Consistent Presentation of Images

R. Horn, Research Scientist
(robert.horn@agfa.com)

G. Claeys, Technology Manager
(geert.claeys@agfa.com)

Agfa Healthcare

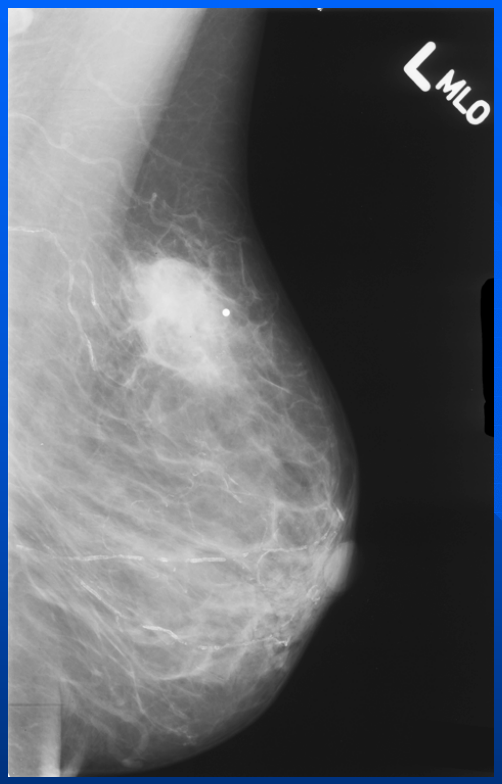
The Grayscale Image Presentation Problem:

The appearance of grayscale images displayed on different types of softcopy display devices or printed on different types of hardcopy output devices has often been inconsistent.

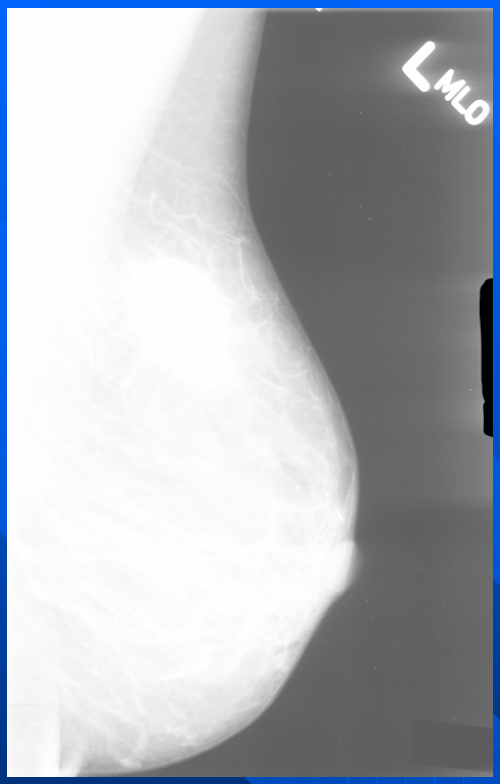
The Grayscale Consistency Problem:

- Optimal image viewing parameters (e.g. window/ level) selected on one device appear different when displayed on a different device
- Device capabilities/ characteristics vary - the same number of gray levels cannot be rendered or perceived on different devices
- Displayed images look different from printed images
- …other

Problems of Inconsistency



mass visible



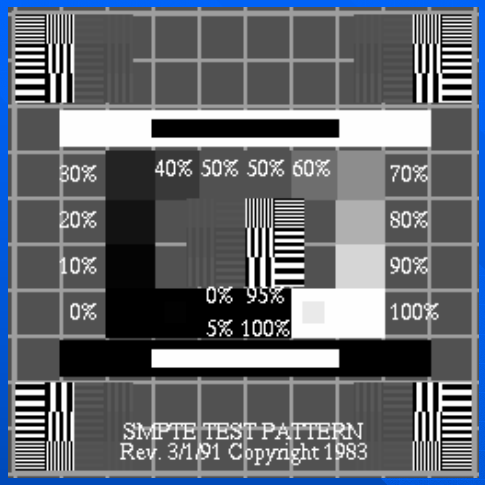
mass invisible

- VOI chosen on one display device
- Rendered on another with different display
- Mass expected to be seen is no longer seen

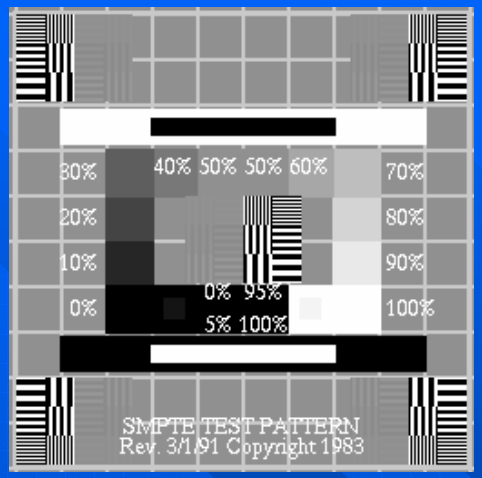
Slide Provided by David Clunie, Quintiles Intelligent Imaging

Problems of Inconsistency

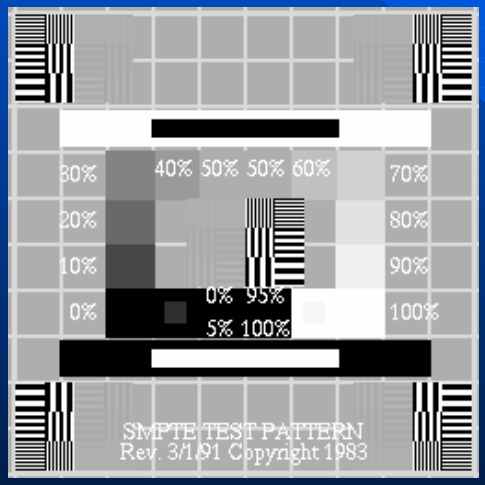
0.5



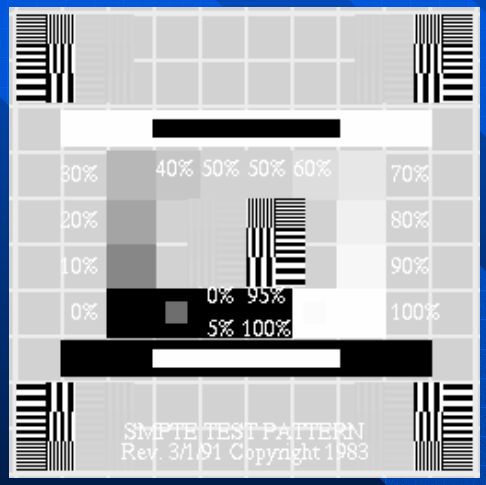
1.0



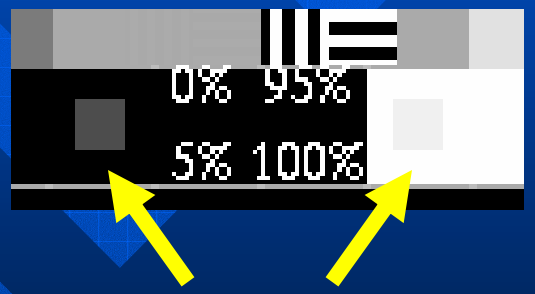
1.5



3.0



- Not all display levels are perceivable on all devices

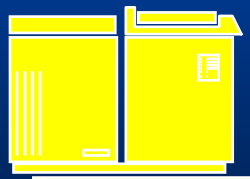


Slide Provided by David Clunie, Quintiles Intelligent Imaging

Problems of Inconsistency

Digital Modality

- Printed images don't look like displayed images



Laser Printer

Slide Provided by David Clunie, Quintiles Intelligent Imaging

Causes of Inconsistency

- Gamut of device
  - Minimum/maximum luminance/density
- Characteristic curve
  - Mapping digital input to luminance/density
  - Shape
  - Linearity
- Ambient light or illumination

Solution of the problem

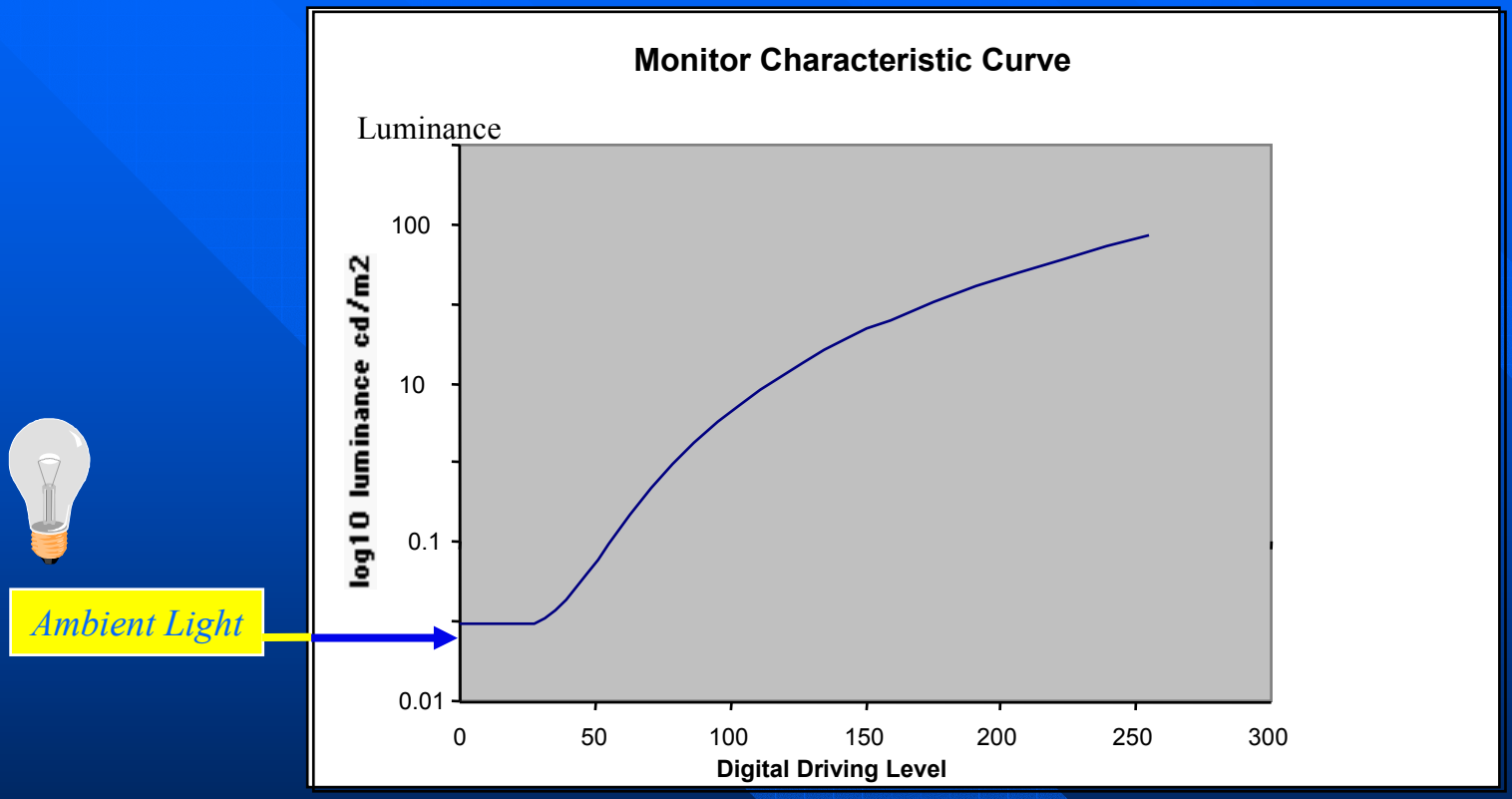
- Device independent reference space
  - Same for hardcopy + softcopy devices
- Perceptual linear reference space
  - Equal distances in reference space are perceived by human visual system as equal distances
  - Unit : JND (Just Noticable Difference)

Device calibration

- Compensates the non-linearity of display device
  - Establish linear relation between
    - » Input Digital Driving Level (DDL) and
    - » Output Luminance (softcopy) or OD (hardcopy)
  - Inverse of characteristic curve

- Characteristic curve
  - Characteristic curve = inherent device characteristic

Monitor Characteristic Curve



Slide Provided by David Clunie, Quintiles Intelligent Imaging

Printer Calibration Tools (Densitometer)

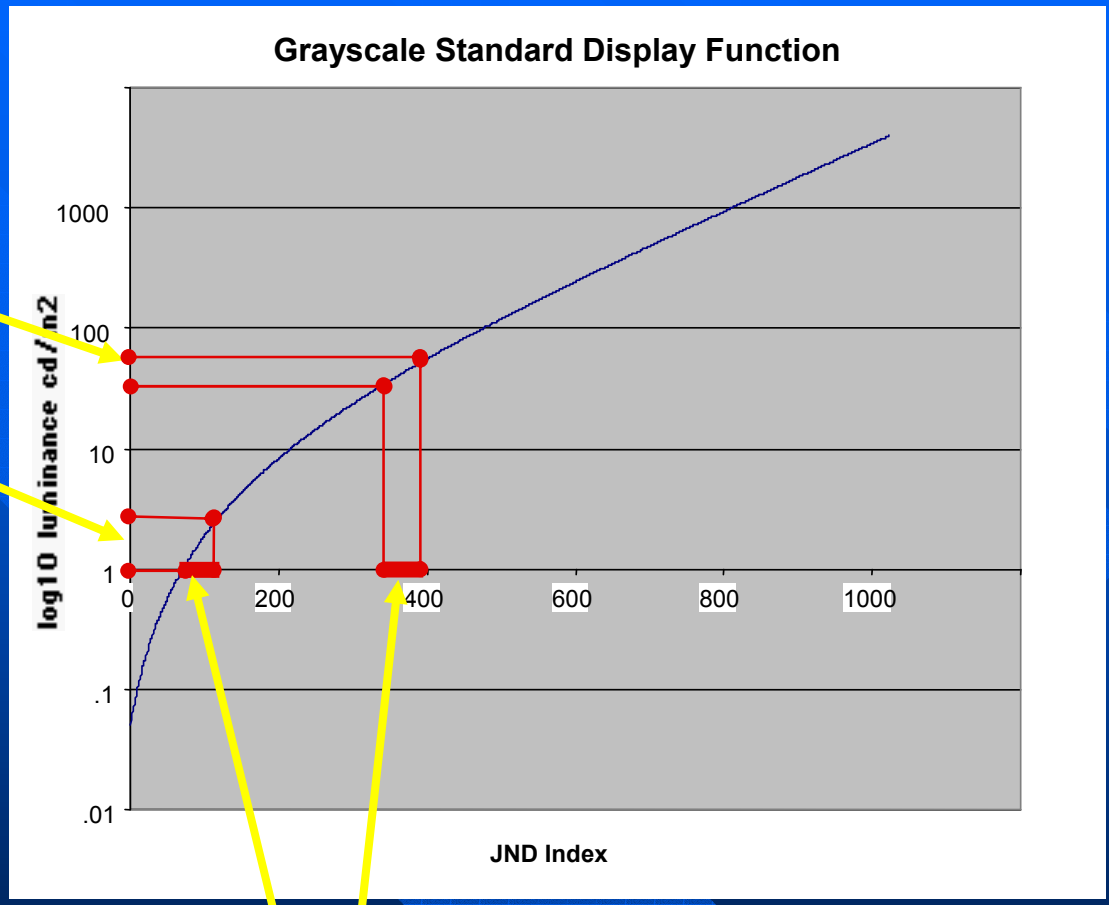
Display Calibration Tools (Photometer)

Slide Provided by Jerry Gaskill, Image Smiths Inc.

Perceptual Linearization :

- Compensates the contrast sensitivity of human visual system
- Grayscale Standard Display Function
  - Input: Just Noticeable Differences (JNDs)
  - Output: absolute luminance
  - Barten's model
  - Described in DICOM Part 14

Grayscale Standard Display Function



Despite different change in absolute luminance

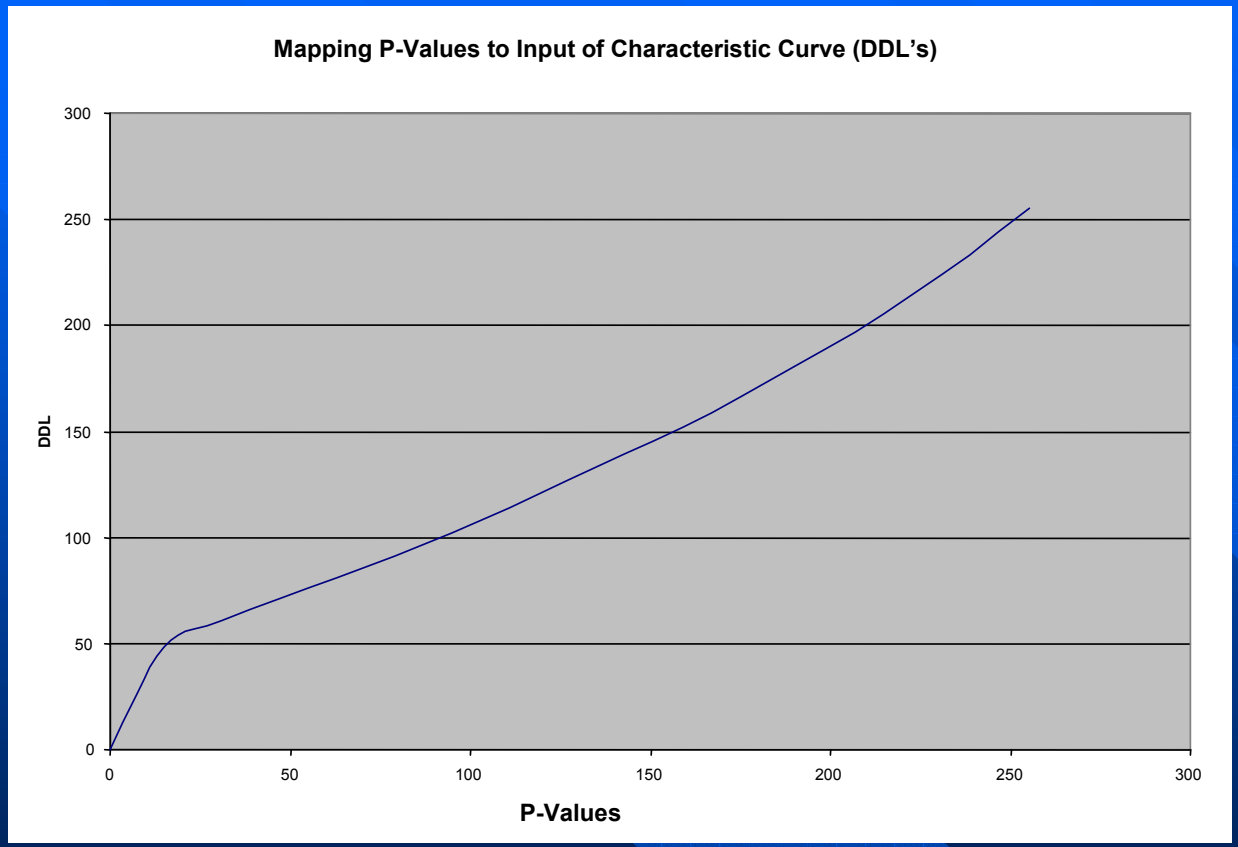
Same number of Just Noticeable Difference == Same perceived contrast

Slide Provided by David Clunie, Quintiles Intelligent Imaging

Perceptual linear device

- Apply
  - Grayscale Standard Display function :
    - » JND -> Luminance (or OD)
  - Inverse characteristic curve
    - » Luminance (or OD) -> DDL

Perceptual linear device - LUT

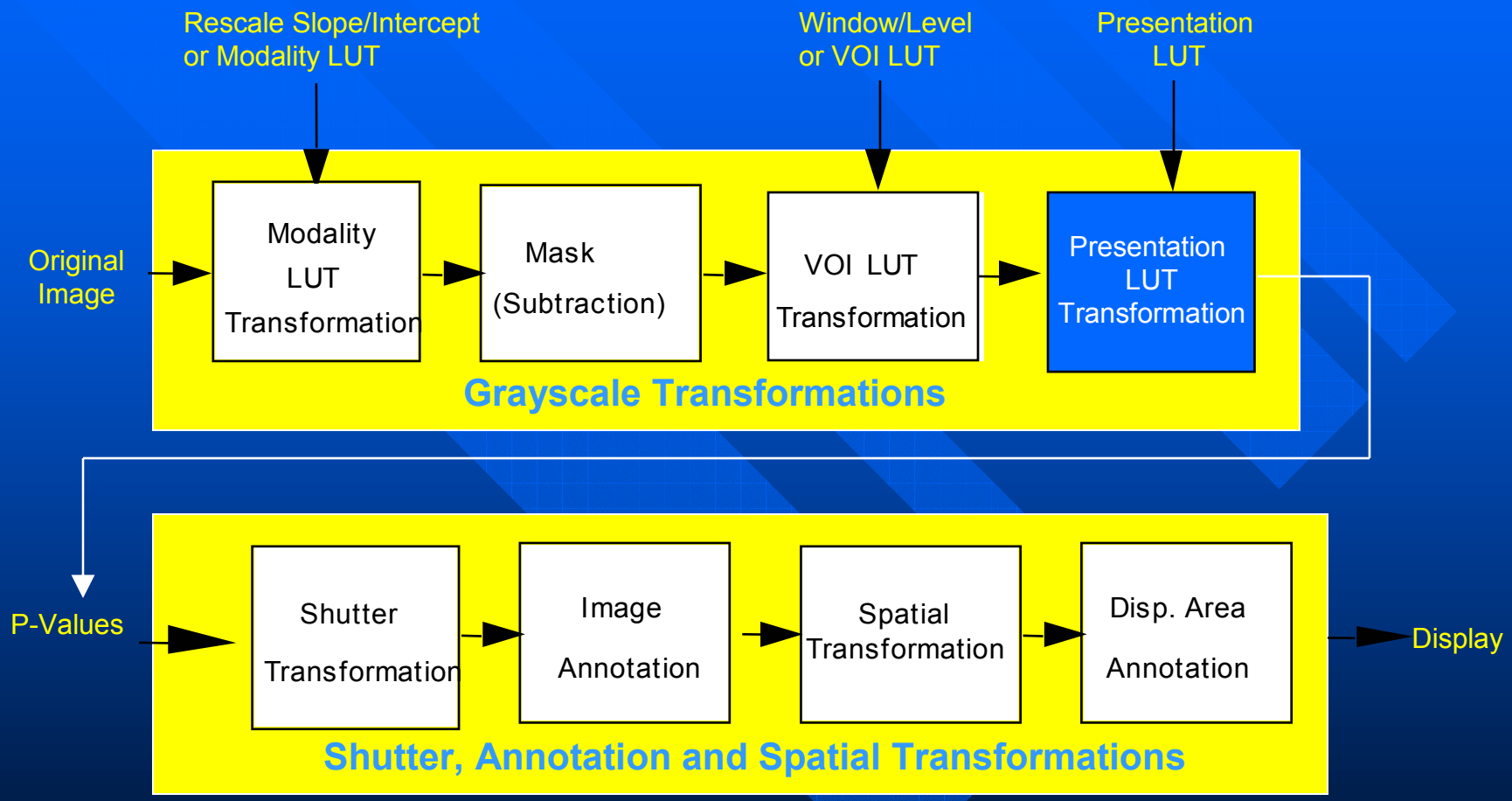


Slide Provided by David Clunie, Quintiles Intelligent Imaging

DICOM & Consistent Presentation of Images

- DICOM Image Transformation Model, including Presentation Look Up Table
- Grayscale Softcopy Presentation State

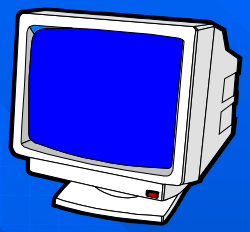
DICOM Grayscale Image Transformation Model

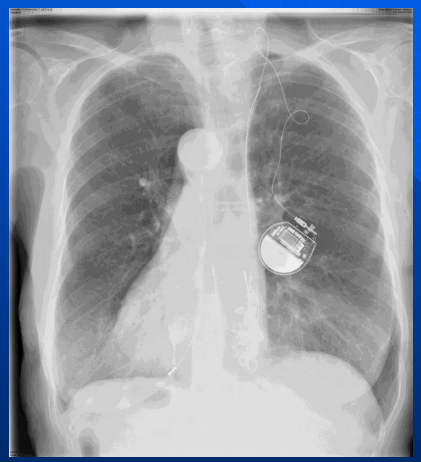


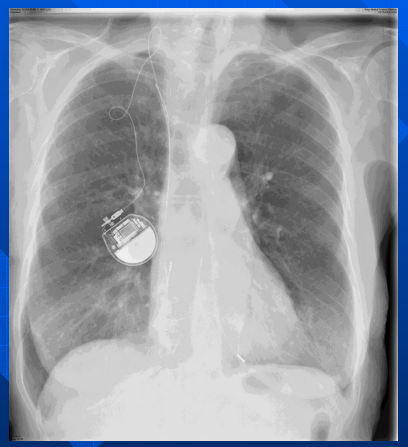
Grayscale Softcopy Presentation State

- Describes the Grayscale Image Transformation Model
- GSPS links to one or more images (Series, filters); stored using same Study Instance UID (same Storage SOP Class!)
- Uses regular Storage services (C-STORE); uses Query/Retrieve services
- GSPS SOP Instances are immutable: changes require a new SOP Instance UID

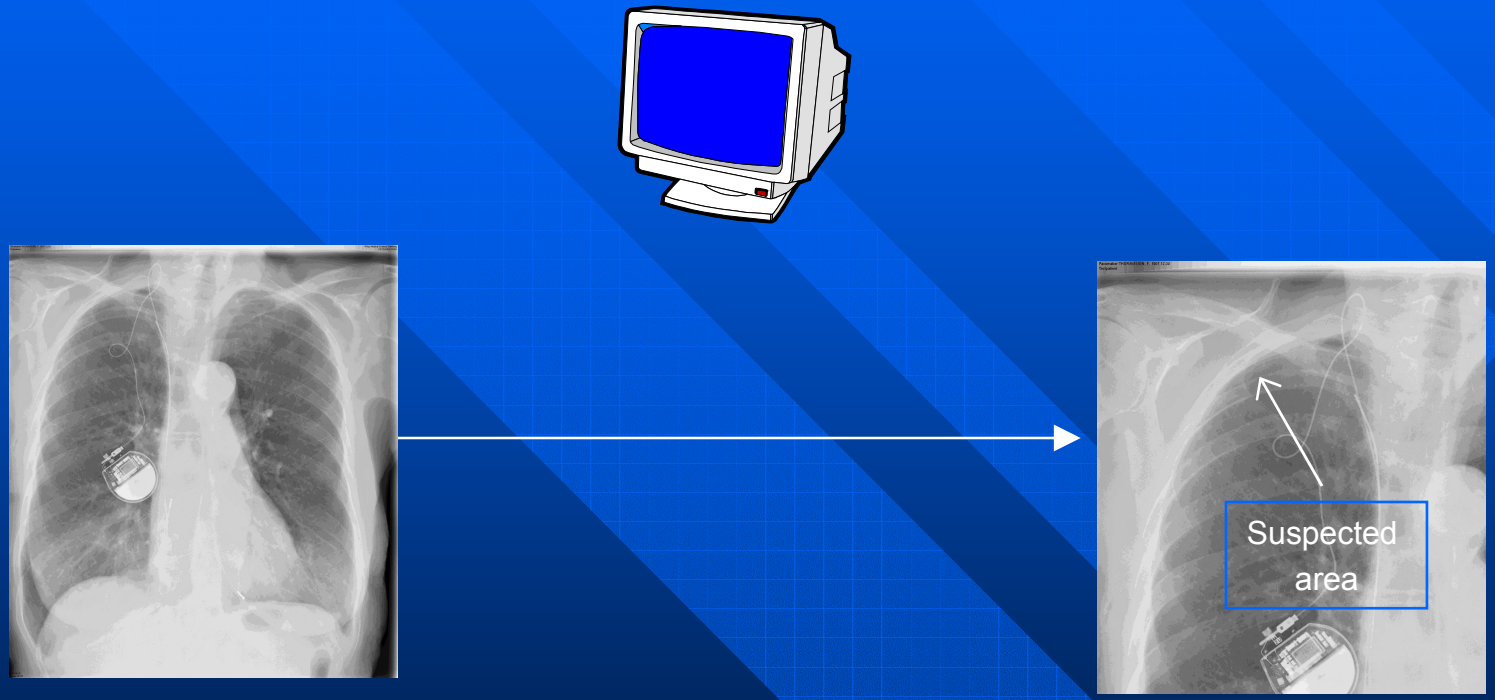
Example: A Radiologist “Flips” Chest XRAY Image on Softcopy Display







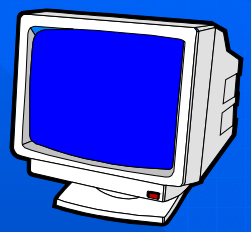
Example Continued: Radiologist Magnifies Chest XRAY Image, Pans to Upper Right Hand Quadrant and Adds an Annotation

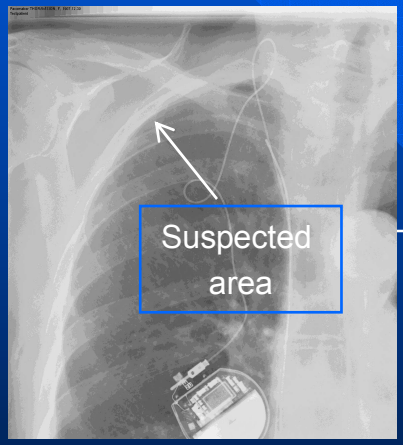


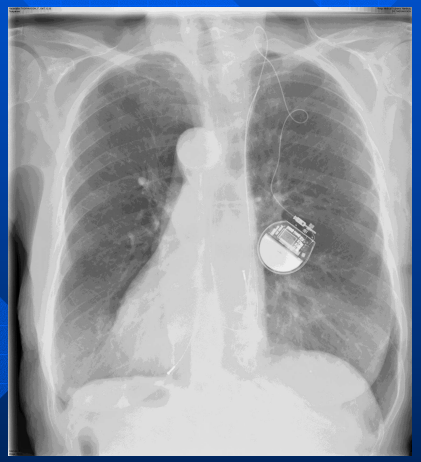
Example Continued: Referring Physician Views the Original Image…

Radiologist:

Referring Physician:







Radiologist Should Store the Viewing Parameters Using GSPS!

GSPS Module Table:

IE	Module	Usage
Patient	Patient	M
Study	General Study	M
	Patient Study	U
Series	General Series	M
	Presentation Series	M
Equipment	General Equipment	M
Presentation	Presentation State	M
	Modality LUT	C - Required if to be applied
	Mask	C - Required if multi-frame and to be applied
	VOI LUT	C - Required if to be applied
	Softcopy Presentation LUT	M
	Graphic Annotation	C - Required if to be applied
	Spatial Transformation	C - Required if rotation, flipping or magnification are to be applied
	Displayed Area	M
	Display Shutter	C - Required if to be applied and the Bitmap Display Shutter Module is not present
	Bitmap Display Shutter	C - Required if to be applied and the Display Shutter Module is not present
	Overlay Plane	C - Required if to be applied or the BM Displ. Shutter Module is present
	Overlay/Curve Activation	C- Required if image contains curve or overlay which is to be displayed
	Graphic Layer	C - Required if Graphic Annotation or Overlays or Curves are to be applied
	SOP Common	M

What about color ?

- Consistency is harder to achieve
  - Gamut of devices much more variable
  - Greater influence of psychovisual effects
- Extensive standards efforts e.g. ICC
- DICOM recently defined color presentation in a manner very similar to grayscale.
  - Many display and print devices already have ICC profiles, but few medical imaging devices support color presentation state.

Color Presentation State

- Final Text in June 2005, Supplement 100
- Color Presentation State
  - Based on ICC Color Profiles
  - Provides consistent color for color images
- Also defined consistent color mechanisms for other objects using color, by defining a relationship to ICC profiles.

Conclusions

- Consistent Presentation is Provided by
  - Device calibration, using GSDF and characteristic curve
  - Use of Presentation LUT for Grayscale Print
  - Use GSPS SOP Instances to capture the presentation of softcopy images.
- Devices that claim conformance to the IHE Consistent Presentation of Grayscale Images provide these functions.

Thank You