

Integrating the Healthcare Enterprise: Connectathons and Testing



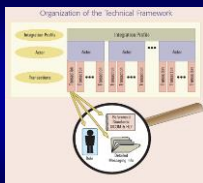
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IHE Process

1. **Define** a clinical use case involving connectivity.
2. **Create** Integration Profiles to specify how existing data standards are to be used for solve clinical problems.
3. **Test** the adherence of clinical systems to Profile specifications.
4. **Publish** results to assist users in selecting interoperable systems.

IHE Testing



IHE Testing is based on specifications laid out in the Technical Framework

Vendors register to test products as one or more Actor(s) within an Integration Profile.

Adherence is tested by demonstrating

1. Behavior (input, output, display) conforms to requirements for each "Transaction".
2. Successful exchange of clinical information with other vendors' products playing the role of other Actors in the Profile.

What is a Connectathon?

Cross-vendor, live, supervised, structured test event

- All participating vendors' products tested together in the same place/time.
- Experts from each vendor available for immediate problem resolution... fixes are often done in minutes, not months!!
- Each vendor tests with multiple trading partners (actual product to product).
- Testing of real-world clinical scenarios with IHE Integration Profiles.
- Supervised by test monitors, i.e. "judges".

Connectathons

- IHE NA Connectathon (annual since 1999)

- Radiology and 9 other domains
- >100 vendors, >550 engineers
- Cleveland Convention Center
- January 23-27, 2017



- IHE-RO Connectathon (since 2007)

- Radiation Oncology Domain
- 5-8 vendors
- Philips, Madison, WI
- October 17-21, 2016



IHE-RO Connectathon

- Annual, week-long event
 - ½ day setup
 - ½ day cleanup
- Hosted at ASTRO HQ, vendor facilities, and academic centers
- Supervised, informal test events ("Domain Pre-Testing") have also been held between connectathons.



IHE-RO Connectathon Venues

Year	Connectathon	Domain Pre-Testing
2006		ASTRO, Fairfax, VA
2007	ASTRO HQ, Fairfax, VA	
2008	MD Anderson, Houston, TX	Brainlab, Munich, Germany
2009	ASTRO HQ, Fairfax, VA	Siemens, Erlangen, Germany
2010	ASTRO HQ, Fairfax, VA	Fundación Icahn, Granada, Spain
2011	ASTRO HQ, Fairfax, VA	Elekta, Stockholm, Sweden
2012	ASTRO HQ, Fairfax, VA	Washington Univ., St. Louis, MO
2013	ASTRO HQ, Fairfax, VA	Brainlab, Munich, Germany
2014	ASTRO HQ, Fairfax, VA	Varian, Zug, Switzerland *
2015	Sun Nuclear, Melbourne, FL	Raysearch, Stockholm, Sweden *
2016	Philips, Madison, WI	

* Included formal testing

IHE-RO Test Process

- IHE-RO judges select test cases and provide instructions for participants to interact with multiple test partners.
- Adherence to a profile is demonstrated for each Actor by successful transactions with
 - 3+ upstream Actors
 - 3+ downstream Actors



Connectathon Judges

- Volunteers (clinical physicists and physicians) who assist in testing adherence of products to IHE-RO Profiles.
- Assist vendors in creating meaningful test data.
 - The purpose of testing is NOT to see which product is "best".
 - Want test data and plans to be as clinically relevant as practical.
- Compare data displayed by "producer" and "consumer" Actors
 - Side-by-side comparison of product displays.
 - Assure consistent interpretation of information in both products.

Test Archive

- A DICOM ARCHIVE is used to store
 - Initial test datasets
 - Output data from “Producer” Actors
 - Input data for “Consumer” Actors
- Initial test dataset
 - Starting data for the first Actor in a Profile
 - Stored in the Archive before testing begins
 - Each vendor starts with their own test dataset instance (Patient ID with vendor code)
- Data produced by Profile Actors can be retrieved for troubleshooting and analysis by judges.
- The Archive is supplied and operated by a vendor volunteer.

```
graph TD; Producer[Producer] --> RTArchive[RT Archive]; Consumer[Consumer] --> RTArchive; RTArchive --> Analysis[Analysis for Profile Adherence, DICOM Conformance];
```

The diagram illustrates the Test Archive system. At the top, a 'Producer' actor (represented by a monitor icon) sends data to a central 'RT Archive' (represented by a blue box). A 'Consumer' actor (represented by a monitor icon) also sends data to the 'RT Archive'. The 'RT Archive' then provides data for 'Analysis for Profile Adherence, DICOM Conformance' (represented by a document icon).



Advanced RT Integration Profile

- Exchange of treatment plan content (DICOM RT Plan)
 - **Producer** (TPS)
 - **Consumer** (TPS/TMS)
- Constraints on plan content are specified for each of 14 *beam techniques*:

Basic Static Beam	Virtual Wedge Beam
Static MLC Beam	Static Electron Beam
Arc Beam	Step & Shoot Beam
MLC Arc Beam	Sliding Window Beam
Conformal Arc Beam	IMAT/VMAT Beam
Hard Wedge Beam	Stereotactic Beam
Motorized Wedge Beam	Stereotactic Arc Beam

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Motorized Wedge Beam	Stereotactic Arc Beam

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Advanced RT Integration Profile Test Procedure

- **Test datasets are created** for each vendor and stored in an Archive (CT images and RT Structure Set).
- **Plan producers retrieve** test datasets and **create and store RT Plans for each beam technique** per planning instructions.
- **Plan consumers retrieve producers' plans** from the archive and display them.
- **Judges compare side-by-side plan displays** on producer and consumer systems to check consistency.
- **Goal: demonstrate successful exchange with 3+ partners**



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The Advanced IT integration (METS) Profile is tested by importing CT image and Structure Set test data to a Producer Actor, creating a treatment plan (and doses) for a supported beam type, and exporting the plan (and doses) to an Actor for retrieval by a test partner (Consumer Actor). Side-by-side comparison of plan displays on the Producer and Consumer Actors is used to verify interoperable exchange of plan information.

- Import and save CT images and Hb^{15}O structures set for both supine and prone patients. Import the multiple brain node patient if you are testing diastolic beams.
- For each procedure, create two plans, one with all supported options and one without options if you want multiple options a.k.a. beam fractionation, dose, kV, etc.

- **Plan** is written as follows:
 - **Suppose patient:** $x = 3$ days, $y = 60$ days, $z = 250$ mm (**CC-CC**)
 - **Prove patient:** $x = 2$ days, $y = 26$ days, $z = 264$ mm (**CC-CC**)
 - **Brain results patient:** $\text{ccscore} = 1$ $\rightarrow$ 42 days, $z = 154$ mm, $z = 65$ mm, $\text{ccscore} = 2$ $\rightarrow$ 10 days, $y = 295$ days, $z = 68$ mm (**CC-CC**)
- Specify a valid date of 04/01/27 at 2 Gs fractionation in pbf4, unless otherwise specified.
- Label the plan accordingly, e.g., **plan_state_etc**.
- Remember, there are two plans and each in its own **CC-CC** Series and use the Series Descriptor to identify the **ADT** Active, i.e., **Brain** lists, that produced it.
- Remember, do not include **Setup** beams in the plan.



Note: The nomenclature is different from the nomenclature used in the Supplement
by the publication of our [supplementary material](#).
DOI: 10.1002/suppl.2014.0125.docx

- 1. **Basic Stamp**  Generate a plate with two opposing screw heads.
- 2. **Basic Stamp (SL)**  Generate a plate with two opposing screw heads.
- 3. **Standard Wedge Beam**  Generate a plate with 40° and 60° wedgebeams.
- 4. **Hard Wedge Beam**  Generate a plate with 40° and 60° wedgebeams.
- 5. **Virtual Wedge Beam**  Generate a plate with 40° and 60° wedgebeams.
- 6. **Art Beam**  Generate a plate with two lateral screws (0, 270, 90, 180).
- 7. **Conformal Beam**  Generate a plate with two lateral screws (0, 270, 90, 180).
- 8. **SL (Art Beam)**  Generate a plate with two lateral screws (0, 270, 90, 180).
- 9. **Step & Shoot Beam**  Generate 4 beams, use structure 40° and 60° .
- 10. **Sliding Window Beam**  Generate 5 beams, use structure 40° and 60° .
- 11. **Static Window Beam**  Generate a plate with 40° and 60° wedgebeams, 100 LEDs.
- 12. **Art Beam (SL)**  Generate a plate with two lateral screws (0, 270, 90, 180).
- 13. **ANYBeam**  Generate a plate with two lateral screws (0, 270, 90, 180).
- 14. **Stochastic Art Beam**  Generate a stochastic plate.

- Instructions for testing ARTI Plan Producer Actors
- Also includes a table of detailed plan parameters to be used.

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Connectathon Scoring

- ARTI checklist of plan parameters used for side-by-side comparison of Producer and Consumer Actors

	Producer	Consumer	Weighted Consumer
Name			
Geographic Area			
Industry / Major Activity			
Capacity			
Location			
Product			
Process			
Plant Size			
Age			
Manager			
Design / Innovation			
Key Customer Segment			
Key Suppliers			
Control of Capital			
Ownership			
Revenue			
Revenue Growth			
Asset Liability			
Market Share			

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Unit	Unit	Book	Page	Def	
Part Name	Structure			Customer	Discipline/Comments
Part Name					
Quantity Start Angle					
Quantity Stop Angle					
Energy					
Length					
Customer					
Part Name					
ISO					
Mu					
Weight Gr					
Apparatus					
Weight orientation					
M.U. shape vector					
A vector points					
Control of cylinder					
Orientation					
Invention					
Customer Design					
Unit display					
Part Name					

IHE-RO Integration Profiles in Testing

- Basic RT Objects Profile (BRTO)
- Advanced RT Integration Profile (ARTI)
- Multi-Modality Image Registration for Radiation Oncology (MMRO-II)
- Dose Compositing Profile (DCOM)
- Treatment Delivery Workflow-II (TDW-II)

IHE-RO Test Tools

- Test Tool software is used to
 - Assist manufacturers with in-house software testing,
 - Assess readiness of products to participate in formal testing at Connectionthons,
 - Assist testers in the formal testing process.
- Connectionthons participants must demonstrate that their products pass Test Tool Validation by submitting Test Tool results to judges.



DVTk DVTk's open-source project, main contributors Philips and ICT Automatisering.

- IHE-RO Test Tools are developed and maintained by ICT Automatisering, using the open-source DICOM Validation Toolkit (DVTk).

IHE-RO Test Tool Operation

- Test Tool software
 - Simulates the behavior of other Actors in a Profile as a surrogate test partner,
 - Provides reference input data to the Actor under test.
 - Validates the content of data objects produced by the Actor.

Test Case	Test Case ID	Test Case Description	Test Case Status
Test Case 1	1.1	Test Case 1.1	Pass
Test Case 2	1.2	Test Case 1.2	Pass
Test Case 3	1.3	Test Case 1.3	Pass
Test Case 4	1.4	Test Case 1.4	Pass
Test Case 5	1.5	Test Case 1.5	Pass
Test Case 6	1.6	Test Case 1.6	Pass
Test Case 7	1.7	Test Case 1.7	Pass
Test Case 8	1.8	Test Case 1.8	Pass
Test Case 9	1.9	Test Case 1.9	Pass
Test Case 10	1.10	Test Case 1.10	Pass



Connectathon Test Results

- Connectathon successes are published.
- Incomplete test(s) or failures are NOT published.
- Vendors release Integration Statements for "IHE-RO Compliant" products to indicate the specific Profile(s) and Actor(s) for which the product has been successfully tested.
- Integration Statements for products that have passed the IHE-RO testing process can be found on the ASTRO website (search "IHE-RO testing")
- Systems tested at a Connectathon must match those referenced in the manufacturer's Integration Statement. Re-testing is needed if some part of the product that affects interoperability is changed.



Thank You
