INTRODUCTION TO IHE-RO:
WHY IS IT IMPORTANT?
HOW DOES IT WORK?

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Radiation Oncology Domain Representative, IHE
International Board
Disclosures

• Funded by AAPM (travel expenses) for participation in DICOM Working Group 7 (RT Extensions to DICOM) meetings

• Funded by ASTRO (travel expenses) for participation in IHE Radiation Oncology domain meetings

• Domain participant for Radiation Oncology to the IHE International Board
What is IHE?

- IHE is an initiative by healthcare professionals and industry to improve the way computer systems in healthcare share information.
- IHE promotes the coordinated use of established standards such as DICOM and HL7 to address specific clinical need in support of optimal patient care.
- Systems developed in accordance with IHE communicate with one another better, are easier to implement, and enable care providers to use information more effectively.

From http://www.ihe.net
How does IHE Function?

- **Participants include:**
  - Users - Clinicians, Staff, Administrators, CIOs, Governments (e.g. NIST, VA).
  - Vendors - Information Systems and Equipment
    - e.g., imaging, cardiology, devices
  - Consultants

- **Maintains formal liaison with Standards Development Organizations (SDOs):**
  - HL7, DICOM, ISO (Liaison D), others

- **ISO TC215 (including ANSI) approved IHE Process and Profiles to be published as technical reports**
Common Issues in Information Transfer in Radiation Oncology

• Manufacturers have interpreted the DICOM Standard differently
  – DICOM was developed by consensus, not always one way to transfer information

• Different limits assigned to TPS information
  – # of ROIs, Contours, Points
  – Representation of a CT-Sim plan
  – Exchange of Dose Information

• “Testing” was envisioned as comparison of DICOM Conformance Statements, too complex in RO
Figure 1  Schematic representation of critical data handoffs within a typical radiation oncology clinic. Solid lines represent connectivity issues for which Integrating the Healthcare Enterprise-Radiation Oncology (IHE-RO) has developed an agreed upon standard (also known as integration profiles). Hatched lines represent a connectivity issue for which IHE-RO is currently working to develop a standard.
IHE–RO GOALS

• Improve the connectivity of various radiation oncology hardware and software products
• Improve radiation oncology work flow
• Help to select products based on features, productivity and cost efficiency
• Improve patient care
Participants in IHE-RO

- Advanced Technology Consortium (ATC)
- American Association of Physicists in Medicine (AAPM)
- American College of Radiology (ACR)
- American Society for Therapeutic Radiology and Oncology (ASTRO)
- Association of Radiation Oncologists of India (AROI)
- Canadian Association of Radiation Oncologists (CARO)
- Chinese Society of Radiation Oncologists (CSRO)
- CMS
- Egyptian Cancer Society – Radiation Oncology
- Elekta
- European Society for Therapeutic Radiology and Oncology (ESTRO)
- International Atomic Energy Agency (IAEA)
- Impac
- Japanese Society for Therapeutic Radiology and Oncology (JASTRO)
- Miranda Solutions
- National Cancer Institute (NCI)
- National Electrical Manufacturers Association (NEMA)
- Nucletron
- Philips
- Tomotherapy
- Radiological Society of North America (RSNA)
- Siemens
- Varian
IHE-RO Participants

INTEGRATING THE HEALTHCARE ENTERPRISE (IHE) – RADIATION ONCOLOGY (RO)

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- Philips
- Tomotherapy
- Radiological Society of North America (RSNA)
- Siemens
- Varian
IHE-RO Structure

- Secretariat
  - ASTRO
  - Oversight
  - Resource Panels
- IHE
  - IHE-RO
    - Plan Cmte
    - Tech Cmte
  - ...Other Domains
- Clinicians (MD, PhD, RN, CMD, RTT)
- IHE-RO Member Organizations
IHE-RO

• IHE-RO is not a standards body, but seeks to improve interoperability of clinical systems through coordinated use of established standards.

• However, IHE (and IHE-RO) do establish standards for testing of interoperability. It is working with partners to conform to ISO/IEC 17025 and achieve international certification.

• IHE-RO Structure
  – IHE-RO Planning Committee
    • Physicians, physicists, marketing and product managers
    • Propose real-world Use Cases involving interoperability problems in radiation oncology
  – IHE-RO Technical Committee
    • Physicists and DICOM engineers
    • Evaluate Use Cases and develop Integration Profiles specifying how standards, such as DICOM or HL7, are to be used to solve these problems
4 Steps of IHE Process

A defined, coordinated process for standards adoption. Repeated annually, promoting steady integration

- Identify Interoperability problems
- Specify Integration Profiles
- Test Integration Profiles at Connectathon
  - Vendor testing using Test Tool Suite
- Publish Integration Profiles for use in RFPs
What are these Standards?

- **DICOM (Digital Imaging and Communications in Medicine)**
  - DICOM is a standard for handling, storing, printing, and transmitting information in medical imaging.
  - DICOM enables the integration of scanners, servers, workstations, printers, and network hardware from multiple manufacturers
  - [http://medical.nema.org](http://medical.nema.org)

- **HL7 (Health Level 7)**
  - HL7 is an international community of healthcare subject matter experts and information scientists collaborating to create standards for the exchange, management and integration of electronic healthcare information.
  - HL7 promotes the use of such standards within and among healthcare organizations to increase the effectiveness and efficiency of healthcare delivery for the benefit of all.
  - [http://www.HL7.org](http://www.HL7.org)

Parts from [http://www.wikipedia.org](http://www.wikipedia.org)
Proven Standards Adoption Process

1. Identify available standards (e.g. HL7, DICOM, IETF, OASIS)
2. Develop technical specifications
3. Document Use Case Requirements
4. Timely access to information
5. Easy to integrate products
6. Testing at Connectathons
7. IHE Demonstrations

Products with IHE
How do you benefit?

• Use cases solved and tested (connectivity issues)
• Connectathon (vendor to vendor testing)

How can you help?

• Participate (clinical expertise is important)
  – TCONs, Meetings, Connectathons
• Request IHE-RO Testing from your Vendors
Thank you
HOW DOES IHE-RO HELP IN THE CLINICAL WORKFLOW

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National Radiation Oncology Program (10P4H)
Veterans Health Administration

Member, IHE RO Technical & Planning Committee
The Problem
Common Issues in Information Transfer in Radiation Oncology

• Manufacturers have interpreted the DICOM Standard differently
  – DICOM was developed by consensus, not always one way to transfer information

• Different limits assigned to TPS information
  – # of ROIs, Contours, Points
  – Representation of a CT-Sim plan
  – Exchange of Dose Information
The Problem

• Physicists spend a lot of time specifying / verifying the connectivity between systems in radiation oncology
• Each new release typically requires significant retesting
• Similarly, it is expensive for manufacturers to test connectivity at customer sites after product release.
What is the solution?

Digital Imaging and Communications in Medicine (DICOM) & Health Level Seven (HL7)
Interoperability

Why doesn’t it work when two devices are DICOM and or HL7 compliant?

• The standards are open to multiple interpretations.
• There is room for data field variations (optional “type 2 and type 3” data, and private data).
• Standards do not specify their use in specific real-world scenarios.
• DICOM/HL7 are paper standard with no real-world testing services.
Steps of IHE Process

A defined, coordinated process for standards adoption. Repeated annually, promoting steady integration

- Identify Interoperability problems – use cases
- Specify Integration Profiles - solutions
- Develop test tools for these profiles – in house testing
- Test systems at Connectathon against profiles
- Publish Integration profiles for use in RFPs

IHE Resources
http://wiki.ihe.net/
IHE Radiation Oncology
http://www.astro.org/ihero
How does IHE work?

Identify available standards (e.g. HL7, DICOM, IETF, OASIS)

Develop technical specifications

Document Use Case Requirements

Testing at Connectathons

IHE Demonstrations

Products with IHE

Timely access to information

Easy to integrate products

Document Use Case Requirements
What is a Connectathon?

Cross-vendor, live, supervised, structured tests

- All participating vendors’ products tested together in the same place/time
- Experts from each vendor available for immediate problem resolution... fixes are 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
Connectathon Testing is based on specifications laid out in the Technical Framework.

**Technical Framework**

**Part 1:** Integration Profiles model the business process problem (use case) and its solution.

**Part 2:** Transactions define in how current standards are used to solve the business problem defined in the Integration Profiles.

**Connectathon:** Vendors register to test their product as an actor(s) within an Integration Profile.
Connectathons

• Cross-vendor, live, supervised, structured tests.
• All participating vendors’ products tested together in the same place/time.
• Experts from each vendor available for immediate problem resolution. Fixes are done in minutes, not months!
• Each vendor tests with multiple trading partners (actual product to actual product).
• Testing of real-world clinical scenarios using IHE Integration Profiles.

RADIATION ONCOLOGY DOMAIN
Challenges in Radiation Oncology

• For seamless interconnectivity and interoperability with 100% fidelity, cross compatibility across a variety of different software and hardware vendors must exist.

– When handoffs fail...
Overall Aim

Fast-track interconnectivity and interoperability initiative in radiation therapy called Integrating the Healthcare Enterprise in Radiation Oncology (IHE-RO)

– Improve efficiency of clinical operations
  • Efficient sharing, transfer, and storage of electronic radiotherapy data

– Improve patient safety

– Fulfill the expectation and requirements of an individual-user electronic health record
Interoperability and Interconnectivity Problems Solved
(http://www.ihe.net/Radiation_Oncology/index.cfm)

1. Simple/Advanced Treatment Planning use case (NTPL-S / ARTI)
   – allows seamless connectivity between different treatment planning systems

2. Multimodality Image Registration use case (MMRO)
   – Integrates PET and MRI data into the contouring and dose review process

3. RT Treatment Workflow use case (TRWF)
   – Integrates daily imaging with radiation therapy treatments using workflow
Simple/Advanced Treatment Planning use case (NTPL-S / ARTI)
(http://www.ihe.net/Radiation_Oncology/index.cfm)

The integration profile for 2007 involves the flow of DICOM images and treatment planning data, from CT scan through dose display, for 3D conformal, external beam radiation therapy. The emphasis for this first Integration Profile is on reducing ambiguity and facilitating basic interoperability in the exchange of DICOM RT objects.
Workflow

Acquisition Modality (CT Scanner)

Contourer

Geometric Planner

Dosimetric Planner

Dose Display
Significance

• Minimum Performance Standards
  – Must handle multiple CT series inputs
  – Must handle irregularly-spaced CT images

• Tested ROI transfers between systems

• Defined basic CT-Sim plan type

• Defined minimal plan information necessary for Dose Viewing
Success Stories from 2007 Connectathon !!

• “At the IHE-RO Connectathon,
  – We were able to take a head and neck patient CT, draw contours on BrainLab, place a non-co-planar beam on BrainLab, create a dose plan on Philips, display the dose on Varian, using archiving and distributing with IMPAC.

  – For the prostate patient CT, we drew contours on TomoTherapy, beam placement and dose plan on CMS, and displayed on Elekta.”
Simple/Advanced treatment planning use case (NTPL-S / ARTI)

- Basic Radiation Therapy Objects Integration Profile
- Illustrates basic functionality for transferring data between treatment planning systems.
- Simple treatment plans, structures, dose could be transferred between treatment planning systems.
- 5 Treatment planning systems passed this profile.
Simple/Advanced treatment planning use case (NTPL-S / ARTI)
Multimodality image registration for Radiation Oncology (MMRO) use case

- Multimodality registration Integration Profile
- Illustrates functionality for transferring multimodality registration data between treatment planning systems.
- Transfer of CT/MR/PET registration data between treatment planning systems.
- 5 Treatment planning systems passed this profile.
Significance

• Required compliant systems to support
  – CT-CT, CT-MR, and CT-PET Image Registration
  – Display of images from HFS, FFS, HFP, and FFP scanning orientations
  – Ability to handle at least 3 image datasets
  – Ability to utilize previously created spatial registrations
Multimodality Image Registration for Radiation Oncology (MMRO)
Treatment delivery workflow profile (TRWF)
Significance

• First implementations of a standards-based scheduling of treatment and imaging data between Treatment Management Systems and Treatment Imaging / Delivery Systems

• Preliminary Profile for working towards workflow for treatment planning, imaging, and 3rd party position verification systems in the treatment process
COULD THIS HAPPEN TO YOU?
2009 IHE-RO Connectathon
DOES IT REALLY WORK?: A CLINICAL PHYSICIST PERSPECTIVE

Lakshmi Santanam Ph.D
Associate Professor, Department of Radiation Oncology, Washington University in St. Louis

Member : Planning and Technical Committee IHE-RO
ASTRO Six Point action plan and Safety is no accident

Target Safely

• Medical error reporting
• Practice accreditation
• CARE Act (licensing standards)
• Education/Training (June 2010 FDA meeting in Miami)

• Compatibility/Interoperability
TREATMENT DELIVERY WORKFLOW
RT Treatment Workflow use case (TRWF) Integrate daily imaging with RT treatment using workflow

**Treatment Planning Process**
- **Hospital Information System**
  - Provide patient demographics
- **CT Simulator**
  - Creates, Imports & Exports
  - RT Structures, Geometric Elements, Image Registration
- **Treatment Planning Systems**
  - Creates, Imports, Exports
  - RT Structures
  - Geometric Elements
  - Image Registration data
  - Defines, Creates, Imports and/or Exports
  - Dosimetric Elements
  - Dose Display
  - Radiation Beams
  - IMRT, VMAT, SRS, ARC & Static Plans

**Treatment Delivery Process**
- **Treatment Management System**
  - Manages treatment machines, stores RT Objects, Treatment Delivery Instructions, Treatment Records, Provides for record and verify capabilities
- **QA Systems**
  - Independent MU Calculation Check systems, IMRT QA Systems Imports
  - RT Objects for treatment, DICOM Worklist Exports
  - Generates a report based on verification of the treatment plan
- **Treatment Delivery Systems**
  - Imports
  - RT Objects for Treatment, DICOM Worklist
  - Exports
  - Treatment Records & history
- **Patient Positioning System (in-room positioning)**
  - Inputs RT Objects for treatment DICOM Worklist
  - Exports Patient Setup Results

- **Intraoperability development in process**
- **Intraoperability developed by IHE-RO**
Failed to perform C-STORE(SCP) operation. Reason: Unable to write DICOM IOD message in C-STORE-RQ from StreamService into the file c:\impac\data\import\DCM00010.027 - Callback cannot comply

SROConversion Failed Reason : SROConverter3D - Not all localization DICOM instances referenced in the SRO were found in the database.

SROConversion Failed Reason : SROConverter3D - The SRO transformation matrix contains rotations.
<table>
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<th>Date</th>
<th>Time</th>
<th>Type</th>
<th>Assoc</th>
<th>Assoc. Name</th>
<th>Final Review Status</th>
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<tr>
<td>1/25/2012</td>
<td>3:15 PM</td>
<td>CT</td>
<td>Site</td>
<td>Pelvis (Rectum)</td>
<td>NA</td>
</tr>
<tr>
<td>2/6/2012</td>
<td>9:42 AM</td>
<td>CT</td>
<td>Site</td>
<td>Pelvis (Rectum)</td>
<td>Rejected</td>
</tr>
</tbody>
</table>
Near Misses

When a plan was transferred from a Tr4 machine to a Truebeam machine, with 4 wedges, the wedges got omitted/dropped from their respective treatment field. This is due to the different wedge codes on the two machines.

MLCs dropped when it transitioned over. When therapists changed the machine, they inadvertently changed the energy choosing electrons, but reverted back to photons, but the MLC shape got dropped.
Quality Assurance with Plan Veto (QAPV) Integration Profile

• Provides a generic framework with several specialized cases including a real-time (just prior to delivery) plan checks.
• Specialized cases (critical checks) identified in the current draft:

  Data Modification Critical Check
  Egregious dose check
QAPV Use Case (Under Development)

- Integrated Patient QA checker
  - Quality Assurance with Plan Veto Profile
QAPV Checker will perform a pretreatment verification of treatment parameters by matching these parameters to the intended plan from the TPS. It will then perform the check and generate a structured report identifying any critical issues found. Upon retrieval of this report, the TDS is expected to trigger a veto of plan delivery if critical problems are identified.
Machine Characterization File from a LINAC (xml)

```xml
<?xml version="1.0" encoding="utf-8"?>
<HECompleteLinacConfiguration
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns="http://www.varian.com/schemas/VarianHELinacConfiguration.xsd"&
&General>&
&&<MachineId>TrueBeamTR7</MachineId>&
&&<MachineSerialNumber>1025</MachineSerialNumber>&
&&<DisplayScale>IEC1217</DisplayScale>&
&&<LinacModelId>TsuHighEnergyVOS</LinacModelId>&
&&<LinacModelName>TsuHighEnergyVOSModelName</LinacModelName>&
&&<SourceAxisDistance>100</SourceAxisDistance>&
&&<ManufacturerName>Varian Medical Systems</ManufacturerName>&
&&<HelpDeskNumber>&
&&<ServiceRepName>&
&&<ServicePhoneNumber>&
&&<LinacOperationStatus>Active</LinacOperationStatus>&
&&<SystemOperationStatus>Clinical</SystemOperationStatus>&
&&&
&&<EnergyId>6x</EnergyId>&
&&<EnergyValue>6</EnergyValue>&
&&<EnergyIntent>Treatment</EnergyIntent>&
&&<EnergyMode>Photon</EnergyMode>&
&&<FluenceMode>STANDARD</FluenceMode>&
&&<HighDoseTechniques>&
&&<HighDoseTechnique>Normal</HighDoseTechnique>&
&&<HighDoseTechnique>SRS</HighDoseTechnique>&
&&<HighDoseTechnique>TBI</HighDoseTechnique>&
&&<FilmCompatible>true</FilmCompatible>&
&&<EnergyDoseRates>&
&&<DoseRateIndex>12</DoseRateIndex>&
&&<DefaultDoseRate>500</DefaultDoseRate>&
&&&
&&&
&&&
&&&
&&&
&&&
&&&
&&&
```

Machine Characterization file from a record and verify system

```
[General]
Type = Template
Description = New machine install JAK/LS 10/8/2012
Source Name = TrueBeamTR5
[Acc_A06]
Machine Code = A06
Modality = Elect
Name = A06
Shape = Square
SizeX = 20
SizeX_12 = 11
SizeX_16 = 11
SizeX_20 = 11
SizeY = 20
SizeY_12 = 11
SizeY_16 = 11
SizeY_20 = 11
Slot = 2
Type = Applicator
Verification Type = Machine
Wedge Angle = 0.0
Wedge Orientation = Top
[Acc_A10]
Machine Code = A10
Modality = Elect
Name = A10
Shape = Square
SizeX = 20
SizeX_12 = 15
SizeX_16 = 15
SizeX_20 = 15
SizeY = 20
SizeY_12 = 15
SizeY_16 = 15
SizeY_20 = 15
Slot = 2
Type = Applicator
```
STANDARDIZING MACHINE CHARACTERIZATION

• Standardizing machine characterization would improve characterizing different LINACS in various TPS and TMS.
Clinical Example for Dose Compositing

- It often happens that patient comes back for re-treatment either in the same facility or from another clinic and might require treatment to a site near to the already treated site. It becomes impossible to combine two radiation plans calculated on different treatment planning systems (TPS). This compromises patient care as the radiation oncologist is forced to make re-treatment decisions based on an estimate of previously delivered dose.
Dose Compositing

- In the above example we had to resort to manual methods of adding doses from different TPS, such as generating from hard copies, drawing pseudo structures etc.
- These methods tend to be crude, labor intensive, and error-prone.
- IHE-RO compatibility could give us accurate data on prior dose, which can guide us in our beam placement and optimizing doses to PTV and OARs. The patient can be safely retreated to the second recurrent location.
Possible Solutions: Dose Compositing Profile

- Treatment planning systems can allow export of RT images, structures, plan, and dose.
- All TPS can allow import of CT images and structure sets;
- Few TPS’s currently allows RT plan and dose import and dose summation of old and new plans;
- All RT structures and planning information (beam angles, field size, MLC, etc.) can accurately be transferred across TPS.
Bugs that got identified during Connectathons:
Eg: April 2013 Connectathon
Vendor A

• Realized we did not populate attributes needed when identifying datasets in PACS (e.g. Series Description)
• Found several bugs causing our import to crash (since we are importing data generated by other vendors)
• Learned about new features in other PACS, enabling us to create a better import for the future
• By trouble shooting with several different PACS systems, we improved error handling for our DICOM Query/Retrieve
• And overall:
  
  Gave us time to focus on interoperability and experiencing what users might experience everyday.
Vendor B

• For the new applications that were tested for the first time this year, there were several issues we fixed
• We had an issue when loading feet-first patients. Then the image data was flipped.
• Points in RT Structure Sets were lost
• For some 32bit RT Dose files, our display was not correct
Vendor C

- Multiple registration objects in same series, only one registration gets displayed.
- Initially vendors were not able to handle FFP datasets.
- SROs were not implicitly checked as part of DICOM till IHE-RO made it a requirement.
Vendor D

• When transferring plans (BRTO) vendor could not display MUs for individual control points
• Cumulative MUs weight was set for MU per control point.
How does this help the practicing radiation oncology physicist?

• More reliable / robust interconnectivity
  – Systems have been tested and observed
    • IHE-RO Test Tools
    • IHE-RO Connectathons
  – Successful results have been published
• Allows easier selection of “Best of Breed” systems in the clinical environment
How can you help?

• Several organizations and companies currently participate in IHE-RO
• Join IHE-RO
• Membership in IHE-RO is through IHE: http://www.ihe.net/governance/index.cfm
Acknowledgments

• IHE-RO Technical and Planning Committee
• Some slides were borrowed from the IHE-RO webinar presented by R.Kapoor, K.Alburquerque, A.Ravi
• ASTRO