ATC Method 2 Test Report – WebSys v. 2.3

The Advanced Technology QA Consortium is working to develop mechanisms for the exchange and review of digital images and treatment planning data used to document treatment delivered on advanced-technology clinical trials in radiation therapy. A review of these methods can be found on the ATC web site (http://atc.wustl.edu). A brief outline of ATC Method 2, including the supported data objects, exchange formats, transport protocols/media, data submission software, and review tools is given below.

ATC Method 2 Overview

ATC Method 2 employs mechanisms for submission and review of data being developed by the Resource Center for Emerging Technologies (RCET) in cooperation with the Image-guided Therapy QA Center (ITC). Data submission is accomplished using RCET WebSys client and server software. A phased development of this method is planned:

- Phase 1 ("Method 2a") – uses the existing ITC Remote Review Tool (requires import of data into RRT filesystem) for web-based review of volumetric treatment planning data and the RCET Rapid Image Viewer applet for review of diagnostic image series
- Phase 2 ("Method 2b") – uses a modified ITC Remote Review Tool (direct access of data from WebSys database) for web-based review of volumetric treatment planning data and the RCET Rapid Image Viewer applet for review of diagnostic image series.

The test process described in this document is part of Phase 1. Extension to Phase 2 is planned following the implementation of Phase 1.

Supported Data Objects

ATC Method 2 supports the submission and review of the following objects:

- CT Images (axial planes)
- MR Images (Only to be used as diagnostics images)
- Organ-at-risk/Target-volume contours
- 3D Dose distributions
- Treatment plan specifications (beams, brachytherapy sources)
- Dose-volume histograms
- Treatment verification images (SC/CR)
- Diagnostic images (CT/MR/US/CR)

Exchange Formats

ATC Method 2 supports the submission of digital treatment planning data as either DICOM RT objects or as RTOG Data Exchange Format files. (Please refer to the ATC web site, http://atc.wustl.edu/resources for RTOG Format specifications and DICOM conformance statements.) Diagnostic radiological and treatment verification (film scans or EPID) images can be submitted as DICOM objects.

Transport Protocols/Media

ATC Method 2 supports the submission of data over the Internet using HTTP. Prior to uploading data to the WebSys server, the WebSys client software anonymizes and encrypts data files selected by the user. Individual accounts are maintained on the WebSys server for institutions participating in advanced-technology protocols. Users may submit data files, and access their own data. Study chairs and their designates can be given access to all data within a study protocol.

Data Submission Software

The WebSys client (Windows/PC-based software, downloaded from the ATC web site) can be used for selecting DICOM/RTOG files to be submitted, anonymizing the data, encrypting data files, uploading data to the WebSys server, and registering submissions in the WebSys database. (The ITC DICOMpiler, available from the ATC web site, can be used for receiving DICOM data over a local area network.)

Review Tools

For Phase 1 implementation of ATC Method 2, submitted data are to be downloaded at the ITC and imported into the Remote Review Tool file system. These data may then be reviewed from any Internet-connected web browser using the ITC Remote Review Tool (RRT). Diagnostic image series can be reviewed immediately after submission using the RCET Rapid Image View applet (linked from the ATC web site.) Phase 2 implementation of this method will use a (yet-to-be developed) modified ITC Remote Review Tool, which will access data directly from WebSys database.

Test Methodology

Prior to the release of ATC Method 2 for use by protocol participants, the WebSys system must be tested to determine the following:
1. the user interface behaves predictably in selecting, anonymizing, and uploading digital data,
2. the client/server system stores and retrieves data reliably and without unintended alteration (corruption) of the data,
3. digital treatment planning data uploaded to the WebSys server can be downloaded and imported successfully into the ITC Remote Review Tool for review,
4. diagnostic and treatment verification images uploaded to the WebSys server can be reviewed using the Rapid Image Viewer tool, and
5. server administration tools are adequate to allow ITC staff to manage the creation and configuration of user accounts, study protocols, and data sets in the WebSys database.

In summary, the purpose of the test procedure is to determine whether ATC Method 2 is ready to be used to support the submission and review of treatment planning and verification data for ATC supported clinical trials.

Test Data Sets

The ITC has selected a test suite comprised of DICOM and RTOG data exchange format data sets representing all of the commercial treatment planning systems, which have been designated *ATC Compliant* (see http://atc.wustl.edu/credentialing/atc_compliant_tps.html) or *Vendor Complete* (data submitted by vendors has been successfully imported by ITC). The ITC test suite includes DICOM data (CT Image, RT Structure Set, RT Plan[*], RT Dose[*], and RT Image objects[*]) submitted using the following treatment planning systems:

- CMS XiO
- Elekta PrecisePlan
- Nucletron PLATO
- Nucletron BPS
- TomoTherapy Hi-Art
- Varian Eclipse
- Varian BrachyVision
- Varian VariSeed

The test suite also contains RTOG Data Exchange format datasets representing the following treatment planning systems:

- CMS XiO
- Nomos Corvus
- Nucletron HELAX TMS
- Nucletron Theraplan Plus
- Philips AcQPlan
- Philips Pinnacle3
- RTek PIPER
- Rosses CTPlan

All test data sets were validated using the ITC Remote Review Tool as for ATC Method 1. Each data set was imported successfully into the RRT database and checked to ensure that all the objects reviewable using the RRT could be visualized.

Test Procedure

Test data sets were uploaded to the ITC POLARIS server and retrieved for comparison with the uploaded data. A DICOM "dump" utility (DCMTK, University of Oldenburg, Germany) was used to display the contents of DICOM files. Differences between DICOM dumps of uploaded files and those of the corresponding, retrieved files were analyzed to identify meaningful differences and to find DICOM encoding errors.

Differences between uploaded and retrieved RTOG data exchange files were identified using the UNIX diff and cmp utilities. Differences were limited to the index ("aapm0000") files of each data set and were the result of anonymization performed by the WebSys client prior to upload.

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[*] Some test datasets do not include one or more of these objects.

In order to test the usefulness of the WebSys system in the context of the proposed ATC Method 2 Phase 1 implementation (review of treatment planning data using the ITC RRT), datasets, which had been uploaded to the WebSys server, were retrieved, imported into the RRT database, and checked using the RRT web interface.

Server Test Mode

In order to maintain a stable test platform on the ITC POLARIS server for evaluation of the WebSys software, the following discipline has been maintained:
1. Two distinct modes of server operation were defined, as follows:
    a. *update mode*, in which internet access to the POLARIS server is enabled to allow RCET personnel to update the database and install server software, and
    b. *test mode*, in which internet access to the POLARIS server is disabled and ITC performs functional, as well as upload/download tests on the server.
2. At the end of the update interval, several RCET/ITC teleconferences were held to review new features in the system, and to identify and correct minor problems with server software.
3. The first week of the test interval was used by ITC to ascertain that the server could be tested meaningfully on the ITC intranet before accepting the system for testing.
4. Once testing had begun, RCET provided ITC with instructions for configuring and using the WebSys software, but was not permitted to modify client or server software.

Testing Time Table

The table below shows the developmental timeline for implementation of ATC Method 2 at ITC. Step 1 (a-h) encompasses the testing of v. 2.3 of the WebSys client/server, the Rapid Image Viewer, and WebSys Administrative Tools.

		Developmental Step	Dates
1		**Complete ATC Method 2 testing on ITC test server until stable version is reached:**	
	a	**RCET to install WebSys 2.3 server software on POLARIS and confirm that compatible client software and Rapid Image Viewer applets are installed in UPDATE MODE.**	4/20/05 – 5/19/05
	b	**RCET/ITC Teleconference to review updated software, POLARIS switched to TEST MODE**	5/19/05
	c	**ITC evaluates design changes in database and perform usability/function checks on WebSys 2.3 user interface**	5/19/05 – 5/26/05
	d	**ITC performs upload/download/comparison tests (including RRT import) using DICOM and RTOG test datasets**	5/26/05 - 6/16/05
	e	**ITC tests Rapid Image Viewer applet 3.0**	6/9/05 – 6/16/05
	f	**ITC tests administrative tools:** Adding users, changing privileges, deleting cases, creating protocols	6/9/05 – 6/16/05
	g	**ITC to report findings in (c, d, e, f) above at ATC Meeting**	6/23/05

	h	Repeat steps (1a) – (1g) above until a stable system (server/client/database/ administrative tools) passes tests (1c) – (1f) above and is judged by both ITC and RCET to be ready for external testing. If not, RCET will evaluate test reports, correct problems found, and prepare a new version of the affected software components, and return to step (1a).	
2		Based on feedback from testing, develop submission and review manuals, FAQ, and other administrative resources. (A draft version of the WebSys submission manual has been prepared, but FAQ and manuals for administrative tools are still needed.)	Requires stable version of WebSys server/client software (step #1)
3		Move test system to a production system at ITC. • ITC will establish data backup procedures • ITC will create user accounts • ITC will establish procedures for making data submitted using Method 2 available for review using RRT.	Requires stable version of WebSys server/client software (step #1) and documentation (step #2)
4		Begin user testing (with selected institutions) of a production system at ITC	Requires WebSys server operating in production mode at ITC (step #3).
5		Based on feedback of user testing, make final corrections to manuals, web pages, and FAQ	Depends on nature of problems found in preliminary user testing.
6		Activate Method 2 production server at ITC for ATC supported protocols data submission and QA review.	

Test Results

The results of the evaluation of version 2.3 of the RCET software (WebSys client/server, Rapid Image Viewer, and WebSys administration tools) are shown below.

General Comments

Several improvements over previous versions of the RCET software, evident in version 2.3, reflect progress in the development of this system. Among these are the following:
1. An improved Case Selector in the WebSys client Login sheet allows sorting of cases by CaseID, Institution, Date, and Description. (The ability to select case data is especially important for Phase III protocols in which the number of cases can exceed 1000.)
2. The previous limit of six protocols per user has been removed. (This change is important since the ITC currently supports nine active, advanced-technology protocols, with more than four others in development.)
3. The performance of the DICOM file scanner is substantially improved.
4. Web-based Administration Tools are now provided to add users, change privileges, delete cases, and add protocols.

The observations listed below indicate suggested improvements to the usability of this software.

1. **The specificity of WebSys client error messages could be greatly improved.** Messages observed in testing appeared to be of little help to the end user in diagnosing the source of problems.
2. The **DICOM RT and RTOG tabs appear on the far right-hand side of the Electronic Folder** page. Moving these to the left-hand side would make this page much easier to use, since these are expected to be the modalities used most frequently for ATC clinical trials.
3. A column indicating the **total number of objects in each "study"** would be helpful in the Electronic Folder.
4. Lower "sheets" in the WebSys client program allow entries before the user has logged in to the server. Locking out entries (at least submission buttons) would reduce confusion/annoyance for users.
5. The current version of the RCET software does not support the review of CT, MR studies or treatment verification (DRRs, EPIs, portal film) images submitted using RTOG data exchange format.

Specific Findings

Functional testing of the RCET software for ATC Method 2 (WebSys client/server, Rapid Image Viewer, WebSys Administration Tools) has identified the problems listed below:

1. The **DICOM file scanner fails to recognize DICOM objects** in the selected directory. These failures were noted in four test data sets and involved RT Structure Set and RT Dose objects. These data cannot be submitted using v2.3. As a result, further testing of the handling of these objects cannot be performed at this time.

2. The **WebSys client fails to create a new case** when the CaseID entered is the same as that of an existing case of another protocol (different ProtocolID) in the database.
   * A popup message indicates, "There was an error communicating with the Server.")
   * After removing the other case with the same CaseID from the database, creation of the new case is permitted.
   * The requirement that CaseIDs be globally unique was identified as an unacceptable limitation in version 2.1.3 of the RCET system. Changes to address this limitation are apparently incomplete in version 2.3.

3. Comparison of data uploaded to WebSys with corresponding downloaded data revealed a class of data for which **data submitted using the system were corrupted**.
   * WebSys v. 2.3 failed to create DICOM-conformant files for download for objects containing data-element sequences when the corresponding uploaded DICOM data files were encoded using Explicit-VR transfer syntax (such as is commonly used for media transfers). WebSys produces DICOM objects encoded using Implicit-VR transfer syntax, however, in these objects, data elements *within* sequences are erroneously encoded using Explicit-VR transfer syntax.
   * Failures were noted in RT Structure Set, RT Plan, RT Dose, and some CT Image files.
   * When the datasets which elicited this failure were converted to Implicit-VR transfer syntax before uploading them to the WebSys server, they were retrieved without error.
   * Fixes for this bug, identified earlier in version 2.1.3, appear to be incomplete in version 2.3.

4. The **WebSys client crashes** when the RTOG file selector attempts to find data files with some non-standard filenames.
    - This problem appears to involve filenames with non-null file extensions: (e.g., ".DAT").
    - Renaming files to remove the extension allows the file selector to succeed.

5. **Multiple usability issues were identified in the Rapid Image Viewer tool:**
    - **The grayscale rendering of some CT studies (four CT series in the ITC test suite) made it impossible to review these images.** No combination of "center" or "width" settings could be found to produce a usable display of these images.
    - **The center/width settings are difficult to interpret for CT images**, since there is no apparent correspondence to image (HU) values and no preset grayscale windows are provided.
    - **The user-interface state is not applied consistently to the display:** when the "Equalize" feature is enabled on an image and a second thumbnail is selected, the new image is not equalized. The use must de-select and re-select "Equalize" to apply the feature to the second image.
    - **A mechanism for applying grayscale settings to multiple images, implemented in earlier versions of the software, appears to be inoperable** in v2.3. Absence of this feature makes review of multiple image slices rather tedious.

6. Web-based server administration tools perform most functions correctly: create protocol, create user account, modify user privileges and protocol access, modify case information, and delete studies submitted under a CaseID. However, **attempts to delete a case record from the database using the web-based Administrative Tools failed.** (The aCase_Delete.asp script failed to execute.)

7. Data retrieved from the WebSys server were successfully imported and reviewed using RRT, with the following **exceptions:**
    a. DICOM objects which were failed to be uploaded by the WebSys client because they were not found by the DICOM file scanner, and
    b. DICOM data encoded using Explicit-VR transfer syntax, which was corrupted by the WebSys server.

It should be noted that these tests may not have uncovered all errors remaining in the software, either due to limitations in scope of the ITC test suite, or to the existence of other errors which have obscured them.

Summary

The RCET software v. 2.3, including WebSys client/server, Rapid Image Viewer, and WebSys Administration Tools, were tested by the ITC to evaluate the readiness of this software to facilitate the submission and review of protocol data for ATC-supported clinical trials. These tests have identified problems, some remaining from earlier versions, which must be corrected before this system is ready to be tested by institutions outside the ATC.

Respectfully submitted,

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