



2006 AAPM Annual Meeting, Orlando, FL

## DICOM: What the Physicist Needs to Know

Kevin Junck, PhD  
UAB Health System  
Birmingham, AL

## What DO you need to know?

- **Medical Physics**
- An applied branch of physics concerned with the application of the concepts and methods of physics to the diagnosis and treatment of human disease. It is allied with medical electronics, bioengineering, and health physics.
- **What Is a Medical Physicist?**
- Medical physicists contribute to the effectiveness of radiological imaging procedures by assuring radiation safety and helping to develop improved imaging techniques (e.g., mammography, CT, MR, ultrasound). They contribute to development of therapeutic techniques (e.g., prostate implants, stereotactic radiosurgery), collaborate with radiation oncologists to design treatment plans, and monitor equipment and procedures to insure that cancer patients receive the prescribed dose of radiation to the correct location.
- From <http://www.aapm.org>

## What DO you need to know?

### Diagnostic Radiological Physics

This particular field pertains to:

the diagnostic applications of x rays, gamma rays from sealed sources, ultrasonic radiation, radio frequency radiation and magnetic fields

the equipment associated with their production, use, measurement and evaluation

the **quality of images** resulting from their production and use

- From <http://www.aapm.org>

## What DO you need to know?

**“I was gratified to be able to answer promptly.**

**I said I don’t know.”**

**Mark Twain**

## Educational Objectives

- History of DICOM
- Nature of the Standards
- DICOM Vocabulary
- Image Quality and DICOM
- Free (shareware) Tools

## “What the Physicist Should Know”

- Where does it come from?
- What does it do?
- What do the terms mean?
- What parts of DICOM does a modality need to support or use?
- How does DICOM affect image quality?

## “Where does it come from?”



The Tower of Babel, by Pieter Bruegel (c. 1525-69)

Prior to establishing standards for data communication, every vendor spoke a different “language.”

## “Where does it come from?”



American College of Radiology (ACR)

National Electrical Manufacturer’s Association (NEMA)

## “Where does it come from?”

- 1983 ACR-NEMA establishes committee
- 1985 First ACR-NEMA standards published
- 1988 Follow up standards (ACR-NEMA 2.0)
- 1993 DICOM Version 3.0 published
- Version 3.0 is “DICOM 3.0” and is updated every year (there is no DICOM 3.1, etc)

## “Where does it come from?”

### DICOM Standards Committee

Vendors – Agfa, Boston Scientific, Camtronics, Carl Zeiss Meditec, Dejarnette, Dynamic Imaging, Eastman Kodak, ETIAM, Fuji, GE, Hologic, IBM, Konica, Matrixview, McKesson, MEDIS, Merge, Philips, RadPharm, R2, Sectra, Siemens, Sony, 3DHISTECH, Toshiba

## “Where does it come from?”

### DICOM Standards Committee

Users – American Academy of Ophthalmology, ACC, ACR, American College of Veterinary Radiology, American Dental Association, College of American Pathologists, Deutsche Roentgenesellschaft, European Society of Cardiology, HIMSS, Medical Image Standards Association of Taiwan, Societa Italiana di Radiologia Medica, SIIM (SCAR), Societe Francaise de Radiologie

## “Where does it come from?”

### 26 DICOM Working Groups

- WG-01 Cardiac and Vascular Information
- WG-02 Projection Radiography
- WG-03 Nuclear Medicine
- WG-11 Display Function Standard
- WG-21 CT
- WG-22 Dentistry

## “What the Physicist Should Know”

- Where does it come from? ✓
- What does it do?
- What do the terms mean?
- What parts of DICOM does a modality need to support or use?
- How does DICOM affect image quality?

## “What does it do?”

- The goals of DICOM are to achieve compatibility and to improve workflow efficiency between imaging systems and other information systems in healthcare environments worldwide.

From DICOM “Strategic Document” on  
<http://medical.nema.org>

## “What does it do?”

- DICOM Standards address 5 areas of functionality....
- Transmission and persistence of complete objects (such as images, waveforms and documents),
- Query and retrieval of such objects,

## “What does it do?”

- Performance of specific actions (such as printing images on film),
- Workflow management (support of worklists and status information) and
- Quality and consistency of image appearance (both for display and print).”

## “What does it do?”

- “Transmission and persistence of complete objects (such as images, waveforms and documents), “

DICOM does define the objects – CT image  
DICOM does define services - transmission

## “What does it NOT do?”

- “DICOM does not define an architecture for an entire system; nor does it specify functional requirements... “

DICOM does not define the network –  
Ethernet, ATM, dial-up, DSL, satellite, VPN,  
carrier pigeon

DICOM does not define functionality - which  
image goes where on the workstation  
display

## “What does it do?”

- Main Entry: **lan-guage**  
Pronunciation: 'la[ng]-gwij, -wij  
Function: *noun*  
Etymology: Middle English, from Anglo-French *langage*, from *lange*, *langue* tongue, language, from Latin *lingua*
- **1 a** : the words, their pronunciation, and the methods of combining them used and understood by a community **b** (1) : audible, articulate, meaningful sound as produced by the action of the vocal organs (2) : a systematic means of communicating ideas or feelings by the use of conventionalized signs, sounds, gestures, or marks having understood meanings (3) : the suggestion by objects, actions, or conditions of associated ideas or feelings <*language* in their very gesture -- Shakespeare> (4) : the means by which animals communicate (5) : a formal system of signs and symbols (as FORTRAN or a calculus in logic) including rules for the formation and transformation of admissible expressions
- From Merriam Webster online dictionary

## “What does it do?”

- Main Entry: **com-mu-ni-cate**  
Pronunciation: k&-'myü-n&-'kAt  
Function: *verb*  
Inflected Form(s): **-cat-ed; -cat-ing**  
Etymology: Latin *communicatus*, past participle of *communicare* to impart, participate, from *communis* common *transitive verb*  
**1 archaic** : share  
**2 a** : to convey knowledge of or information about : make known <*communicate* a story> **b** : to reveal by clear signs <his fear *communicated* itself to his friends>  
**3** : to cause to pass from one to another <some diseases are easily *communicated*>

## “What the Physicist Should Know”

- Where does it come from? ✓
- What does it do? ✓
- What do the terms mean?
- What parts of DICOM does a modality need to support or use?
- How does DICOM affect image quality?

## “What do the terms mean?”

- DICOM Standards address 5 areas of functionality....
- Transmission and persistence of complete **objects** (such as images, waveforms and documents),
- Query and retrieval of such objects,

## “What do the terms mean?”

- “Objects” - NOUN
  - Information Object Definitions or “IOD”
  - Defined in DICOM Part 3
  - “Recipes” for what items are required to define an “instance” of a
    - CT Image, Digital X-ray (DX) Image
    - Basic Film Session (part of DICOM print)
    - Scheduled Procedure (for a worklist)

## “What do the terms mean?”

- Information Object Definitions
  - Attributes (characteristics) of the object are grouped in “modules”
    - Patient Module
      - Patient Name, Patient ID, MRN
    - Study Module
      - Study UID, Study Date, Accession Number
    - Image Plane Module
      - Pixel Spacing, Slice Thickness, Slice Location
    - And more...

Found in DICOM Part 3: Information Object Definitions

Table A.3-1  
CT IMAGE IOD MODULES

IE	Module	Reference	Usage
Patient	Patient	C.7.1.1	M
	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
Frame of Reference	Frame of Reference	C.7.4.1	M
Equipment	General Equipment	C.7.5.1	M
Image	General Image	C.7.6.1	M
	Image Plane	C.7.6.2	M
	Image Pixel	C.7.6.3	M
	Contrast/bolus	C.7.6.4	C - Required if contrast media was used in this image
	CT Image	C.8.2.1	M
	Overlay Plane	C.9.2	U
	VOI LUT	C.11.2	U
SOP Common	C.12.1	M	

“What do the terms mean?”

“Tags”

Uniquely identify the attribute

Group and Element

Tags are composed of a group number and element number

Value Representation (VR)

How the data is to be stored

“What do the terms mean?”

PS 3.3 - 2004  
Page 213

C.2.2 Patient Identification Module

Table C.2.2 defines the Attributes relevant to identifying a patient.

Table C.2.2  
PATIENT IDENTIFICATION MODULE ATTRIBUTES

Attribute Name	Tag	Attribute Description
Patient's Name	(0010,0010)	Patient's full name
Patient ID	(0010,0020)	Primary hospital identification number or code for the patient.
Issuer of Patient ID	(0010,0021)	Identifier of the Assigning Authority (system, organization, agency, or department) that issued the Patient ID. Note: Issuer of Patient ID (0010,0021) is equivalent to HL7 v2 PID-3 component 4.
Other Patient IDs	(0010,1000)	Other identification numbers or codes used to identify the patient.
Other Patient Names	(0010,1001)	Other names used to identify the patient.
Patient's Birth Name	(0010,1005)	Patient's birth name.
Patient's Mother's Birth Name	(0010,1060)	Birth name of patient's mother.
Medical Record Locator	(0010,1090)	An identifier used to find the patient's existing medical record (e.g. film jacket).

“What do the terms mean?”

Table C.7-10  
IMAGE PLANE MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Pixel Spacing	(0028,0030)	1	Physical distance in the patient between the center of each pixel, specified by a numeric pair - adjacent row spacing (delimiter) adjacent column spacing in mm.
Image Orientation (Patient)	(0020,0037)	1	The direction cosines of the first row and the first column with respect to the patient. See C.7.6.2.1.1 for further explanation.
Image Position (Patient)	(0020,0032)	1	The x, y, and z coordinates of the upper left hand corner (center of the first voxel transmitted) of the image, in mm. See C.7.6.2.1.1 for further explanation.
Slice Thickness	(0018,0050)	2	Nominal slice thickness, in mm.
Slice Location	(0020,1041)	3	Relative position of exposure expressed in mm. C.7.6.2.1.2 for further explanation.

## “What do the terms mean?”

- Type 1 = Mandatory and non-NULL
- Type 2 = Mandatory but can be NULL or EMPTY
- Type 3 = Optional

Found in DICOM Part 3: Information Object Definitions

## “What do the terms mean?”

Attributes also have a defined “value representation”

Patient Name (0x0010, 0x0010)

is of a type Person Name (PN)

Family^Given Junck^Kevin

Family name complex ^given name complex^  
middle name^name prefix^name suffix.

Junck^Kevin^Lee^Dr^PhD

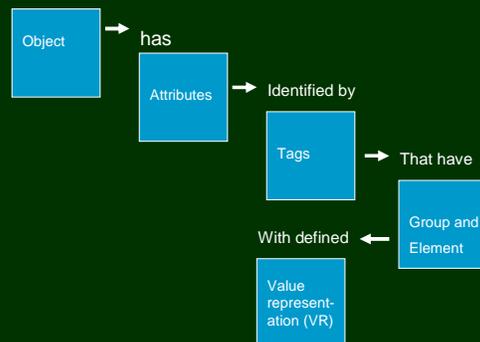
## “What do the terms mean?”

Attributes also have a defined “value representation”

### Value Representation (DICOM Part 5)

Date (DA)	yyyymmdd (20060804)
Time (TM)	hhmmss.fff (091312.99999)
Date Time (DT)	yyyymmddhhmmss.fff

## “What do the terms mean?”



## “Reality Check #1”

- Hapless PACS newbie says  
“When I make measurements on DX images with my PACS workstation, they come out in pixels instead of millimeters”

Why?

## “Reality Check #1”

The Digital X-ray (DX) IOD requires the *DX Detector Module* which calls for “Imager Pixel Spacing” in DICOM tag (0018,1164)  
The CT IOD uses the *Image Plane Module* with pixel spacing defined in (0028,1130).

PACS Workstation/Viewer vendor may not be looking for pixel spacing in correct location.

## “Reality Check #2”

- Hapless Physician says  
“I can’t find the images for my patient!!!!!!  
Her Medical Record Number is 1347586”

Why?

## “Reality Check #2”

Patient ID is type LO  
Long string  
64 characters  
Images are under MRN of “01347586” which is not the same as “1347586”

Tag	Name	VR	VM
(0010,0010)	Patient's Name	PN	1
(0010,0020)	Patient ID	LO	1
(0010,0021)	Issuer of Patient ID	LO	1
(0010,0030)	Patient's Birth Date	DA	1
(0010,0032)	Patient's Birth Time	TM	1
(0010,0040)	Patient's Sex	CS	1
(0010,0050)	Patient's Insurance Plan Code Sequence	SI	1
(0010,0101)	Patient's Primary Language Code Sequence	SI	1

Human interprets MRN as integer  
PACS Workstation/Viewer doesn't

## “Reality Check #3”

- Hapless Radiologist says  
“These images aren’t displaying right.”

Why?

## “Reality Check #3”

PS 3.3-2004  
Page 258

Table C.7.8  
GENERAL IMAGE MODULE ATTRIBUTES

Attribute Name	Tag	Type	Attribute Description
Instance Number	(0020,0013)	2	A number that identifies this image. Note: The attribute may contain multiple values in some versions of the Standard.

CT scan has

Series 1 with 2 images and Series 2 with 48 images.

Vendor X has chosen to use Instance Numbers of  
1, 2, 3, 4, 5, 6, 7, 8, ...46, 47, 48, 49, 50

Vendor Y has chosen to use Instance Numbers of  
1, 2, 1, 2, 3, 4, 5, 6, 7, 8, ... 46, 47, 48

## “What do the terms mean?”

- **Transmission** and persistence of complete objects (such as images, waveforms and documents),
- **Query and retrieval** of such objects,
- Performance of specific **actions** (such as printing images on film),
- Workflow management (support of worklists and status information) and
- Quality and consistency of image appearance (both for display and print)."

From DICOM "Strategic Document" on <http://medical.nema.org>

## “What do the terms mean?”

- Actions are DICOM “services” = VERB
  - Storage Service
  - Query/Retrieve Service
  - Basic Grayscale Print (meta) Service
- Services act on or with objects
  - “Service-object-pair” or SOP
  - CT Image Storage SOP (class)

From DICOM Part 4: Service Class Specifications

## “Services”

- Services are implemented in a client / server relationship
- Client is the service “user” or “service class user” (SCU)
- Server is the service “provider” or “service class provider” (SCP)

From DICOM Part 4: Service Class Specifications

## “Services”

- Printing images from a CT scanner to a DICOM printer is an example of:
  - Basic Grayscale Print (meta) SOP Class
  - Where the CT scanner is the SCU and the DICOM printer is the SCP

From DICOM Part 4: Service Class Specifications

## DICOM Print – an aside

- Basic Grayscale/Color Print (Meta) SOP Class
  - Called a “meta” SOP class because it really requires and uses
    - Printer SOP Class
    - Basic Film Session SOP Class
    - Basic Film Box SOP Class
    - Basic Grayscale/Color Image Box SOP Class

From DICOM Part 4: Service Class Specifications

## “Services”

- Sending images from a CT scanner to a workstation is an example of:
  - CT Storage SOP Class
  - Where the CT scanner is the SCU and the workstation is the SCP
  - Configuration:
    - IP address, Port number, AE Title

## Common DICOM Services

- “DICOM Verification”
  - Ability to “Ping” other DICOM devices
- “DICOM Storage”
  - CT Image Storage SOP Class, CR Image Storage SOP Class (useful to have as SCU and SCP on modality)
- Storage Commitment
  - Enhancement to standard storage SOP classes, dropped images or series will be detected (SCU only)

## Common DICOM Services

- “DICOM Print”
  - Basic Grayscale Print Management (Meta) SOP Class (SCU only)
- Query/Retrieve aka Find/Move
  - Poll a DICOM device for a list of studies or patients, then retrieve one or more (SCU and SCP useful)

## “What do the terms mean?”

- “Transmission and persistence of complete objects (such as images, waveforms and documents),
- Query and retrieval of such objects,
- Performance of specific actions (such as printing images on film),
- Workflow management (support of worklists and status information) and
- Quality and consistency of image appearance (both for display and print).”

From DICOM “Strategic Document” on <http://medical.nema.org>

## “DICOM Part 10: Media Storage”

This Part specifies:

- a layered model for the storage of medical images and related information on storage media. This model introduces the concept of Media Storage Application Profiles, which specify application specific subsets of the DICOM Standard to which a Media Storage implementation may claim conformance. Such a conformance applies only to the writing, reading and updating of the content of storage media. Specific Application Profiles are not included in this Part but in Parts 3, 11 of the DICOM Standard.
- a DICOM File Format supporting the encapsulation of any Information Object Definition;
- a Secure DICOM File Format supporting the encapsulation of a DICOM File Format in a cryptographic envelope;
- a DICOM File Service providing independence from the underlying media format and physical media. The policies specific to the DICOMDIR file used to store the Media Storage Directory Service/Object Pair Class are also addressed.

- How are images stored in your archive?
- Does it matter?

## “Reality Check #4”

Hapless Administrator says  
“We’re buying a new PACS!”

Hapless Radiologist says  
“ We will need to transfer all of our old images.”

Hapless System Administrator runs  
screaming from the room.

## “DICOM Part 10: Media Storage”

- Exchange of DICOM image studies via removable media (CD-ROM, DVD, etc)
- Many vendors include as an option – “burn DICOM CD’s”

## “DICOM Part 10: Media Storage”

- Nice concept but issues exist ...
  - How do I change the Patient ID?
  - Image Quality aka compression?
  - Ability to send images from CD?
  - Ability to extract images from CD?
- Outside films were never easy,  
**and still aren’t!**

## “What does it do?”

- ✓ “Transmission and persistence of complete objects (such as images, waveforms and documents),
- ✓ Query and retrieval of such objects,
- ✓ Performance of specific actions (such as printing images on film).
  - Workflow management (support of worklists and status information) and
  - Quality and consistency of image appearance (both for display and print).”

From DICOM “Strategic Document” on <http://medical.nema.org>

## DICOM Workflow

- Worklist Management
  - Download a list of “scheduled procedures” to the modality from the RIS through a Worklist Management provider (modality is an SCU)
  - Ensures quality of patient demographics
- Configuration
  - Promiscuous connections
  - Who gets what exam?

## “Reality Check #5”

- Hapless Field Engineer says
    - “I am not getting a worklist. My hostname is KDS1.”
- Why?

## “Reality Check #5”

- Modality performs DICOM Storage class with AE Title of KDS1
- Modality performs DICOM Modality Worklist with AE Title of WL\_KDS1

## DICOM Workflow

Modality Performed Procedure Step  
Modality tells RIS that the scheduled procedure has been performed (automatically) (SCU only)

## “What do the terms mean?”

- ✓ “Transmission and persistence of complete objects (such as images, waveforms and documents),
- ✓ Query and retrieval of such objects,
- ✓ Performance of specific actions (such as printing images on film),
- ✓ Workflow management (support of worklists and status information) and
- **Quality and consistency of image appearance (both for display and print).”**

From DICOM “Strategic Document” on <http://medical.nema.org>

## DICOM Image Quality

- **Grayscale Standard Display Function (DICOM Part 14)**
  - Identifies a standard method to calibrate the luminance response of emissive (monitors), transmissive (film) and reflective (paper) media



## “What the Physicist Should Know”

- Where does it come from? ✓
- What does it do? ✓
- What do the terms mean? ✓
- **What parts of DICOM does a modality need to support or use?**
- How does DICOM affect image quality?

## What DICOM do I need for a modality?

- DICOM Storage (SCU and SCP)
  - Identify what objects it creates (CT, MR, etc) – does it also create secondary capture (SC)?
  - If it is an SCP, does it only accept certain kinds of images? Processed only, etc.

## What ~~DICOM~~ do I need for a modality?

- **Functionality for sending images**

Can it do multiple destinations?

Is it autosend or manual transfer? Can you send if the study is not finished (stat brain exams or pulmonary embolism evals)

Does it send both processed and unprocessed images (CR, DX, and MG objects)

Can you resend easily?

Is there a queue? Can you stop, start, clear it?

## What ~~DICOM~~ do I need for a modality?

- **Functionality for printing**

Can you have multiple printers?

Is it easy to switch printers on the fly?

Can you print to two printers simultaneously?

Can you configure min/max O.D., layouts, and requested lookup tables (in Configuration Information)?

## What ~~DICOM~~ do I need for a modality?

- **Functionality for Printing**

Does it have a queue? Can you stop, start or delete from it?

Is there visual indication of successful print?

Is it automatic print? Can you reprint easily?

Is there an error log?

## What DICOM do I need for a modality?

- **Worklist Management (SCU)**

Can I query by date? Patient ID? Modality? Any combination of these? Is it configurable?

## What ~~DICOM~~ do I need for a modality?

- Worklist Functionality
  - Is the query ad hoc or does it run every so many minutes automatically? Is it configurable?
  - Can you drive it with a barcode reader easily (not if you go through 6 dialog boxes first)
  - Will it automatically start the correct exam procedure (CT brain, two view chest, etc)
  - Is there an error log?
  - How do I fix the images when the tech has selected the wrong patient?????????

## What DICOM do I need for a modality?

- Modality Performed Procedure Step (SCU)
  - May be useful for CT, MR
  - More challenging for mixed RF/CR studies like BE or UGI
- Storage Commitment (SCU)
  - This is very useful and helps to guarantee that all images/series are properly transferred

## What DICOM do I need for a modality?

- Grayscale Standard Display Function
    - Monitors must be capable of calibration to GSDF
- Warning! This is often an overlooked piece!**
- Monitors are present in most modalities aka control workstation or QC workstation

## What DICOM do I need for a modality?

- DICOM Conformance Statement
  - Tells precisely what pieces the modality will do.
  - Caveat Emptor
    - "The integration of any device into an overall system of interconnected devices goes beyond the scope of standards (DICOM v3.0) and of this introduction and associated Conformance Statements when interoperability with non-VendorX equipment is desired. The responsibility to analyze the applications requirements and to design a solution that integrates VendorX imaging equipment with non-VendorX systems is the **user's** responsibility and should not be underestimated."
  - From Vendor X DICOM Conformance Statement for CT scanner

## What DICOM do I need for a modality?

- DICOM Conformance Statement

**2.2.1 DICOM Server AE Specification**

The Application Entity provides Standard Conformance to the following DICOM v3.0 SOP Classes as an SCP:

SOP Class Name (SC/CP)	SOP Class UID
1.1 image information storage	1.2.840.10008.5.1.4.1.1.2
1.1.1 image information storage	1.2.840.10008.5.1.4.1.1.4
Secondary Capture image storage	1.2.840.10008.5.1.4.1.1.7
Secondary Capture storage	1.2.840.10008.5.1.4.1.1.8
Study Root Query/Retrieve - FIND	1.2.840.10008.1.4.1.2.2.1
Study Root Query/Retrieve - MOVE	1.2.840.10008.1.4.1.2.2.2
Verification (Echo)	1.2.840.10008.1.1

The Application Entity provides Standard Conformance to the following DICOM v3.0 SOP classes as a SCP:

SOP Class Name (SC/CP)	SOP Class UID
Verification (Echo)	1.2.840.10008.1.1
1.1 information storage	1.2.840.10008.1.4.1.1.2
1.1.1 information storage	1.2.840.10008.1.4.1.1.4
Secondary Capture image storage	1.2.840.10008.5.1.4.1.1.7
Secondary Capture storage	1.2.840.10008.5.1.4.1.1.8
Study Root Query/Retrieve - FIND	1.2.840.10008.1.4.1.2.2.1
Study Root Query/Retrieve - MOVE	1.2.840.10008.1.4.1.2.2.2

## “What the Physicist Should Know”

- ✓ Where does it come from?
  - ✓ What does it do?
  - ✓ What do the terms mean?
  - ✓ What parts of DICOM does a modality need to support or use?
- How does DICOM affect image quality?

## DICOM Image Quality

- Grayscale Standard Display Function (DICOM Part 14)
- Identifies a standard method to calibrate the luminance response of emissive (monitors), transmissive (film) and reflective (paper) media

## DICOM Image Quality



Technologist's Workstation

Radiologist's Workstation

## Grayscale Standard Display Function (GSDF)

- Blume, Daly, and Muka *"Presentation of Medical Images on CRT Displays: a renewed proposal for a display function standard,"* Proc SPIE 1897, 1993
- Blume, Hartwig *"ACR/NEMA Proposal for a grayscale display function standard,"* Proc SPIE 2707, 1996

## Grayscale Standard Display Function (GSDF)

- Why not just calibrate to a linear luminance response?
- Contrast sensitivity (ability to detect changes in luminance) varies with luminance
  - low levels very sensitive
    - can perceive difference of  $0.005 \text{ Cd/m}^2$  at  $\sim 0.05 \text{ Cd/m}^2$
  - high levels not as sensitive
    - can only perceive difference of  $\sim 25 \text{ Cd/m}^2$  at  $\sim 4000 \text{ Cd/m}^2$

## Grayscale Standard Display Function (GSDF)

- Adopted a model of the Human Visual System (Barten model)
- Concept of "perceptual linearization"
- Equal change in input pixel value (grayscale) should result in equal "perceived" change in output luminance

## Grayscale Standard Display Function (GSDF)

- The graphics card and monitor converts from a digital value within the image to a brightness on the display.
- Calibrate a monitor by input of a series of digital values and measuring the output brightness with a light meter.
- Modify the lookup table for the monitor to follow the GSDF.

## Grayscale Standard Display Function (GSDF)



## Grayscale Standard Display Function (GSDF)



## DICOM Image Quality

- Softcopy Grayscale Presentation State IOD
  - Defines an object which can store or preserve the "state" of a referenced object (like an image)
  - Stores flip/rotate, window/level, annotations, masking or shutters, etc

## "What the Physicist Should Know"

- Where does it come from?
- What does it do?
- What do the terms mean?
- What parts of DICOM does a modality need to support it?
- How does DICOM affect image quality?

“What the Physicist Should Know” -  
Summary

- Did we cover it all?

NO!!!!!!!



“What the Physicist Should Know” –  
Advanced Topics

- HL7
- IHE
- HIPAA

“What the Physicist Should Know”

Questions /  
Answers  
Comments /  
Discussion