Informatics Management 1.0 to 2.0

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Informatics Management

- Objectives:
  - Understand different areas of imaging informatics and the methodology for developing informatics standards.
  - Understand the current status of informatics standards, role of physicists and radiologists in the process, and the current technology for validating the function of these systems.

- IT Areas of Interest for Radiology
  - Data format
  - Systems connectivity and information workflow

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Data Format

- Digital Image and Communication (DICOM) Standard
  - Information Object Definition (IOD)
    - Image IOD
      - Standard and enhanced
    - Non-image IOD
      - Structured reports
      - Waveforms
      - Registration

- Information Communication Standards
  - Health Level 7 (HL7)

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DICOM

- Utilizes an open standards development process that encourages the involvement and consensus of both manufacturers and *users*

- Specification of a conformance mechanism so that a user can determine whether or not devices are likely to interoperate

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DICOM Review

- DICOM Standards Committee (DSC)
  - DICOM's executive body whose members are imaging equipment manufacturers, physician organizations, and other interested groups
    - 25 manufacturer members
    - 19 user members
    - 12 general interest members
- DICOM's activities are coordinated through MITA, a division of the National Electrical Manufacturers Association (NEMA)

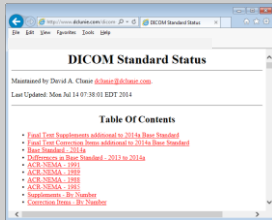|	
Secretariat	MITA (Medical Imaging & Technology Alliance, a Div. of NEMA)
General Secretary	Stephen Vastagh, MITA
	svastagh@medicalimaging.org
Co-Chair	John A. Carrino, MD, MPH, American College of Radiology
	Johns Hopkins School of Medicine
	Jcarrin2@jhmi.edu
Co-Chair	Harry Solomon, GE Healthcare
	harry.solomon@med.ge.com

DICOM Standards Committee (DSC)

- Development of DICOM Standard is done through committees termed "Working Groups" (WG)

WG-01: Cardiac and Vascular Information	WG-16: Magnetic Resonance
WG-02: Projection Radiography and Angiography	WG-17: 3D
WG-03: Nuclear Medicine	WG-18: Clinical Trials and Education
WG-04: Compression	WG-19: Dermatologic Standards
WG-05: Exchange Media	WG-20: Integration of Imaging and Information Systems
WG-06: Base Standard	WG-21: Computed Tomography
WG-07: Radiotherapy	WG-22: Dentistry
WG-08: Structured Reporting	WG-23: Application Hosting
WG-09: Ophthalmology	WG-24: Surgery
WG-10: Strategic Advisory	WG-25: Veterinary Medicine
WG-11: Display Function Standard	WG-26: Pathology
WG-12: Ultrasound	WG-27: Web Technology for DICOM
WG-13: Visible Light	WG-28: Physics
WG-14: Security	WG-29: Education, Communication and Outreach
WG-15: Digital Mammography and CAD	WG-30: Small Animal Imaging

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- Working groups propose "Work Items" based on suggestions from members, users or at the direction of the DSC

DICOM Standard Status

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Last Updated: Mon Jul 14 07:38:01 EDT 2014

Table Of Contents

- Final Text Supplements additional to 2014a Base Standard
- Final Text Correction Items additional to 2014a Base Standard
- Base Standard - 2014a
- Differences in Base Standard - 2013 to 2014a
- ACR-NEMA - 1001
- ACR-NEMA - 1989
- ACR-NEMA - 1988
- ACR-NEMA - 1985
- Supplements - By Number
- Correction Items - By Number

- Work Items are divided into Supplements and Change Proposals (sometimes called Correction Proposal)
  - Supplements define new objects, content or structure
  - Change Proposals modify the existing Standard

http://medical.nema.org/

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Slide 8

DICOM Part 1: Introduction and Overview
DICOM Part 2: Conformance
DICOM Part 3: Information Object Definitions
DICOM Part 4: Service Class Specifications
DICOM Part 5: Data Structures and Encoding
DICOM Part 6: Data Dictionary
DICOM Part 7: Message Exchange
DICOM Part 8: Network Communication Support for Message Exchange
DICOM Part 10: Media Storage and File Format for Media Interchange
DICOM Part 11: Media Storage Application Profiles
DICOM Part 12: Media Formats and Physical Media for Media Interchange
DICOM Part 14: Grayscale Standard Display Function
DICOM Part 15: Security and System Management Profiles
DICOM Part 16: Content Mapping Resource
DICOM Part 17: Explanatory Information
DICOM Part 18: Web Access to DICOM Persistent Objects (WADO)
DICOM Part 19: Application Hosting
DICOM Part 20: Transformation of DICOM to and from HL7 Standards

Each Part is now available in multiple formats

New Part Added 2013

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- Attributes describe the properties of an IOD

- Data Element Type defines whether an attribute is required
  - Type 1 = mandatory attribute that must *always* be included
  - Type 2 = mandatory attribute that must be included *if known*
  - Type 3 = optional attribute

- In some instances attribute may be conditional based on specified criteria
  - Type is followed by a "C", i.e. Type 1C, 2C or 3C

**Table 5.4.1
Example Module Table**

Attribute Name	Tag	Type	Attribute Description
Attribute A	(aaaa,aaaa)	1	This is an example.
Attribute B Sequence	(bbbb,bbbb)	1	This is an example of a Sequence Attribute
>Include 'Example Macro Table 5.4.2			In this Module, Attribute D (dddd,dddd) is Type 1

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DICOM - Modules

- Sets of attributes can be referenced by Modules instead of listing the same attributes in each IOD
  - Reference to Annex C that contains Modules
- Usage Code
  - M = module support is *mandatory*
  - C = module support is *conditional*
  - U = module support is *optional*

Table A.26-1
DIGITAL X-RAY IMAGE IOD MODULES

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	Specimen Identification	C.7.1.2	U
	Clinical Trial Subject	C.7.1.3	U
Study	General Study	C.7.2.1	M
	Patient Study	C.7.2.2	U
	Clinical Trial Study	C.7.2.3	U
Series	General Series	C.7.3.1	M
	Clinical Trial Series	C.7.3.2	U
	DX Series	C.8.11.1	M
Frame of Reference	Frame of Reference	C.7.4.1	U
Equipment	General Equipment	C.7.5.1	M
Image	General Image	C.7.6.1	M
	Image Pixel	C.7.6.3	M
	Contrast/Bolus	C.7.6.4	U
	Display Shutter	C.7.6.11	U
	Device	C.7.6.12	U
	Intervention	C.7.6.13	U
	DX Anatomy Imaged	C.8.11.2	M
	DX Image	C.8.11.3	M
	DX Detector	C.8.11.4	M
	X-Ray Collimator	C.8.7.3	U
	DX Positioning	C.8.11.5	U
	X-Ray Tomo Acquisition	C.8.7.7	U

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DICOM - Example

Series Root : DX : 1.3.51.0.7.11924953542.35688.48968.34263.50351.38874.52683 : Clavicle AP 10 Degree Cephalic
- 0x00080021 (8) - Series Date: 20131111
- 0x00080031 (6) - Series Time: 093837
- 0x00080060 (2) - Modality: DX
- 0x00080070 (4) - Manufacturer: Agfa
- 0x0008103e (30) - Series Description: Clavicle AP 10 Degree Cephalic
- 0x00081090 (4) - Manufacturer's Model Name: DX-S
- 0x00181000 (10) - Device Serial Number: PB51601172
- 0x0020000e (58) - Series Instance UID: 1.3.51.0.7.11924953542.35688.48968.34263.50351.38874.52683
- 0x00200011 (1) - Series Number: 2
- Instance Root: 1.3.51.0.7.3462668936.55929.41549.37000.21015.7504.63595
  - 0x00020001 (4) - [null] AQÁ=
  - 0x00020002 (27) - [null]: 1.2.840.10008.5.1.4.1.1.1.1
  - 0x00020003 (56) - [null]: 1.3.51.0.7.3462668936.55929.41549.37000.21015.7504.63595
  - 0x00020010 (19) - [null]: 1.2.840.10008.1.2.1
  - 0x00020012 (25) - [null]: 2.16.840.1.114151.100.1.1
  - 0x00020013 (13) - [null]: MergeCOM3_390
  - 0x00070000a (19) - Last image inserted time: 11/11/2013 09:45:11
  - 0x00070010 (4) - Pixel maximum value: 4284
  - 0x00070011 (5) - Pixel minimum value: -3570

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DICOM - SOP Class vs. Modality

- Standard SOP Classes (PS 3.4)
  - Modality attribute listed in the Modality Data Element (0008,0060) may not match the name of the IOD in which it appears

SOP Class Name	SOP Class UID	Modality Data Element (0008, 0060)
Computed Radiography	1.2.840.10008.5.1.4.1.1.1	CR
Digital X-Ray - For Presentation	1.2.840.10008.5.1.4.1.1.1.1	DX
Digital X-Ray - For Processing	1.2.840.10008.5.1.4.1.1.1.1.1	DX
Digital Mammography - For Presentation	1.2.840.10008.5.1.4.1.1.1.2	MG
Digital Mammography - For Processing	1.2.840.10008.5.1.4.1.1.1.2.1	MG
Breast Tomosynthesis	1.2.840.10008.5.1.4.1.1.13.1.3	MG
CT	1.2.840.10008.5.1.4.1.1.2	CT
Enhanced CT	1.2.840.10008.5.1.4.1.1.2.1	CT
MR	1.2.840.10008.5.1.4.1.1.4	MR
Enhanced MR	1.2.840.10008.5.1.4.1.1.4.1	MR
MR Spectroscopy	1.2.840.10008.5.1.4.1.1.4.2	MR
Enhanced MR Color	1.2.840.10008.5.1.4.1.1.4.3	MR

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Slide 13 — DICOM Header

Series Root : DX : 1.3.51.0.7.11924953542.35688.48968.34263.50351.38874.52683 : Clavicle AP 10 Degree Cephalic
- 0x00080021 (8) - Series Date: 20131111
- 0x00080031 (6) - Series Time: 093837
- 0x00080060 (2) - Modality: DX
- 0x00080070 (4) - Manufacturer: Agfa
- 0x0008103e (30) - Series Description: Clavicle AP 10 D...
- 0x00081090 (4) - Manufacturer's Model Name: DX-S
- 0x00181000 (10) - Device Serial Number: PB51601172
- 0x0020000e (58) - Series Instance UID: 1.3.51.0.7.119...
- 0x00200011 (1) - Series Number: 2
- Instance Root: 1.3.51.0.7.3462668936.55929.41549.37000.21015.7504.63595
  - 0x00020001 (4) - (null) AQ4e
  - 0x00020002 (27) - (null): 1.2.840.10008.5.1.4.1.1.1.1
  - 0x00020003 (56) - (null): 1.3.51.0.7.3462668936.55929.41549.37000.21015.7504.63595
  - 0x00020010 (19) - (null): 1.2.840.10008.1.2.1
  - 0x00020012 (25) - (null): 2.16.840.1.114151.100.1.1
  - 0x00020013 (13) - (null): MegaCOM3_390
  - 0x0007000a (19) - Last image inserted time: 11/11/2...
  - 0x00070010 (4) - Pixel maximum value: 4284
  - 0x00070011 (5) - Pixel minimum value: -3570

Media Storage SOP Class UID – defines SOP Class associated with the Data Set from PS.3.10, use this UID to determine data element information

Digital X-Ray – For Presentation

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Slide 14 — Conformance Statements

- List of SOP Classes supported
- Provides details on how vendor implements Standard

SOP Class Name	UID
Grayscale Softcopy Presentation State Storage	1.2.840.10008.5.1.4.1.1.11.1
MR Image Storage	1.2.840.10008.5.1.4.1.1.4
Enhanced MR Image Storage	1.2.840.10008.5.1.4.1.1.4.1
MR Spectroscopy Storage	1.2.840.10008.5.1.4.1.1.4.2
Raw Data Storage	
Secondary Capture Image Storage	1.2.840.10008.5.1.4.1.1.7

Changes to multi-frame image format, may not be handled efficiently by legacy systems

- Both enhanced and non-enhanced IOD supported
  - Which is used for image storage needs to be set by vendor during installation/acceptance

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Slide 15 — Conformance or Not?

Standard MR SOP Class stored

Includes many data elements that are from Enhanced MR SOP Class

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- Data is organized into coded templates
  - Describes the Content Items, Value Types, etc …
  - Analogous to a Module from an image IOD

- Template TID (TID) information given in PS 3.16

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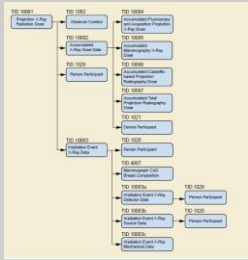
- NL = nesting level (i.e. > first level , >> second level …)
- Rel*ation* with Parent (e.g. Contains, Observation, Acquisition, Has Concept Modifier …)
- VT = Value Type (e.g. Container, Code, Date, UIDREF, NUM, Image, Text …)
- Concept Name = "Coded Triplet" (e.g. Code Value, Coding Scheme, Code Meaning)
  - May also include Coding Scheme Version Coded Quadruplet?
- VM = Value Multiplier (i.e. 1, 1-n, …)
- Req*uirement* Type, similar to Modules (i.e. Mandatory, Conditional , Optional)

	NL	Rel with Parent	VT	Concept Name	VM	Req Type	Condition	Value Set Constraint
1			CONTAINER	EV (113706, DCM, "Irradiation Event X-Ray Data")				
2	>	HAS CONCEPT MOD	CODE	DTID 1021				
3	>	CONTAINS	INCLUDE	DTID 1020 "Person Participant"	1-n	U		$PersonProcedureRole = EV (113851, DCM, "Irradiation Administering")
4	>	CONTAINS	INCLUDE	DTID 10003A "Irradiation Event X-Ray Detector Data"	1	MC	IFF TID (10001) Row 8 is absent or has a value of (R-0038D, SRT, "Yes")	
5	>>	HAS CONCEPT MOD						Attribute in the images
6	>	CONTAINS	DATETIME	DT (111526, DCM, "DateTime Started")	1	M		

May include pointers to other TID

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Dose Area Product

Dose Total

Data element tag values are the same

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DICOM Standard

- Current version on site – July 2014
- New change Proposals and Supplements occurring continuously

DICOM Support

- Anyone can assist in the creation of the Standard
- Physicists are needed to be involved

DICOM Calendar

DICOM Chairs and Secretariats

Systems Connectivity and Information Workflow

- Hospital Information Systems (HIS)
  - Now more commonly called Electronic Medical Record (EMR)
- Radiology Information System (RIS)
- PACS
- Modalities
- Post-processing systems
  - 3D processing labs
  - Computer-Aided Detection/Diagnosis (CAD)
- Other Information databases
  - Data analytics
    - Natural language report searches
  - Dose reporting

Systems Connectivity

- Integrating the Health Enterprise (IHE)
  - Purpose: "both a process and a forum for encouraging integration efforts"
  - IHE does not make standards, but instead utilizes existing standards to develop profiles to help improve integration

- Standards Developing Organizations (SDO)
  - American National Standards Institute (ANSI)
  - Health Level 7 (HL7)
  - National Electrical Manufacturers Association (NEMA)
    - Medical Imaging and Technology Alliance (MITA)/DICOM
  - International Electrotechnical Commission (IEC)
  - International Organization for Standardization (ISO)

IHE

- 638 member organizations from around the world
  - 66 Healthcare Professional Associations
  - 8 Standards Organizations
  - 4 Health Information Exchanges
  - 22 Healthcare Provider Organizations
  - 37 Healthcare Education and Research Organizations
  - 9 Trade Associations
  - 386 Healthcare IT and Consulting Companies

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IHE Domains

- Organized by clinical and operational domains

- Domains identify integration and information sharing priorities and develop consensus/standards-based solutions to address these issues

12 Active Domains:

- Anatomic Pathology
- Cardiology
- Dental
- Eye Care
- IT Infrastructure
- Laboratory
- Patient Care Coordination

- Patient Care Devices
- Pharmacy
- Quality, Research and Public Health
- Radiation Oncology
- Radiology

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IHE Profiles

- Describe specific solutions to integration problems

  - A profile documents how standards will be used by each system
    - Each system is called an "Actor"

  - IHE Actors are responsible for producing, managing and/or acting on information in the context of an IHE Profile

  - For convenient reference, each Profile has a short acronym name
    - e.g. [**REM**] for Radiation Exposure Monitoring

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- Facilitates the collection and distribution of information about estimated radiation exposure resulting from imaging procedures

- Utilizes the DICOM Radiation Dose Structured Report (RDSR)

IHE Radiation Exposure Monitoring Profile
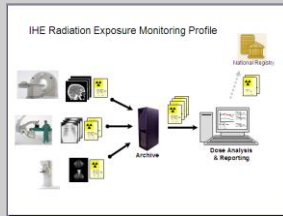
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REM is intended to facilitate the following:

- View estimated dose a patient (or particular organs) received for a certain exam

- Determine if the estimated dose for a given procedure, system or physician regularly exceeds some reference level
  - Potential to trigger an "outlier" requiring further investigation

- Compute population "dose summary"
  - for a specific exam in a certain hospital or region
  - for a certain pathology or indication

- Compare exam-specific "dose summaries" against other sites/regions
  - Dose Registry

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REM
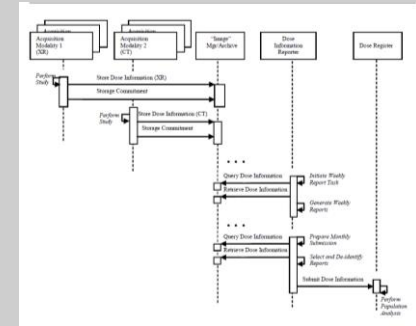
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Information Workflow

- Lexicons
  - International Classification of Diseases (ICD)
    - Health Insurance Portability and Accountability Act (HIPAA) transaction code set for diagnosis coding
    - Physicians use Volumes 1 and 2 only to assign diagnosis codes
    - In US currently using 9th ed, 10th ed implemented in 2015 or …
  - Current Procedure Terminology (CPT)
    - Published by American Medical Association to report medical and surgical procedures and physician service codes
      - Used instead of Volume 3 of the ICD
      - Linked to billing
  - Systematized Nomenclature of Medicine - Clinical Terms (SNOMED-CT)

RADLEX

- Unified language of radiology terms
- RadLex Playbook provides orderables and procedure step codes/names

IHE Validation

- Connectathon
  - Held annually in Asia, Europe and North America
  - systems exchange information with complementary systems from multiple vendors, performing all of the transactions

- Testing Tools
  - Software tools to facilitate testing and implementation of IHE Integration Profiles in healthcare information technology systems
  - Available for download and licensed by their developers for *free* use

What should/can a Physicist Do?

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- Modality Worklist configuration and function
  - Correct orders to correct devices
  - Patient identifiers
  - Procedure Code Mapping

- Data Integrity/Image Quality
  - From acquisition to storage and display
    - Display characteristics
    - Annotation

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- Fault Tolerance
  - What happens when a component of the system goes down
    - Is there a vendor-suggested strategy for component failure?

- Correction Workflow
  - Incorrect manual entries
  - Mismatched studies

- Network Performance
  - Required bandwidth
  - Network reliability

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- Physicists may not have the expertise or equipment to perform actual validation testing, especially of IT components

- Current testing may consist of simply following the workflow to validate that the end results are accurate/acceptable

- Majority of physicist interaction is through problem analysis and assistance with determining problem resolution
  - Requires working knowledge of all system components, workflow and how to find required information

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