# IHE-RO Technical Committee
# Domain Pre-Testing Report
# June 3-9, 2009
# Siemens Medical Solutions Training Center
# Erlangen, Germany


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Wednesday, June 3rd

- We have a group of 16 individuals in Erlangen, representing Tomotherapy (2), Nucletron (2), Siemens (2), Varian (3), AccuRay (2), BrainLab (2), Elekta/IMPAC (2), and ASTRO (1).
- Siemens has graciously provided a spacious meeting room in their Medical Solutions Training Center for our use, with network, power cords, and food/coffee. Thanks to Bernd Becker, Josia Kammler, and the others at Siemens for their hospitality.
- Today was dedicated to setting up equipment, establishing network connections, and getting systems configured for testing.
- In preparation for testing the Advanced RT Objects profile, anonymized Head/Neck test dataset instances consisting of a CT images series and RT Structure Set are being created for each vendor. Datasets are identified by the vendor whose actor is to produce Advanced Object RT Plans. Patient names for these datasets are of the form "AdvObj_[V]^[Vendor]", where [V] is the initial character of the Vendor name and [Vendor] is the Vendor name with first character capitalized. Patient IDs are of the form "AO1_[V]". It is expected that one instance of each dataset per vendor, with multiple Producer Actors generating RT Plans with different Series Instance UIDs and Series Descriptions to facilitate retrieval from the archive.
- In preparation for testing the Integrated Positioning and Delivery profile, vendors of Positioning and Delivery systems (Varian, Elekta, Tomotherapy, Accuray) have downloaded the SET_201 Head/Neck data (CT, RTSS) from the 2007 Connectathon in order to create deliverable RT Plans for their systems. Patient names for these datasets are of the form "IPDtest_[V]^[Vendor]", where [V] is the initial character of the Vendor name and [Vendor] is the Vendor name with first character capitalized. Patient IDs are of the form "IPD1_[V]".
- There are 4 vendors planning to test the Advanced RT Objects profile and 5 vendors planning to test the Integrated Positioning and Delivery Workflow profile. IMPAC is providing archive support for both profiles.

Thursday, June 4th

- CT image / RT Structure Set data for Advanced RT Objects profile testing were loaded into the archive and retrieved by four vendors, who were asked to create simple (one- or two-beam static beam plans and store the RT Plans in the archive along with corresponding RT Dose (3D dose matrices). To aid in evaluating import of plans by

consumer actors, the vendors were also asked, where possible, to save screen captures of isodose plots in T/S/C planes through the iso-center, as well as beam's eye view displays from their TPSes.

- Several concerns regarding RT Structure Set object in the test data were identified:
  - The ROI Interpreted Type (3006,00a4) of all structures is "ORGAN". The "Body" contour should be labeled as "EXTERNAL", the PTVs should be labeled as "PTV", etc.
  - The ROI Generation Algorithm (3006,0036) of all structures is NULL. This DICOM Type 2 attribute is required by the 2007 Basic Treatment Planning profile.
- Testing of the Advanced RT Objects profile can be outlined as follows:
  1. Each vendor participating will retrieve the CT image series and RT Structure Set instances corresponding to the Patient assigned to the vendor.
  2. For each beam technique, the vendor will use the corresponding "Producer" actor to create and store a simple (one- or two-beam) plan. This plan/dose is to be labeled as "original".
  3. Each original plan, along with the referenced CT images and RT Structure Set is to be retrieved by all vendors and imported in their corresponding "Consumer" actor.
  4. Vendors will then make a small, reversible change in the plan and then un-do the change before storing the plan (and dose) in the archive in order to create a new instance of a functionally equivalent plan.
  5. Vendors will also save screen captures in compressed format (JPEG or PNG) of isodose plots in T/S/C planes through isocenter and Beam's Eye View including beam apertures, where applicable.
  6. Adherence to the profile for Producer actors will be evaluated by analyzing their "original" RT Plans (using the Test Tools and DICOM dump utilities.
  7. Ability of Consumer actors to import RT Plans will be evaluated by comparing the corresponding input and output RT Plan objects for the plans they consume, as well as any or all of the following:
     - RT Dose,
     - Iso-dose plots in T/S/C planes,
     - Beam's Eye View displays,
     - DRRs
- Care will be needed in labeling RT Plans and RT Doses loaded into the archive from actors under test. Series Descriptions and Plan Labels may need to be edited on the archive web interface to distinguish Original (Producer) and Secondary (Consumer) plans, doses, and possibly DRRs (RT Images) for various Beam Techniques.
  - Plans/Doses produced by the original vendor should have a Series Desciption/ Plan Label/Dose Label starting with "Original".
  - Plans/Doses exported from Consumer actors should have a Series Description/Plan Label/Dose Label starting with the Vendor name and identifying the beam technique / Retrieval Transaction number / Storage Transaction number of the Consumer actor.

- If the same Series is used for all plans from a Vendor, the consumer will have to retrieve all plans in the Series and sort them out locally before importing one of them.
- By the end of the day, Varian had stored a plan, retrieved it, and stored a new instance of the plan. The original and "consumer" plan were compared using both the DVTk DCM Compare tool and the WU/MESA dcm_diff tool. As expected, differences were limited to Instance UIDs, dates, and the (modified) plan label.

- A plan generated by Siemens was imported by Nucletron. Both the original and "consumer" RT Plan objects were compared. Differences encountered included instance UIDs, dates, differing precision in attributes with a VR of DS, numerous private tags, and the presence of re-calculated values such as SSD. In general, however, the plans appeared to be functionally equivalent. Doses have been captured for these plans and may be compared as time permits.
- Integrated Positioning and Delivery profile testing began among the TMS (2) and PDS (3) vendors present. Some differences among vendors in interpreting the profile (and DICOM Supp 96) regarding the SOP Classes used for procedure step notifications were encountered. This matter is to be discussed by the Workflow sub-group on Friday morning.
- Walter has uploaded several datasets to the "Datasets_2009" directory on the ICT FTP server (ftp.ict.nl) for use in Test Tool development

    1. In directory 2009_Adv_Objects_Interop
        a. Varian – contains Varian machine descriptions and VarianAdvObjects.zip with RT Plans corresponding to the various beam techniques in the Adv Objects profile.
        b. AdvObjData_ICT.zip – contains CT images and RT Structure Set for a head/neck patient as a starting point for Producer actors in this profile.

    2. In directory 2009_Delivery_Worklist
        a. Accuray – Accuray RT Plan and RT Treatment Record
        b. ELEKTA – Elekta plan
        c. Tomotherapy – Tomotherapy plan
        d. Varian – Varian RT Plan and RT Treatment Record for a complete delivery and an interrupted delivery
        e. SET_101 – CT images and RT Structure Set for a head/neck patient as a starting point for generating plans to be used this profile

## Friday, June 5th

- A discussion of Integrated Positioning and Delivery Profile issues indentified the following concerns:
    - Confusion regarding the interpretation of SOP Services and SOP Classes to be used for Procedure Step notifications has resulted in interoperability problems between TMS and PDS actors.
    - It is not entirely clear whether DICOM WG-6 will ultimately settle on a Image- or Hierarchical SOP Instance Macro for Supp 96. Uli Busch has volunteered to work out the implications for both approaches so clarifying text can be added to the Profile.
    - The IHE-RO Technical Committed should clarify whether AE configurations are to be defined per Actor or per Transaction.
- Testing of IPD profile is expect to follow a clinical scheduling and delivery process:

    1. Schedule a delivery on the TMS
    2. Perform a normal (complete) positioning and delivery, capturing network packets treatment records, and TMS as well as PDS system logs.
    3. Perform an interrupted positioning and delivery and a subsequent completion, capturing network packets treatment records, and TMS as well as PDS system logs.

- Testing should include more than one patient and plan to determine that the correct patient and plan are selected for delivery, i.e., that user choices are made and followed appropriately.

- We should consider what state variables and events are visible in the TMS? In the PDS? In their logs? In the treatment record object(s).
- It should be possible to capture DIMSE packets, TMS/PDS logs, and (perhaps) treatment records to verify that the expected events have occurred in the proper sequence.
- Patient/Plan selection should be verified to determine whether query keys are honored, e.g., in filtering by Station Name. Use RO17 as a guide.
- Advanced Objects Integration (AOI) Profile Issues were reviewed:
  - It should be make clear that AOI consumer actors that are TPSs are extension of the Dosimetric Planner Actor, and thus, are expected to use use the RT Plans they consume to create RT Plans and RT Doses.
  - It may be helpful and appropriate to split several of the Beam Technique Types in the AOI profile to accommodate Actors that handle optional features, but not all of the currently required baseline features. (E.g., Basic Static producer/consumer that supports MLC apertures, but not blocks.) Thus,
    - Split Basic Static and Arc beams types into (a) MLC and (b) non-MLC sub-types
    - Split Stereotactic into (a) Stereo Beam and (b) Stereo Arc.
  - We need to decide whether a system that imports RT Plans, but is capable of using only a subset of plan information to create its own new plan (e.g., using only beam orientations to create an IMRT plan for the patient) can participate as a Consumer Actor. What does it mean to perform re-planning based on the output of another TPS? How much of the information in the input plan must be interpreted and used in re-planning? Is it only necessary that the import support a legitimate clinical use case?
- Corrections identified for IHE-RO Technical Framework v3.0 Part 2 document:
  - In Appendix A2: RO Critical Modules for RT Plan IOD, the RT Patient Setup Module has IHE-RO Usage of "U", but the Patient Position attribute (0018,5100) in the module is of type "R+" and must be one of HFS, HFP, FFS, FFP (See Appendix A.3).
  - The second Module Table in Appendix A.2 describing modules for the RT *Dose* IOD is labeled "RT *Plan* IOD Modules".
- TPS vendors participating as AOI actors will contribute RT Plans, RT Doses, Iso-dose screen captures, and Beams-Eye-View screen captures to prepare more consistent test data for the 2009 test tools (and connectathon).
  - Three treatment machine models where identified for these plans
    - Elekta Beam Modulation machine ( "IHE_EBM" ) to be used for Motorized Wedge beams – Uli Busch to provide description
    - Siemens with 160-leaf MLC ( "IHE_S160" ) to be used for IMRT Step and Shoot beams– Marc Ruehlaender to provide description
    - Varian Millenium 80-leaf MLC ( "IHE_V80" ) to be used for all others. – Uli Busch to provide description
  - Vendors will create and push to the archive Plans and Doses for each of the beam types they are capable of producing.
    - If possible, plans should be stored one per series
    - Screen captures (JPEG) images should also be uploaded to the archive.

Saturday, June 6th

- Work continues today on profile testing (AOI and IPD) and on collection of test data (AOI).
- Validation of RT Plans produced for AOI datasets has pointed out some problems. Vendors are working to correct these.
- Two IPD/TMS vendors are working through the IPD profile with PDS vendors to capture DIMSE packets, logs, and treatment records for complete and interrupted/completed deliveries.
- AOI vendors will need to use Monday to complete production of "test data" and to attempt consumption of others' plans.
- The group plans to wrap-up on Tuesday morning with a review of Profile issues to generate proposals to the TC for filling-in TBDs and correcting errors and inconsistencies.

Monday, June 8th

- Testing and data collection concludes today with collection of AOI test data and final check of IPD protocol.
- DICOM objects for AOI beam type plans and doses, as well as JPEG screen captures have been retrieved from the Archive by Walter.
- Copies of CT/RT Structure Set/RT Plan for plans that include beam modifiers have been collected by Stuart for generation of Test Datasets to be forwarded to ICT to facilitate Test Tool production.
- DICOM Associations between TMS and PDS actors for the IPD protocol were captured from the network using the DVTk DICOM Sniffer (v2.8) tool. This approach appears to be workable for confirming the sequence and content of DICOM messages.
- At the end of the day, the archive was shutdown and prepared for shipment. A discussion of outstanding Profile and Testing issues is scheduled for Tuesday morning.

Tuesday, June 9th

- A discussion of outstanding Profile and Testing issues was held on Tuesday morning. Issues identified in this session (shown below) were posted to the BBS as IHE-RO_Profile_Issues_2009-0609.doc.

## PROFILE AND TESTING ISSUES

### Advanced RT Object Integration Profile Issues

1. A clarification of the Use Cases addressed by the Advanced RT Integration Profile is need: to be addressed jointly by IHE-RO PC and TC. Specifically, what are use cases for consuming plans? How much of the information in the consumed plan must be used by the consumer?

    - Primary intention of profile is to address CONTENT of RT Plan
    - Consumer must be able to interpret and *display* the plan content.

- **Proposal:** Producers to create plans with richest mutually-supported subset of options. *Union plans can be defined by combining beams* in the matrix of supported beam types and options.
- **Proposal:** Participants to submit draft integration statements by mid-July 2009.
- **Question:** Is one of the use cases for this profile for re-planning, i.e., as extensions of the Dosimetric Planner Actor? Are consumer actors expected to use the RT Plans they consume to create RT Plans and RT Doses? (The answer has important implications for testing.)

2. Advanced Objects Integration (AOI) Profile Issues were reviewed:
    **a.** It seems helpful and appropriate to split several of the Beam Technique Types in the AOI profile to accommodate Actors that handle optional features, but not all of the currently required baseline features. (E.g., Basic Static producer/consumer that supports MLC apertures, but not blocks.) **Proposal:**
        i. Split the "Basic Static" and "Arc" beam types into (a) MLC and (b) non-MLC sub-types
        ii. Split Stereotactic into (a) Stereo Beam and (b) Stereo Arc.

3. Corrections identified for IHE-RO Technical Framework v3.0 Part 2 document:
    a. In Appendix A2: RO Critical Modules for RT Plan IOD, the RT Patient Setup Module has IHE-RO Usage of "U", but the Patient Position attribute (0018,5100) in the module is of type "R+" and must be one of HFS, HFP, FFS, FFP (See Appendix A.3). **Proposal:** Make RT Patient Setup Module Mandatory (Type "M").
    b. The second Module Table in Appendix A.2 describing modules for the RT *Dose* IOD is labeled "RT *Plan* IOD Modules". **Correction Required**
    c. Compensator Sequence Tags. **Cleanup Required:** for optional modifiers, utilize the most constrained definition used for that modifier for all transactions (presumably in the modifier transaction).
    d. Block sequence: number of blocks has maximum of 8. **(No change needed.) Proposal:** Add explanatory text that this limit is needed for interoperability with existing actors.
    e. Bolus: restricted to one bolus per beam. **Proposal:** Re-evaluate maximum number of boli. (There are clinical scenarios that use two or more. Current clinical upper limit is not known.)
    f. Electron Arcs. **Proposal:** For Arc Beam, Radiation Type is PHOTON. If Radiation Type of ELECTRON is needed for arcs, create a new Beam Type.
    g. Number of Control Points has no upper limit: Should one be defined? **Proposal:** Define as 999 or explicitly specify safe handling in Consumer.
    h. Motorized Wedge: **Proposal:** Need to specify how to handle extreme wedge angles, i.e., zero and 60 degrees.
    i. Gantry Pitch Angle: **Proposal:** Add note indicating that Gantry Pitch Angle is assumed to be zero, unless explicitly specified.
    j. Beam Dose Specification Point: **Proposal:** Require Beam Dose Specification Point (since Beam Dose is mandatory). Must also be displayed.

k. Virtual Wedge angle issues: (coupling of Wedge ID and Wedge Angle; only discrete set of angles is available) **Proposal:** constrain set of wedge IDs for the purpose of testing (assuming no inherent limitation in actor).
l. Conformal Arc collimator behavior: Beam Limiting Device behavior (Step and Shoot Style or Sliding Window Style) is not specified. **Proposal:** TDS vendors to clarify capabilities/behaviors.
m. Beam Limiting Device (MLC) angle in Step and Shoot says "TBD" and "value must be constant". **Proposal:** remove "TBD"; keep "Value must be constant".
n. Wedge Tray Distance is currently required in transaction. **No change.**
o. Interpretation of Collimator Specification: **Proposal:** for TDDs which have only have an MLC and no fixed collimator in one direction, decide whether (a) to specify *either* two jaws *or* one MLC and one jaw, or (b) *always* specify one jaw and one MLC. Siemens to clarify implication for treatment record.
p. Fundamental Interoperability issues exist when applicators are involved, not just content of applicator sequence. E.g., what Beam Limiting Devices are expected to be specified when applicators are used: (a) as the physical positions the Beam Limiting Devices are in when applicator is in use or (b) as "effective aperture"? At present, field size is encoded in applicator ID. **Proposal:** Remove Electrons from 2009 Profile. Refer issue to DICOM WG-7.

**Advanced RT Object Integration Testing Issues**

1. **Use of one patient dataset (CT, RTSS) per vendor appears to work for testing, but care/coordination will be needed in labeling RT Plans and RT Doses loaded into the archive from actors under test.** Series Descriptions and Plan Labels may need to be edited on the archive web interface to distinguish Original (Producer) and Secondary (Consumer) plans, doses, and possibly DRRs (RT Images) for various Beam Techniques.
    a. Plans/Doses produced by the original vendor should have a Series Desciption/ Plan Label/Dose Label starting with "Original".
    b. Plans/Doses exported from Consumer actors should have a Series Description/Plan Label/Dose Label starting with the Vendor name and identifying the beam technique / Retrieval Transaction number / Storage Transaction number of the Consumer actor.
2. **Problems identified with RTSS in test data:**
    a. The ROI Interpreted Type (3006,00a4) of all structures is "ORGAN". The "Body" contour should be labeled as "EXTERNAL", the PTVs should be labeled as "PTV", etc.
    b. The ROI Generation Algorithm (3006,0036) of all structures is NULL. This DICOM Type 2 attribute is required by the 2007 Basic Treatment Planning profile.
3. **Testing of the Advanced RT Objects profile** can be outlined as follows:
    a. Each vendor participating will retrieve the CT image series and RT Structure Set instances corresponding to the Patient assigned to the vendor.
    b. For each beam technique, the vendor will use the corresponding "Producer" actor to create and store a simple (one- or two-beam) plan. This plan/dose is to be labeled as "original".

    c. Each original plan, along with the referenced CT images and RT Structure Set is to be retrieved by all vendors and imported in their corresponding “Consumer” actor.
    d. Vendors will then make a small, reversible change in the plan and then un-do the change before storing the plan (and dose) in the archive in order to create a new instance of a functionally equivalent plan.
    e. Vendors will also save JPEG screen captures of isodose plots in T/S/C planes through isocenter and Beam’s Eye View displays, including beam apertures, where applicable.
    f. Adherence to the profile for Producer actors will be evaluated by analyzing their “original” RT Plans (using the Test Tools and DICOM dump utilities.
    g. Ability of Consumer actors to import RT Plans will be evaluated by comparing the corresponding input and output RT Plan objects for the plans they consume (using the DVTk DCM Compare tool and/or the WU/MESA dcm_diff tool)
    h. The following data may also be used for comparing producer plans with consumer re-planning output:
        i. RT Dose,
        ii. Iso-dose plots in T/S/C planes,
        iii. Beam’s Eye View displays,
        iv. DRRs
4. Three treatment machine models have been identified for Test Data generation and Connectathon testing:
    a. Elekta Beam Modulation machine ( “IHE_EBM” ) to be used for Motorized Wedge beams – Uli Busch to provide description
    b. Siemens with 160-leaf MLC ( “IHE_S160” ) to be used for IMRT Step and Shoot beams– Marc Ruehlaender to provide description
    c. Varian Millenium 80-leaf MLC ( “IHE_V80” ) to be used for all others. – Uli Busch to provide description
5. What are difference between produced and consumed (output) Plan are acceptable?
6. Explicit instructions for generating plans are needed.
7. Review Uli Busch email regarding Image Reference Sequence in RTSS.

**Integrated Positioning and Delivery Profile Issues**

1. Confusion regarding the interpretation of SOP Services and SOP Classes to be used for Procedure Step notifications has resulted in interoperability problems between TMS and PDS actors. This is especially true in the DIMSE Responses.
    a. The exact values/combinations of SOP Services and (Affected/Requested) SOP Classes for each transaction should be made clear in the profile.
2. It is not clear at present,whether DICOM WG-6 will ultimately settle on a Image- or Hierarchical SOP Instance Macro for Supp 96. Uli Busch has volunteered to work out the implications for both approaches so clarifying text can be added to the Profile. **Note:** WG-6 has agreed to accept use of Hierarchical SOP Instance Macro. **Proposal:** Document use of Hierarchical SOP Instance Macro in profile.
3. The IHE-RO Technical Committee should clarify whether AE configurations are to be defined per-Actor or per-Transaction.

**Integrated Positioning and Delivery Testing Issues**

1. Use of one patient dataset (RT Plan) per PDS actor appears to work for testing.
2. Issues with RT Plan test data have been identified. Some have been resolved during Pre-Testing, while others will be addressed point-to-point. Stuart will upload to SFTP server for Test Tool development.
3. Testing of IPD profile is expect to follow a clinical scheduling and delivery process:
    a. Schedule a delivery on the TMS
    b. Perform a normal (complete) positioning and delivery, capturing network packets treatment records, and TMS as well as PDS system logs.
    c. Perform an interrupted positioning and delivery and a subsequent completion, capturing network packets treatment records, and TMS as well as PDS system logs.
4. Testing should include more than one patient and plan to determine that the correct patient and plan are selected for delivery, i.e., that user choices are made and followed appropriately. I.e., Patient/Plan selection should be verified to determine whether query keys are honored, e.g., in filtering by Station Name. Use RO17 as a guide.
5. Capture of DIMSE packets has been demonstrated. TMS/PDS logs and (perhaps) treatment records can also be used to verify that the expected events have occurred and are in the proper sequence.
6. Areas of concern, e.g., locking of records, must be identified. Representatives of TMS, PDS vendors to be consulted regarding tests to expose these concerns as a means of considering state variables and events.