helical TomoTherapy Beam’ Fixed Angle: TomoTherapy name of corresponding fixed angle beam

Attribute Name	Element Tag	Type	Usage notes
>Beam Description	(300A,00C3)	3	ALWAYS: For helical beams: English-language description of delivery beam pitch and field size For fixed angle beams: 'TomoTherapy fixed-angle beam:' followed by beam angle in degrees.
>Beam Type	(300A,00C4)	1	ALWAYS: Value 'DYNAMIC'
>Radiation Type	(300A,00C6)	2	ALWAYS: Value 'PHOTON'
>Referenced Verification Image Sequence	(300C,0060)	3	ANAP: Present if one or more CTrue Image sets were acquired and registered in order to position patient. Number of items = number of images in CTrue Image scan acquired and registered immediately prior to delivery. If the last CTrue Image set was acquired but not registered, this sequence will not be present.
>>Referenced SOP Class UID	(0008,1150)	1C	ALWAYS (if sequence present): Value '1.2.840.10008.5.1.4.1.1.2' (CT Image)
>>Referenced SOP Instance UID	(0008,1155)	1C	ALWAYS (if sequence present): The TomoTherapy UID of the CTrue Image data object, suffixed with '.' followed by the image number
>Private Creator	(300D,0010)	3	ALWAYS (if Tomo Registration Translations and Tomo Registration Rotations are present): Value 'TOMO_HA_01'
>Tomo Registration Translations	(300D,10B0)	3	ANAP: X,Y,Z translations in mm between reference image set and registered CTrue image, if a registration was performed and accepted.

Attribute Name	Element Tag	Type	Usage notes
			Note: These translations do not necessarily represent the actual corrections applied to the delivery, and hence should not be used for dose accumulation or similar purposes. TOMOTHERAPY PRIVATE ATTRIBUTE.
>Tomo Registration Rotations	(300D,10B1)	3	ANAP: X,Y,Z rotations in degrees between reference image set and registered CTrue image, if a registration was performed and accepted. Note: These rotations do not necessarily represent the actual corrections applied to the delivery, and hence should not be used for dose accumulation or similar purposes. TOMOTHERAPY PRIVATE ATTRIBUTE.
>Source-Axis Distance	(300A,00B4)	3	ALWAYS: Value 850.0
> Beam Limiting Device Leaf Pairs Sequence	(3008,00A0)	1	ALWAYS: Number of items = 2. Note that only the aperture collimator, and not the multileaf collimator, is represented in this object.
>>RT Beam Limiting Device Type	(300A,00B8)	1	ALWAYS: 1st item: Value 'X' (collimator slit length) 2nd item: Value 'ASYMY' (jaw width)
>>Number of Leaf/Jaw Pairs	(300A,00BC)	1	ALWAYS: 1st item: Value 1 2nd item: Value 1
>Referenced Patient Setup Number	(300C,006A)	3	ALWAYS: Value 1

Attribute Name	Element Tag	Type	Usage notes
>Number of Wedges	(300A,00D0)	1	ALWAYS: Value 0
>Number of Compensators	(300A,00E0)	1	ALWAYS: Value 0
>Number of Boli	(300A,00ED)	1	ALWAYS: Value 0
>Number of Blocks	(300A,00F0)	1	ALWAYS: Value 0
>Current Fraction Number	(3008,0022)	2	ALWAYS: Fraction number for this treatment fraction.
>Treatment Delivery Type	(300A,00CE)	2	ALWAYS: Value 'CONTINUATION' if part of the fraction was attempted in a previous unified procedure step (UPS), 'TREATMENT' otherwise.
>Treatment Termination Status	(3008,002A)	1	ALWAYS: Termination status for the current beam. Value one of: 'NORMAL' for normal (completed) procedure 'OPERATOR' for procedure interrupted by operator 'MACHINE' for procedure terminated early by interlock or other failure 'UNKNOWN' for procedure terminated early for unknown reason Only 'NORMAL', 'MACHINE' and 'UNKNOWN' are supported in this release. Fixed angle beams not yet attempted in an interrupted fraction will be encoded as 'MACHINE' with a Delivered Primary Meterset (3008,0036) of 0.0.
>Treatment Verification Status	(3008,002C)	2	ALWAYS: Value 'VERIFIED' (TomoTherapy software does not permit overridden or unverified treatments)

Attribute Name	Element Tag	Type	Usage notes
>Specified Primary Meterset	(3008,0032)	3	ALWAYS: Expected total treatment time in minutes when delivery is completed. This includes treatment time for this beam from all previous interrupted procedures for the fraction.
>Specified Secondary Meterset	(3008,0033)	3	ALWAYS: Expected total Monitor Units (MU) for the beam when delivery is completed. This includes MU for this beam from all previous interrupted procedures for the fraction. See Note 1.
>Delivered Primary Meterset	(3008,0036)	3	ALWAYS: With default DICOM Compliant setting:Recorded total treatment time in minutes for this delivery. If no meterset was delivered for this beam in this delivery, this value will be 0.0 With Alternate meterset setting: Recorded total treatment time in minutes for all deliveries previous to and including the current one for this fraction (For reporting agreement with certain versions of Treatment Management Systems. See the Corrected Parameter Sequence (3008,0068))
>Delivered Secondary Meterset	(3008,0037)	3	ALWAYS: Recorded total Monitor Units (MU) for the beam when delivery is completed. This includes MU for this beam from all previous interrupted procedures for the fraction. See Note 1.

Attribute Name	Element Tag	Type	Usage notes
>Specified Treatment Time	(3008,003A)	3	ALWAYS: Expected total treatment time in seconds when beam is completed. This includes treatment time for this beam from all previous interrupted procedures for the fraction. Equal to Specified Primary Meterset (3008,0032) divided by 60.

Attribute Name	Element Tag	Type	Usage notes
>Delivered Treatment Time	(3008,003B)	3	ALWAYS: Recorded total treatment time in seconds when beam is completed. This includes treatment time for this beam from all previous interrupted procedures for the fraction. Value will be 0.0 if beam delivery was never attempted.
>Number of Control Points	(300A,0110)	1	ALWAYS: Value 2
>Control Point Delivery Sequence	(3008,0040)	1	ALWAYS: Number of items = 2. This sequence contains the start control point of the actual delivery, and the end control point of the actual delivery. If a treatment does not complete normally, the end control point will not coincide with the last control point in the plan.
>>Referenced Control Point Index	(300C,00F0)	3	ALWAYS first control point, ANAP second control point: Sequential index of the referenced control point. 1st item: Value 0 2nd item: Index of last Control Point in plan if the delivery terminated normally, otherwise ABSENT (i.e. the delivery did not terminate at a planned control point).
>>Treatment Control Point Date	(3008,0024)	1	ALWAYS (all control points): Date on which treatment was delivered.

Attribute Name	Element Tag	Type	Usage notes
>>Treatment Control Point Time	(3008,0025)	1	ALWAYS (all control points): 1st item: Time at which first beam started during delivery. 2nd item: Time at which last beam ended during delivery. Indicative value only – use Delivered Meterset as measure of delivery progress. Note: For Fixed Angle plans, this value is meaningful only for the first control point of the first beam, and last control point of the last beam.
>>Specified Meterset	(3008,0042)	2	ALWAYS (all control points): Expected treatment time in minutes for current control point. 1st item: Value 0.0 2nd item: Expected treatment time in minutes.
>>Delivered Meterset	(3008,0044)	1	ALWAYS (all control points): Actual treatment time in minutes when treatment control point is reached. 1st item: 0.0 for all procedures in initial unified procedure step (UPS) for this fraction, or end Delivered Meterset of previous unified procedure step (UPS) delivery for continuation treatments. See also Treatment Delivery Type (300A,00CE). 2nd item: Actual treatment time in minutes when the treatment terminated (normally or otherwise).
>>Private Creator	(300D,0010)	3	ALWAYS: Value ‘TOMO_HA_01’

Attribute Name	Element Tag	Type	Usage notes
>>Tomo Delivered Secondary Meterset	(300D,10B5)	3	ALWAYS (all control points): Actual delivery MU when treatment control point is reached. 1st item: 0.0 for all procedures in initial unified procedure step (UPS) for this fraction, or end Delivered Secondary Meterset of previous unified procedure step (UPS) delivery for continuation treatments. See also Treatment Delivery Type (300A,00CE). 2nd item: Actual total delivery MU when the treatment terminated (normally or otherwise). TOMOTHERAPY PRIVATE ATTRIBUTE. See Note 1.
>>Dose Rate Set	(300A,0115)	2	EMPTY (both control points)
>>Dose Rate Delivered	(3008,0048)	2	EMPTY (both control points)
>>Nominal Beam Energy	(300A,0114)	3	ALWAYS (first control point only): Value 6
>>Nominal Beam Energy Unit	(300A,0015)	1C	ALWAYS (first control point only): Value ‘MV’
>>Beam Limiting Device Position Sequence	(300A,011A)	1C	ALWAYS (first control point only): Number of items = 2. Note that only the aperture collimator, and not the multileaf collimator, is represented in this object.
>>>RT Beam Limiting Device Type	(300A,00B8)	1C	ALWAYS: 1st item: Value ‘X’ (collimator slit length) 2nd item: Value ‘ASYMY’ (jaw width)

Attribute Name	Element Tag	Type	Usage notes
>>>Leaf/Jaw Positions	(300A,011C)	1C	ALWAYS: 1st item: 2 values, -200.0 and 200.0 2nd item: 2 values, Y1 (front) and Y2 (back) jaw position at isocenter, in mm.
>>Gantry Angle	(300A,011E)	1C	ALWAYS (both control points): TomoTherapy continuous gantry angle represented on IEC 0-359.9 degree scale (IEC GANTRY coordinate system)
>>Gantry Rotation Direction	(300A,011F)	1C	ALWAYS (first control point only): Helical: Value 'CW' Fixed Angle: Value 'NONE'
>>Beam Limiting Device Angle	(300A,0120)	1C	ALWAYS (first control point only): Value 0.0
>>Beam Limiting Device Rotation Direction	(300A,0121)	1C	ALWAYS (first control point only): Value 'NONE'
>>Patient Support Angle	(300A,0122)	1C	ALWAYS (first control point only): Value 0.0
>>Patient Support Angle Rotation Direction	(300A,0123)	1C	ALWAYS (first control point only): Value 'NONE'
>>Table Top Eccentric Angle	(300A,0125)	1C	ALWAYS (first control point only): Value 0.0
>>Table Top Eccentric Rotation Direction	(300A,0126)	1C	ALWAYS (first control point only): Value 'NONE'
>>Table Top Vertical Position	(300A,0128)	2C	EMPTY (first control point only)
>>Table Top Longitudinal Position	(300A,0129)	2C	EMPTY (first control point only)
>>Table Top Lateral Position	(300A,012A)	2C	EMPTY (first control point only)
>>Corrected Parameter Sequence	(3008,0068)	3	ANAP: Present if value for Delivered Primary Meterset (3008,0036) has been adjusted based on alternate meterset

Attribute Name	Element Tag	Type	Usage notes
			calculation. Introduces single entry detailing the adjustment applied to the Delivered Primary Meterset
>>>Parameter Sequence Pointer	(3008,00610	1	ALWAYS (if sequence is present): Contains the data element tag of the parent sequence containing the attribute that was corrected. Value is always (3008, 0020)
>>>Parameter Item Index	(3008,0063)	1	ALWAYS(if sequence is present): Contains the value of the index of the corrected attribute in the parent sequence
>>>Parameter Pointer	(3008,0065)	1	ALWAYS(if sequence is present):Contains the data element tag of the attribute that was corrected. Value is always (3008,0036)
>>>Correction Value	(3008,006A)	1	ALWAYS (if sequence is present): The value that was added to the value referenced by this sequence when the correction was applied.
>Referenced Calculated Dose Reference Sequence	(3008,0090)	3	ALWAYS (Last RT Beams Treatment Record in a Fraction Only): Introduces sequence of doses estimated for each fraction. The sequence will only contain one item. See Note 2
>>Referenced Dose Reference Number	(300C,0051)	1C	Uniquely identifies dose reference specified by Dose Reference Number (300A,0012) in Dose Reference Sequence (300A,0010) in RT Prescription Module of referenced RT Plan
>>Calculated Dose Reference Dose Value	(3008,0076)	1C	Treatment Plan Fraction calculated dose in Gy
No other fields sent from the RT Beams Session Record Module			

NOTE 1: When a treatment fraction (procedure) is started on one Delivery Machine but completed on another, the delivered dose rate for the second machine may not be equal to that of the initial machine. In such a case, Delivered Secondary Meterset (3008,0037) and the Tomo Delivered Secondary Meterset (300D,10B5) for the control points (both specified in MU) will no longer correspond to the expected secondary metersets in some cases. In all cases, the delivery times recorded in Delivered Primary Meterset (3008,0036) and Delivered Meterset (3008,0044) shall be used as the primary indication of treatment progress.

NOTE 2: The calculated dose sequence will only appear on the final procedure for a fraction. It will report the portion of the estimated Gy delivered for the fraction for that beam. It will also indicate the Dose Refrence Sequence Number from the plan that was the prescription target for the plan.

Table 97: SOP Common Module

Attribute Name	Element Tag	Type	Usage notes
SOP Class UID	(0008,0016)	1	ALWAYS: Value '1.2.840.10008.5.1.4.1.1.481.4'
SOP Instance UID	(0008,0018)	1	ALWAYS: If delivered under OIS Workflow, and reporting on a single delivery, the TomoTherapy UID from the delivered treatment procedure being transmitted. If delivered under OIS Workflow, but encompassing multiple deliveries, the TomoTherapy UID from the last procedure delivered, concatenated with ".3" at the end. Otherwise, the TomoTherapy UID from the procedure delivered concatenated with ".1" at the end.
Specific Character Set	(0008,0005)	1C	ALWAYS: Value 'ISO_IR 100'
Instance Creation Date	(0008,0012)	3	ALWAYS: Date of actual object construction (object send time)
Instance Creation Time	(0008,0013)	3	ALWAYS: Time of actual object construction (object send time)
No other fields sent from the SOP Common Module			

7.1.1.8 Multi-frame True Color SC Image Storage Class

The following tables identify the entities for each IOD module for a Multi-frame True Color SC Image Store Request operation. The table indicates which IOD Entities have fields that will be retrieved from the

TomoTherapy Data Server to construct the object(s) for the C-STORE operation. Note that only a single frame is stored by TomoTherapy applications using this SOP Class.

Note that all type 3 fields are populated if the field value is non-blank. If it is blank, it will not be sent.

Table 98: Multi-Frame True Color SC Image IOD Entities

Entity Name	Module Name	Usage	Reference
Patient	Patient	M	Table 43
	Clinical Trial Subject	U	Not used
Study	General Study	M	Table 44
	Patient Study	U	Table 45
	Clinical Trial Study	U	Not used
Series	General Series	M	Table 99
	Clinical Trial Series	U	Not used
Frame of Reference	Frame of Reference	C	Not used
	Synchronization	U	Not used
Equipment	General Equipment	U	Table 46
	SC Equipment	M	Table 100
Image	General Image	M	Table 101
	Image Pixel	M	Table 102
	Cine	C	Not used
	Multi-frame	M	Table 103
	Frame Pointers	U	Not used
	Device	U	Not used
	Multi-frame Functional Groups	U	Not used
	Multi-frame Dimension	U	Not used
	Specimen	U	Not used
	SC Image	M	Table 104
	SC Multi-frame Image	M	Table 105
	SC Multi-frame Vector	C	Not used
	SOP Common	M	Table 106
	Frame Extraction	C	Not used

Table 99: General Series Module

Attribute Name	Element Tag	Type	Usage notes
Modality	(0008,0060)	1	See SC Equipment Module
Series Instance UID	(0020,000E)	1	ALWAYS: The TomoTherapy UID from the related treatment procedure database object being transmitted, with '.111' appended.
Series Number	(0020,0011)	2	ALWAYS: Value equal to the Series Date month and day values (with any leading zero removed), concatenated with the Series Time hour, minute, and whole-number second portions, e.g. '1231235959'.
Laterality	(0020,0060)	2C	ABSENT
Series Date	(0008,0021)	3	ALWAYS: The date the related treatment procedure was created in the TomoTherapy database
Series Time	(0008,0031)	3	ALWAYS: The time the related treatment procedure was created in the TomoTherapy database
Series Description	(0008,103E)	3	ALWAYS: Value 'TomoTherapy Registration Images'
Patient Position	(0018,5100)	2C	EMPTY
Referenced Performed Procedure Step Sequence	(0008,1111)	3	ANAP: Present (one item) if image was generated under workflow management.
>Referenced SOP Class UID	(0008,1150)	1	ALWAYS: Value '1.2.840.10008.5.1.4.34.4.1' (Supplement 96 Frozen Draft UPS Push SOP Class)
>Referenced SOP Instance UID	(0008,1155)	1	ALWAYS: The UPS SOP Instance under which the image was generated.
No other fields sent from the General Series Module			

Table 100: SC Equipment

Attribute Name	Element Tag	Type	Usage notes
Conversion Type	(0008,0064)	1	'WSD'
Modality	(0008,0060)	1	ALWAYS: Value 'CT'
No other fields sent from the SC Equipment Module			

Table 101: General Image Module

Attribute Name	Element Tag	Type	Usage notes
Instance Number	(0020,0013)	2	ALWAYS: Value '1'.
Patient Orientation	(0020,0020)	2C	ALWAYS: Patient direction of the rows and columns of the captured image
Image Type	(0008,0008)	1	ALWAYS: 1st value: ORIGINAL 2nd value: SECONDARY"
Acquisition Date	(0008,0022)	3	ALWAYS: Creation date of the image
Acquisition Time	(0008,0032)	3	ALWAYS: Creation time of the image
Derivation Description	(0008,2111)	3	ALWAYS: Value "Screen-captured registration image"
Images in Acquisition	(0020,1002)	3	ALWAYS: Value 1
No other fields sent from the General Image Module			

Table 102: Image Pixel Module

Attribute Name	Element Tag	Type	Usage notes
Samples per Pixel	(0028,0002)	1	ALWAYS: Value 3
Photometric Interpretation	(0028,0004)	1	ALWAYS: Value 'RGB'

Attribute Name	Element Tag	Type	Usage notes
Rows	(0028,0010)	1	ALWAYS: The number of pixel rows in the principal registration view on the Operator Station
Columns	(0028,0011)	1	ALWAYS: The number of pixel columns in the principal registration view on the Operator Station
Bits Allocated	(0028,0100)	1	ALWAYS: Value 8
Bits Stored	(0028,0101)	1	ALWAYS: Value 8
High Bit	(0028,0102)	1	ALWAYS: Value 7
Pixel Representation	(0028,0103)	1	ALWAYS: Value 0 (unsigned data)
Pixel Data	(7FE0,0010)	1	ALWAYS: The 24-bit RGB array data for the principal registration view on the Operator Station
Planar Configuration	(0028,0006)	1C	ALWAYS: Value 0 (color-by-pixel)
Pixel Aspect Ratio	(0028,0034)	1C	ALWAYS (sagittal and coronal images may have differing pixel width and height).
No other fields sent from the Image Pixel Module. Duplicate field definitions in the CT Image Module are described in the CT Image Module.			

Table 103: Multi-frame Module

Attribute Name	Element Tag	Type	Usage notes
Number of Frames	(0028,0008)	1	ALWAYS: Value 1
Frame Increment Pointer	(0028,0009)	1	ABSENT: (Per SC Multi-frame Image Module requirements)
No other fields sent from the Multi-frame Module			

Table 104: SC Image Module

Attribute Name	Element Tag	Type	Usage notes
Nominal Scanned Pixel Spacing	(0018,2010)	3	ALWAYS: Size in mm of row spacing and column spacing in the principal registration view on the Operator Station
No fields sent from the SC Image Module			

Table 105: SC Multi-frame Image Module

Attribute Name	Element Tag	Type	Usage notes
Burned In Annotation	(0028,0301)	1	ALWAYS: Value 'NO'
No other fields sent from the SC Multi-frame Image Module			

Table 106: SOP Common Module

Attribute Name	Element Tag	Type	Usage notes
SOP Class UID	(0008,0016)	1	ALWAYS: Value = '1.2.840.10008.5.1.4.1.1.7.4'
SOP Instance UID	(0008,0018)	1	ALWAYS: Unique UID generated using TomoTherapy UID root prefix.
Specific Character Set	(0008,0005)	1C	ALWAYS: Value 'ISO_IR 100'
Instance Creation Date	(0008,0012)	3	ALWAYS: Date of actual object construction (object send time)
Instance Creation Time	(0008,0013)	3	ALWAYS: Time of actual object construction (object send time)
No other fields sent from the SOP Common Module			

7.1.2 Usage of Attributes from Received IODs

7.1.2.1 CT Image Storage Class

The following tables identify the entities for each IOD module for a CT Image Store operation. The tables indicate which IOD Entities have fields that will be stored in the TomoTherapy Data Server upon successful completion of the C-STORE operation.

Table 107: CT Image IOD Entities

Entity Name	Module Name	Usage	Reference
Patient	Patient	M	Table 108
	Clinical Trial Subject	U	Not used
Study	General Study	M	Table 109
	Patient Study	U	Table 110
	Clinical Trial Study	U	Not used
Series	General Series	M	Table 111
	Clinical Trial Series	U	Not used
Frame of Reference	Frame of Reference	M	Table 112
Equipment	General Equipment	M	Table 113
Image	General Image	M	Table 114
	Image Plane	M	Table 115
	Image Pixel	M	Table 116
	Contrast/bolus	C	Table 117
	Device	U	Not used
	Specimen	U	Not used
	CT Image	M	Table 118

Entity Name	Module Name	Usage	Reference
	Overlay Plane	U	Not used
	VOI LUT	U	Not used
	SOP Common	M	Table 119

Patient Association

If a received patient module matches a patient record in the TomoTherapy Data Server, TomoProvider does not update any fields for that record, even if the received elements comprise a superset of information already in the Data Server. A received patient module is considered to match an existing patient record if the patient ID is identical and if the patient name fields match. Two patient names are considered to match if both of the following conditions are true:

- Both names have the same number of name subparts (character strings separated by punctuation or space)
- All the name parts in one patient name match exactly one name part in the other patient name without respect to case.

If there is no patient match, a new patient record is created in the database, and all supplied optional fields shall be recorded with the new patient record.

If a patient name is "_phantom", TomoProvider performs the following:

- CT images are put into the single phantom patient on the TomoTherapy Data Server. This phantom patient has an automatically generated patient ID of "phantomMRN".
- A new disease is created, using the patient ID as the disease name.
- The received CT image is placed into the new disease under the single phantom patient.

Table 108: Patient Module

Attribute Name	Element Tag	Type	Usage notes
Patient's Name	(0010,0010)	2	Required field: must be non-blank
Patient ID	(0010,0020)	2	Required field: must be non-blank
Patient's Birth Date	(0010,0030)	2	Optional field: stored if present.
Patient's Sex	(0010,0040)	2	Optional field: stored if present.
Patient's Birth Time	(0010,0032)	3	Optional field: stored if present.

Attribute Name	Element Tag	Type	Usage notes
Other Patient IDs	(0010,1000)	3	Optional field: stored if present.
Other Patient Names	(0010,1001)	3	Optional field: stored if present.
Ethnic Group	(0010,2160)	3	Optional field: stored if present.
Patient Comments	(0010,4000)	3	Optional field: stored if present.
No other fields used or stored from the Patient Module			

Table 109: General Study Module

Attribute Name	Element Tag	Type	Usage notes
Study Instance UID	(0020,000D)	1	Required field: used for sorting items in the transmission for processing. Also used as Study Instance UID for further objects created by the TomoTherapy System.
Study Date	(0008,0020)	2	Stored if valued.
Study Time	(0008,0030)	2	Stored if valued.
Referring Physician's Name	(0008,0090)	2	Optional field: if present and field Physician(s) of Record is not present, it is used for the patient's oncologist
Study ID	(0020,0010)	2	Optional field: if valued, used for the disease name
Accession Number	(0008,0050)	2	Stored if valued.
Study Description	(0008,1030)	3	Optional field: stored if present.
Physician(s) of Record	(0008,1048)	3	Optional field: if present, first physician is used for the patient's oncologist
No other fields used or stored from the General Study Module			

Table 110: Patient Study Module

Attribute Name	Element Tag	Type	Usage notes
Admitting Diagnoses Description	(0008,1080)	3	Optional field: stored if present.
Patient's Age	(0010,1010)	3	Optional field: stored if present.
Patient's Size	(0010,1020)	3	Optional field: stored if present.
Patient's Weight	(0010,1030)	3	Optional field: stored if present.
Additional Patient's History	(0010,21B0)	3	Optional field: stored if present.
No other fields used or stored from the Patient Study Module			

Table 111: General Series Module

Attribute Name	Element Tag	Type	Usage notes
Modality	(0008,0060)	1	Required field: must be 'CT'
Series Instance UID	(0020,000E)	1	Required field: always stored as the originating UID of the series (but is not used for the Tomo database UID)
Patient Position	(0018,5100)	2C	Required field: must be one of HFS, FFS, HFP, or FFP; always stored; must be the same for all slices in the series.
No other fields used or stored from the General Series Module			

Table 112: Frame of Reference Module

Attribute Name	Element Tag	Type	Usage notes
Frame of Reference UID	(0020,0052)	1	Required field: always stored with the series.
Position Reference Indicator	(0020,1040)	2	Stored if valued
No other fields used or stored from the Frame of Reference Module			

Table 113: General Equipment Module

Attribute Name	Element Tag	Type	Usage notes
Manufacturer	(0008,0070)	2	Optional field: stored if present.
Institution Name	(0008,0080)	3	Optional field: stored if present.
Manufacturer's Model Name	(0008,1090)	3	Optional field: stored if present.
Device Serial Number	(0018,1000)	3	Optional field: stored if present.
Software Versions	(0018,1020)	3	Optional field: only the first item in the series will be kept
Pixel Padding Value	(0028,0120)	3	Not used
No other fields used or stored from the General Equipment Module			

Table 114: General Image Module

Attribute Name	Element Tag	Type	Usage notes
Image Type	(0008,0008)	3	See CT Image Module
Acquisition Date	(0008,0022)	3	Optional field: stored if present.
Acquisition Time	(0008,0032)	3	Optional field: stored if present.
No other fields used or stored from the General Image Module			

Table 115: Image Plane Module

Attribute Name	Element Tag	Type	Usage notes
Pixel Spacing	(0028,0030)	1	Required field: the variation across slices for this field permitted for a valid image series is +/-0.005cm / rows (for Y pixel spacing) and +/-0.005cm / columns (for X pixel spacing)

Attribute Name	Element Tag	Type	Usage notes
Image Orientation (Patient)	(0020,0037)	1	Required field: Angles corresponding to direction cosines must be less than +/-0.6 degrees off vertical and no more than +/-0.6 degrees off perpendicular to the Z plane
Image Position (Patient)	(0020,0032)	1	Required field: The variation across slices for the horizontal value must be less than 0.01 cm. The variation across slices for the vertical value must be less than the value specified by the 'VerticalDeviation' configuration parameter. See the Section "Parameters," page 53.
Device Serial Number	(0018,1000)	3	Optional field: stored if present.
Software Versions	(0018,1020)	3	Optional field: only the first item in the series will be kept
Pixel Padding Value	(0028,0120)	3	Not used
No other fields used or stored from the Image Plane Module			

Table 116: Image Pixel Module

Attribute Name	Element Tag	Type	Usage notes
Samples per Pixel	(0028,0002)	1	See CT Image Module
Rows	(0028,0010)	1	Required field: must be identical for all images in the series
Columns	(0028,0011)	1	Required field: must be equal to rows for all images in the series (i.e., images must be square)
Bits Allocated	(0028,0100)	1	See CT Image Module
Bits Stored	(0028,0101)	1	See CT Image Module
High Bit	(0028,0102)	1	See CT Image Module

Pixel Representation	(0028,0103)	1	Required field: must be identical for all images in the series
Pixel Data	(7FE0,0010)	1	Required field
No other fields used or stored from the Image Pixel Module			

Image Dimensions

The TomoTherapy Treatment System supports planning based on square image slices only, i.e. where Rows (0028,0010) and Columns (0028,0011) have equal values and the two values of Pixel Spacing (0028,0030) are also equal. Although CT scanners normally generate square images, these images may be cropped to rectangles using a CT simulation or treatment planning system. When cropping images, be sure that the resulting dimensions are square. In addition, for maximum flexibility during the optimization process, the number of pixels in the rows and columns should also be divisible by 4.

Table 117: Contrast/bolus Module

Attribute Name	Element Tag	Type	Usage notes
Contrast/Bolus Agent	(0018,0010)	2	Not used
No other fields used or stored from the Contrast/bolus Module			

Table 118: CT Image Module

Attribute Name	Element Tag	Type	Usage notes
Image Type	(0008,0008)	1	Required field: AXIAL must be present in the third item of the sequence for all slices
Samples per Pixel	(0028,0002)	1	Required field
Bits Allocated	(0028,0100)	1	Required field: must be identical for all images in the series
Bits Stored	(0028,0101)	1	Required field: must be identical for all images in the series
High Bit	(0028,0102)	1	Required field: must be identical for all images in the series
Rescale Intercept	(0028,1052)	1	Required field: used for translation of image pixel values
Rescale Slope	(0028,1053)	1	Required field: used for translation of image pixel values

KVP	(0018,0060)	2	Optional field: if present and equal to or greater than 6000kV, image is considered to be a CTrue Image; otherwise it is a KVCT image
No other fields used or stored from the CT Image Module			

Table 119: SOP Common Module

Attribute Name	Element Tag	Type	Usage notes
SOP Class UID	(0008,0016)	1	Required field: Used to verify object type
SOP Instance UID	(0008,0018)	1	Required field
No other fields used or stored from the SOP Common Module			

7.1.2.2 RT Structure Set Storage Class

The following tables identify the entities for each IOD module for an RT Structure Set store operation. The tables indicate which IOD Entities have fields that will be stored in the TomoTherapy Data Server upon successful completion of the C-STORE operation.

Table 120: RT Structure Set IOD Entities

Entity Name	Module Name	Usage	Reference
Patient	Patient	M	Table 121
	Clinical Trial Subject	U	Not used
Study	General Study	M	Table 122
	Patient Study	U	Not used
	Clinical Trial Study	U	Not used
Series	RT Series	M	Table 123
	Clinical Trial Series	U	Not used
Equipment	General Equipment	M	Not used
Structure Set	Structure Set	M	Table 124

Entity Name	Module Name	Usage	Reference
	ROI Contour	M	Table 125
	RT ROI Observations	M	Table 126
	Approval	U	Not used
	SOP Common	M	Table 127

Table 121: Patient Module

Attribute Name	Element Tag	Type	Usage notes
Patient's Name	(0010,0010)	2	Required field: must be non-blank and verified to closely match a patient name in the TomoTherapy Data Server
Patient ID	(0010,0020)	2	Required field: must be non-blank and verified to exactly match a patient ID in the TomoTherapy Data Server
No other fields used or stored from the Patient Module			

Table 122: General Study Module

Attribute Name	Element Tag	Type	Usage notes
Study Instance UID	(0020,000D)	1	Required field: used for sorting items in the transmission for processing.
No other fields used or stored from the General Study Module			

Table 123: RT Series Module

Attribute Name	Element Tag	Type	Usage notes
Modality	(0008,0060)	1	Required field: must be RTSTRUCT
Series Instance UID	(0020,000E)	1	Required field
No other fields used or stored from the RT Series Module			

Table 124: Structure Set Module

Attribute Name	Element Tag	Type	Usage notes
Structure Set Label	(3006,0002)	1	Required field
Referenced Frame of Reference Sequence	(3006,0010)	3	Required field
>Frame of Reference UID	(0020,0052)	1C	Required field
>RT Referenced Study Sequence	(3006,0012)	3	Required field
>>RT Referenced Series Sequence	(3006,0014)	1C	Required field
>>>Series Instance UID	(0020,000E)	1C	Required field: must be identical to the Series Instance UID from a transmitted CT Image Series
Structure Set ROI Sequence	(3006,0020)	3	Required field
>ROI Number	(3006,0022)	1C	Required field
>Referenced Frame of Reference UID	(3006,0024)	1C	Required field: must match one of the items in Referenced Frame of Reference Sequence, and be identical for all ROIs
>ROI Name	(3006,0026)	2C	Required field
No other fields used or stored from the Structure Set Module			

Table 125: ROI Contour Module

Attribute Name	Element Tag	Type	Usage notes
ROI Contour Sequence	(3006,0039)	1	Required field
>Referenced ROI Number	(3006,0084)	1	Required field
>ROI Display Color	(3006,002A)	3	Optional field: if not present, one will be automatically assigned
>Contour Sequence	(3006,0040)	3	Optional field

Attribute Name	Element Tag	Type	Usage notes
>>Contour Data	(3006,0050)	1C	Required field if Contour Sequence present: all contour points must be in the image volume represented by the referenced CT Image series and lie in the same axial plane.
No other fields used or stored from the ROI Contour Module			

Points of Interest

ROI Contour Sequence items that are points (i.e. with one contour containing one point) are not processed. The TomoTherapy Treatment System does not store point ROIs received in DICOM RT Structure Set objects.

Table 126: RT ROI Observations Module

Attribute Name	Element Tag	Type	Usage notes
RT ROI Observations Sequence	(3006,0080)	1	Required field
>Referenced ROI Number	(3006,0084)	1	Required field
>RT ROI Interpreted Type	(3006,00A4)	2	Optionally valued: defaults to null-valued if not present or not one of EXTERNAL, PTV, CTV, GTV, AVOIDANCE, ORGAN, or CAVITY.
No other fields used or stored from the RT ROI Observations Module			

Table 127: SOP Common Module

Attribute Name	Element Tag	Type	Usage notes
SOP Class UID	(0008,0016)	1	Required field: Used to verify object type
SOP Instance UID	(0008,0018)	1	Required field
No other fields used or stored from the SOP Common Module			

7.1.3 Attribute Mapping

In some cases attributes received by the TomoProvider AE are either not stored, or converted to a different enumeration or scaling prior to storage in the TomoTherapy Data Server. When CT Image or RT Structure Set objects are re-exported, these attributes will either be missing from the exported object, or have values that may have been changed. These mappings are documented in Sections “Created SOP Instances,” page 59, and “Usage of Attributes from Received IODs,” page 132, in the attribute descriptions.

7.1.4 Coerced/Modified Fields

Coercion: When an RT Structure Set object is received by the TomoProvider SCP, an attempt is made to match the Patient ID (exactly) and Patient Name (closely), as described in the Section “CT Image Storage Class,” page 132. If a match is made, the Patient Name is coerced (if necessary), and all other attributes in the Patient and Study entities are coerced to the values that were present in the CT objects transferred previously.

Table 128: Coerced Fields for RT Structure Set Import

Attribute Name	Element Tag	Coercion Conditions
Patient’s Name	(0010,0010)	Coerced to Patient Name already stored in Data Server if match conditions described in the Section “CT Image Storage Class,” page 132, are satisfied.
Patient ID	(0010,0020)	Never Coerced
All other Patient and Study level attributes		Coerced to corresponding attribute value already stored in Data Server if match conditions described in 7.1.2.1 are satisfied.

Modification: Modification of attributes prior to storage in the TomoTherapy Data Server is noted throughout Section “Usage of Attributes from Received IODs,” page 132, when they occur.

7.2 Data Dictionaries

7.2.1 Private Attributes

The TomoTherapy-specific private attributes added to created composite SOP Instances are listed in the following tables. For all composite SOP Instances excluding the Raw Data IE, the Private Creator is constrained to always have a value of (300D,0010). For the Raw Data IE, the Private Creator is constrained to (300D,0020). Further details on usage of these private attributes are contained in the Section “IOD Contents,” page 59.

7.2.1.1 Private Creator Identification (TOMO_HA_01)

Table 129: TomoTherapy Private Attributes for Composite IODs excluding the Raw Data IE

Tag	Attribute Name	VR	VM
(300D,0010)	Private Creator	LO	1
(300D,1010)	Tomo Structure Blocking	CS	1
(300D,1012)	Tomo Overlap Precedence	IS	1
(300D,1014)	Tomo Modulation Factor	DS	1
(300D,1016)	Tomo Target Minimum Dose Penalty	IS	1
(300D,1017)	Tomo Target Maximum Dose Penalty	IS	1
(300D,1018)	Tomo Organ At Risk Maximum Dose Penalty	IS	1
(300D,1019)	Tomo Organ At Risk Full Volume Dose Penalty	IS	1
(300D,101B)	Tomo Primary Prescription Type	CS	1
(300D,1040)	Tomo Gantry Period	DS	1
(300D,1050)	Tomo Machine UID	UI	1
(300D,1060)	Tomo Treatment Pitch	DS	1
(300D,1080)	Tomo Couch Speed	DS	1
(300D,1090)	Tomo Performed Work Items	CS	3
(300D,10A4)	Tomo Plan Geometry	CS	1
(300D,10A7)	Tomo Projection Sinogram Data	DS	64
(300D,10A9)	Tomo Reference Isocenter	DS	3
(300D,10B0)	Tomo Registration Translations	DS	3

Tag	Attribute Name	VR	VM
(300D,10B1)	Tomo Registration Rotations	DS	3
(300D,10B5)	Tomo Delivered Secondary Meterset	DS	1

7.2.1.2 Private Creator Identification (TOMO_DD_01)

Table 130: TomoTherapy Private Attributes for Raw Data IE

Tag	Attribute Name	VR	VM
(300D,0020)	Private Creator	LO	1
(300D,2010)	Procedure Number	SH	1
(300D,2011)	Procedure Type	CS	1
(300D,2012)	Procedure Purpose	CS	1
(300D,2020)	Detector channel count	IS	1
(300D,2021)	Dataset length	IS	1
(300D,2022)	Detector data scaling factor	DS	1
(300D,2024)	Compression Type	CS	1
(300D,2025)	Compression Factor	IS	1
(300D,2026)	Active Projection Beam Sequence	SEQ	1
(300D,2030)	Detector unit of measure	CS	1
(300D,2031)	Element width	DS	1
(300D,2032)	Curvature radius	DS	1
(300D,2033)	Surface to Axis Distance	DS	1
(300D,2034)	Surface to Center Distance	DS	1
(300D,2035)	Channel range	IS	2

7.3 Coded Terminology and Templates

None specific to this application. See DICOM Supplement 74 for codes and templates used in this application.

7.4 Grayscale Image Consistency

TomoTherapy applications do not support the DICOM Grayscale Standard Display Function.

7.5 Standard Extended/Specialized/Private SOPs

The RT Plan instances, Raw Data instances and RT Beams Treatment Record instances created by the TomoTherapy Treatment System are Standard Extended objects. Extension is via addition of private attributes listed in Table 129 and Table 130 and described in Section “Created SOP Instances,” page 59.

7.6 Private Transfer Syntaxes

TomoTherapy applications do not implement any private transfer syntaxes.