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Achieve “Soft-Copy” Medical Display Accuracy with Sencore accuGray™

Would a medical imaging professional ever accept a hard-copy (film) imaging study produced without an inherent QA/QC process? Of course the anwer is no, but that is exactly the result if your facility has no way to accurately measure and calibrate the luminance output of its soft-copy display system!

Sencore's AccuGray software, in conjunction with the ColorPro color and luminance analysis sensors, gives you that capability. AccuGray analyzes the gamma curve of the workstation/display combination and changes the workstation Look Up Table (LUT) to achieve the tightest possible compliance with the DICOM gamma specification.

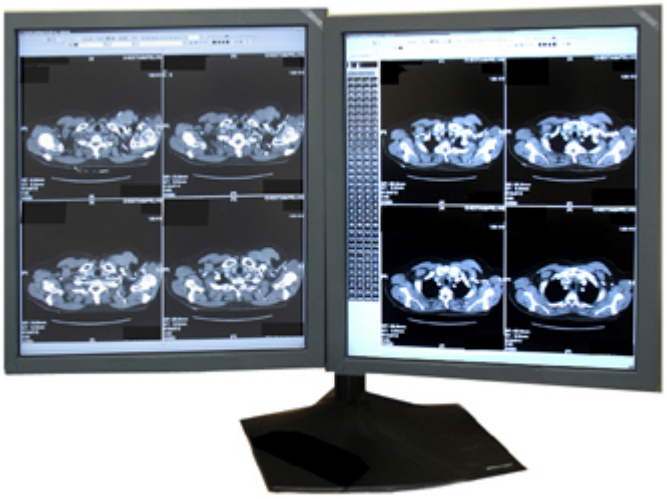

Figure 1. Accurately measure and calibrate your soft-copy display system with Sencore’s accuGray™ software.

That's a lot of jargon. For the sake of those without a working knowledge of the DICOM standard, some “ground work” may be in order. DICOM (Digital Imaging and Communications in Medicine) is a standard jointly developed by the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA). While other parts of the standard deal with how digital image data is moved from system to system, part 14 of the DICOM standard deals specifically with how that data should be interpreted or displayed..

We can think of a medical workstation and display as the “last mile” in the digital imaging signal path. Even if everything else is done right, this last mile can be the most difficult to travel. According to the foreword to Part 14 of the DICOM standard, “images produced by the same signal may have completely different visual appearance, information, and characteristics on different display devices.”

The importance of accurate image reproduction cannot be overstated. The foreword of Part 14 goes on to state:

> “In the absence of any standard which regulates how these images are to be visually presented on any device, a digital image which has good diagnostic value when viewed on one device could look very different and have greatly reduced diagnostic value when viewed on another device. Accordingly, PS 3.14 (Part 14) was developed to provide an objective and qualitative mechanism for mapping digital image values into a given range of luminance. An application which knows this relationship between digital values and display luminance can produce better visual consistency in how that image appears on diverse display devices. The relationship that PS 3.14 defines between digital image values and displayed luminance is based upon measurements and models of human perception over a wide range of luminance, not upon the characteristics of any one image presentation device or of any one imaging modality. It is also not dependent upon user preferences, which can be more properly handled by other constructs such as the DICOM Presentation Look Up Table.”

For those with an interest in exploring the DICOM part 14 standard further, the DICOM site and that of Task Group 18 are chock full of valuable information! Task Group 18, by the way, is a working group of imaging professionals seeking to develop more concrete specifications relating to display calibration intervals and everyday QA/QC functions, to verify specific display performance parameters.

Just how do AccuGray and the ColorPro work to achieve the best possible DICOM gamma compliance? To achieve the goal, we need to accurately measure the luminance output of a display. This is the job of the ColorPro sensor (it can also calibrate the color performance of a “non-grayscale” display). The ColorPro sensor uses special light filtering technology to mimic the vision characteristics of the human eye. To achieve the ideal display gamma characteristics, as defined in DICOM Part 14, we also need a “template.”

Gamma is the expressed relationship between a display’s video input signal and the amount of light produced at each signal level, from black to peak white. A gamma of one describes a linear relationship between input signal and light output. A gamma response curve is often nonlinear, though, to compensate for non-linearities in the display's or human eye's response. A CRT computer monitor (or an LCD that emulates a CRT) has an inherent gamma of approximately 2.2. To compensate for this, a workstation’s video adapter card usually sends the monitor a video signal with a pre-corrected gamma of 1/2.2 (0.45), to produce a net system gamma of one.

If we plot a system gamma of one on an x,y graph, we see a straight line, beginning at zero and extending diagonally up and to the right, ending at the maximum luminance value a particular display is capable of producing. A CRT, with a native gamma of 2.2, produces less light output from midrange input signal levels than it would if it had a linear gamma of 1.

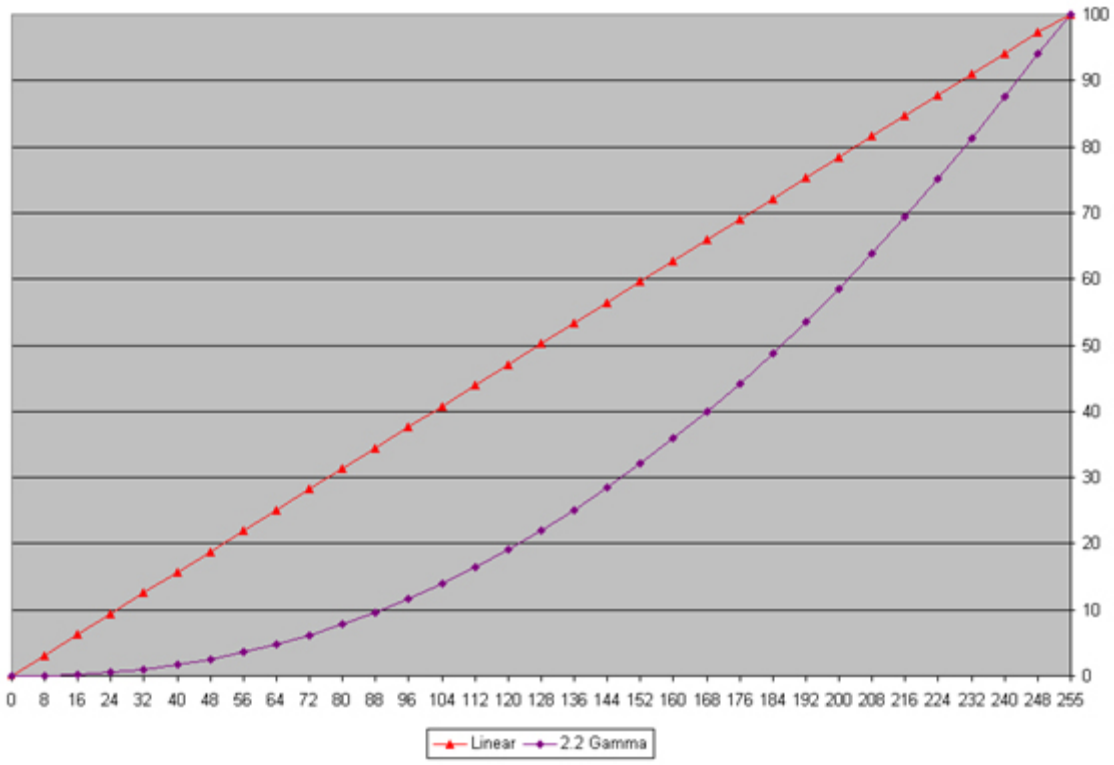

Figure 2. Linear and 2.2 gamma luminance responses, plotted with a linear y scale.

The above chart, plotted with a linear y scale, often doesn’t show small differences between plots as well as it could. To enhance the chart viewability, we usually show a luminance response plot on a logarithmic y scale. The same data from the chart above is shown below with the traditional log y scale.

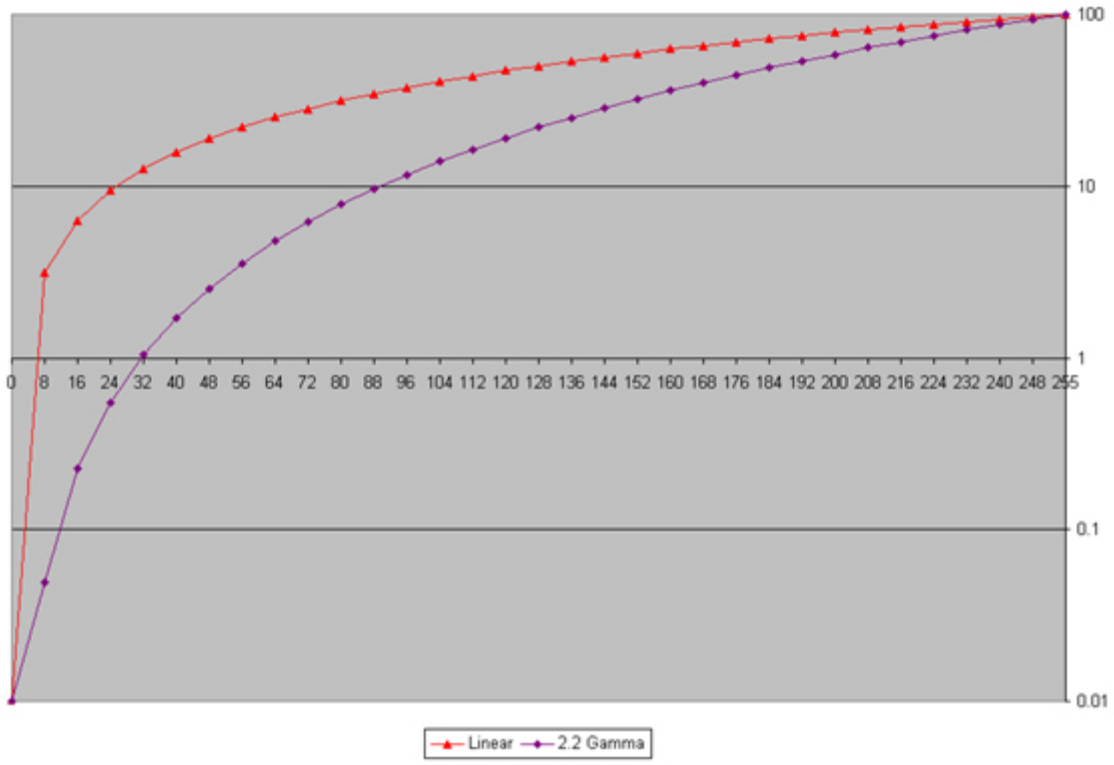

Figure 3. Linear and 2.2 gamma luminance responses, plotted with a logarithmic y scale.

DICOM gamma compensates for more than just the monitor’s non-linearity. The developers understood certain non-linear response characteristics of human contrast sensitivity and compensated for them in the Grayscale Standard Display Function (GSDF) specified by DICOM:

> “Human contrast sensitivity is distinctly non-linear within the luminance range of the Grayscale Standard Display Function. The human eye is relatively less sensitive in the dark areas of an image than it is in the bright area of an image.” (p.11, PS 3.14-2003)

The DICOM developers mathematically correct for this non-linear characteristic in the GSDF. The result is a gamma curve that is “bowed up” at the bottom to equalize the intervals of Just Noticeable Differences (JND) to the human eye. We see that quite easily in x/y terms.

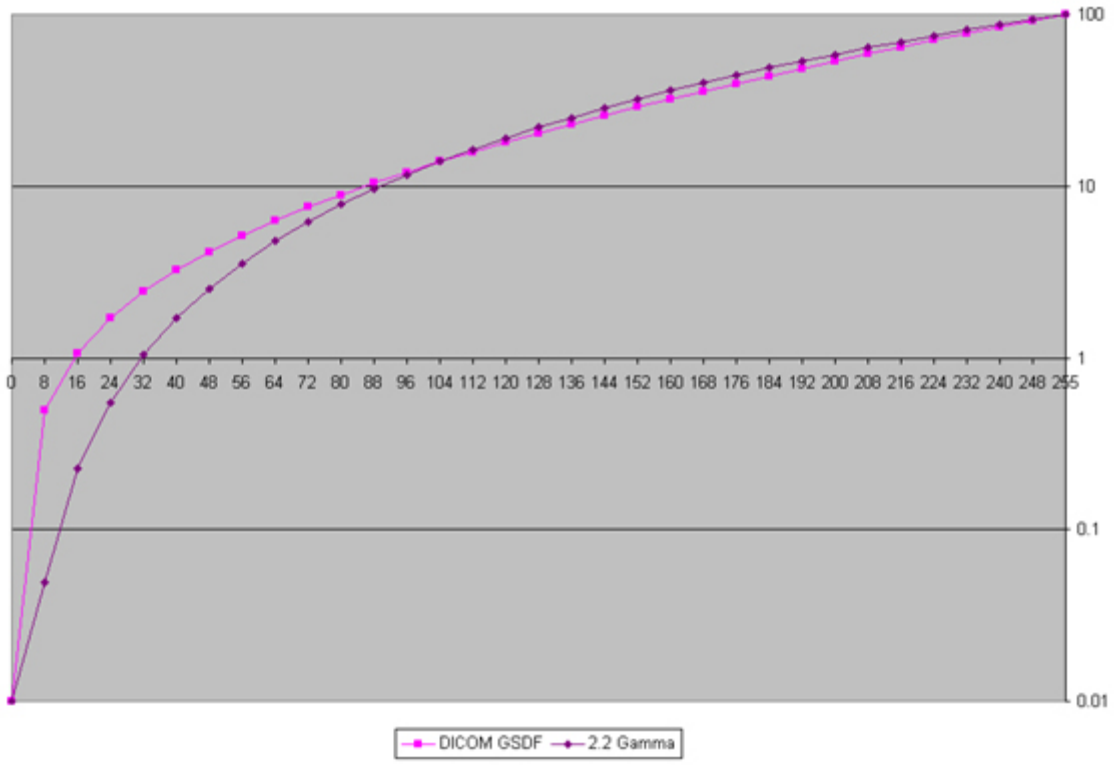

Figure 4. DICOM GSDF and 2.2 gamma luminance responses, plotted with a logarithmic y scale. Note that the DICOM curve produces higher light output at low driving (IRE) levels (on the left side of the graph) than with a monitor’s natural 2.2 gamma response.

Adjusting a workstation/display to produce DICOM gamma response can be accomplished only with a software program capable of receiving light measurements from a device like the ColorPro sensor. AccuGray, Sencore's exclusive DICOM calibration software solution for imaging workstations, produces test patterns on the workstation/display being calibrated. It then analyzes the luminance (and color) information gathered by the ColorPro sensor pod. The ColorPro sensor and AccuGray software characterize the workstation/display's native gamma. This data is compared to the DICOM gamma model and calculations are made to change the Look-Up Table (LUT) on the system's video card. These changes to the LUT result in the best possible DICOM gamma compliance for a particular workstation/display configuration.

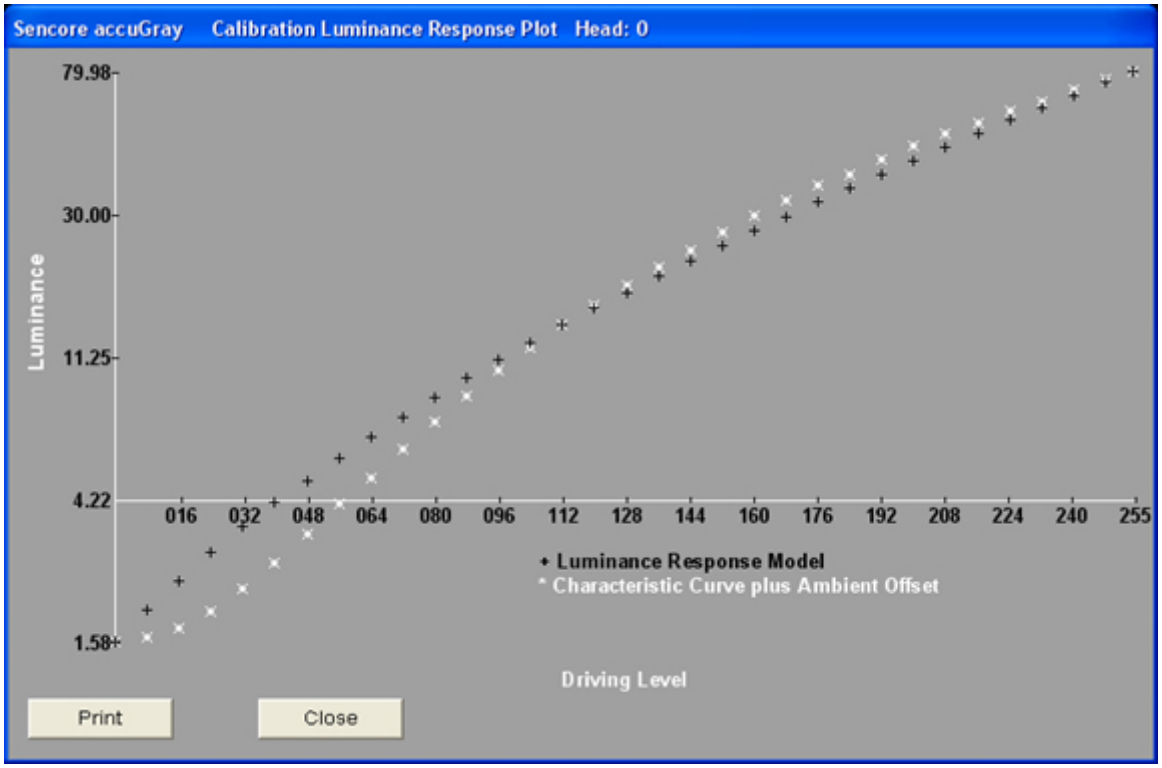

Figure 5. Uncalibrated monitor gamma curve (white crosses), plus DICOM response model (black crosses), plotted with a logarithmic y scale.

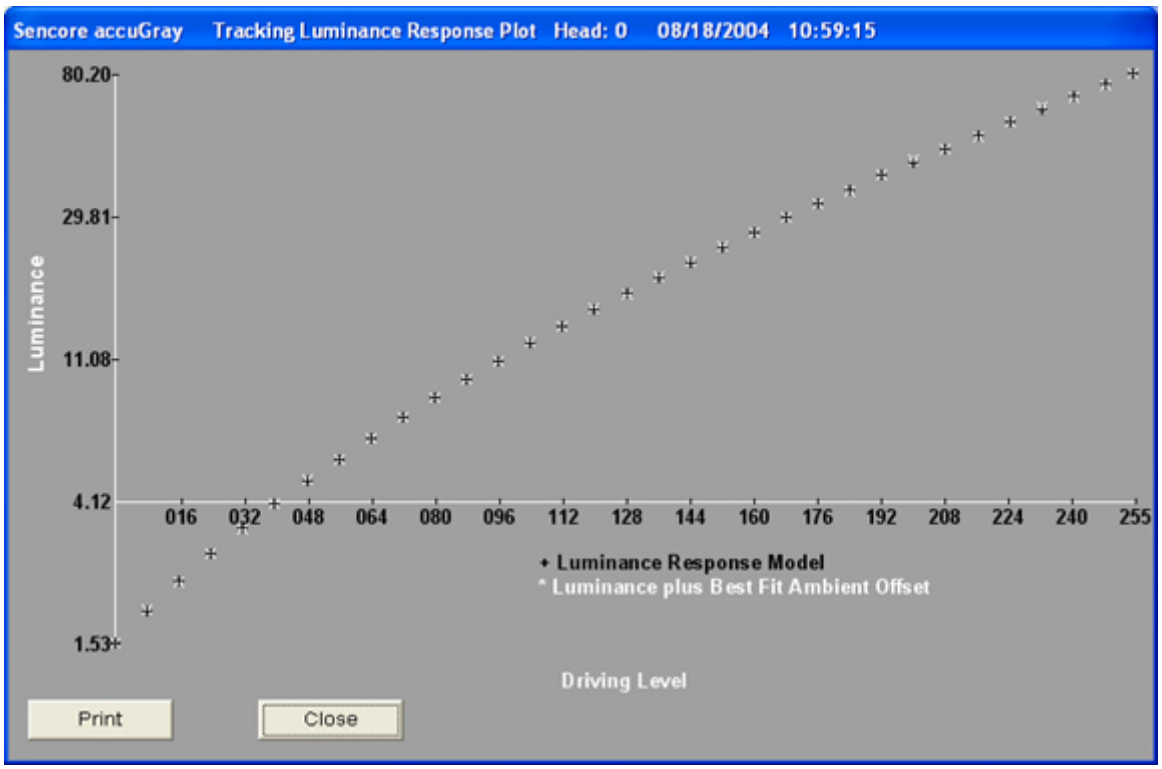

Figure 6. Calibrated monitor gamma curve (white crosses), plus DICOM response model (black crosses), plotted with a logarithmic y scale.

AccuGray's advantage to the medical imaging professional is that the process of system gamma analysis and calibration is almost completely automated! AccuGray also includes color reference calibration and tools for the acceptance testing of displays, in which the user can objectively evaluate a display's absolute white and black level perfomance (or adjust these levels accordingly).

What about color calibration? You might wonder why calibrating a display's color settings would be important to a gray scale modality. This too can be an issue during review and diagnosis.

Many radiologists, being long-familiar with blue-base film, want to have the display calibrated to a color close to that of the film they are used to viewing. AccuGray provides you with the capability of calibrating the workstation/display to any white reference you choose. A white reference of 9300 Kelvin (9300K) achieves a close match to the blue-base film standard.

Other modalities may be more accurately displayed with a more neutral gray scale. The NTSC broadcast color temperature reference of D65 (aka 6500K) is generally accepted as a “neutral gray” standard, though it is slightly more blue than a true neutral white point of 5400K.

There is also the issue of “diagnostic” vs. “clinical review workstations.” Generally, a “review” station will not have the spatial resolution of a diagnostic workstation. They also tend to use standard (albeit “higher end”) desktop monitors. This means that a strong argument can be made that proper color/grayscale calibration is just as critical to a “review” station as it is for a “diagnostic” station. How else can the user even hope to be assured that the images displayed are even close to accurate in their reproduction?

The AccuGray calibration package produces calibration test patterns on the workstation on which it is being run. When you are calibrating a surgical or endoscopic display device, it isn’t fed from a computer workstation, so we need a different source for calibration test patterns. For these display calibrations, a video test generator will be used to produce the reference test patterns to calibrate the non-workstation monitor.

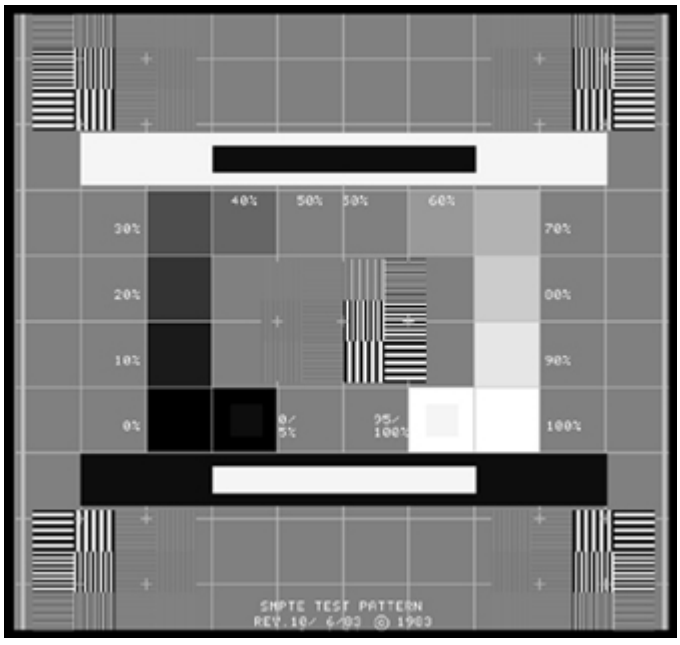

Figure 7. AccuGray software produces calibration test patterns such as the SMPTE test pattern.

Sencore manufactures the VP400 series of video test generators. The VP401 model

outputs all of the formats currently used on medical monitors, including the emerging DVI standard already found on many new medical imaging monitors.

You will still use the ColorPro sensor to measure the light output from the surgical or endoscopic monitor when calibrating the display's color tracking (often referred to as “white balance”). In this case, though, you will use the native CP5000 software included with every ColorPro system, rather than the workstation-based AccuGray software.

Sencore has authored many articles covering white balance calibration. References and links to older articles can be found by clicking on the “Archived Newsletters” link in the lower left-hand corner of the home page of each new issue of the standard Sencore News.

In addition to general display calibration information, Sencore has produced a Macromedia Flash presentation covering white balance calibration on the Sony PVM-20M2MDU (and similar) video displays used in surgical and endoscopic applications.

For more information on how Sencore’s “total display calibration” solution can help you maintain “soft-copy” display accuracy, please contact your Sencore account managers today. They will be happy to consult with you on DICOM compliance or display calibration in general, and support you in conjunction with our experienced Application Engineering staff.