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## Tech Talk: Uniform Luminance Differentiates LCDs

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*The reality of the medical display world is that all liquid crystal displays (LCDs), both monochrome and color, are associated with potential quality issues. Two key quality issues are non-uniformity and spatial noise.*

Variations in digital display luminance may impair the radiologist's ability to interpret a lesion-free image as normal, according to research conducted by Elizabeth Krupinski, PhD, associate director for evaluation and assessment, research associate professor, departments of radiology, telemedicine and psychology, division of radiology research at University of Arizona in Tuscon and published on eMedicine. She and fellow researchers found that luminance changes may increase the time needed to search an image thoroughly and determine it is lesion-free. What's more, non-uniformity could negatively impact workflow. The best monitors currently available are approximately five times less bright than a typical radiographic viewbox (1,000 vs. 250 foot-lambert).



In fact, non-uniformity and spatial noise may affect observer performance, so it's critical that IT and radiology implement systems and solutions to minimize or eliminate the negative impacts of non-uniformity and noise.

New technology can provide substantial assistance and help address and overcome these problems. Barco's Uniform Luminance Technology offers a superior mechanism to achieve luminance uniformity, color uniformity and true DICOM Grayscale Standard Display Function (GSDF) over the complete display surface. Barco's new Coronis Color Diagnostic Luminance display systems incorporate the Uniform Luminance Technology, differentiating Barco's LCDs from others on the market.

### Non-uniformity & spatial noise: The essential primer

Aldo Badano, PhD, of the Food & Drug Administration's NIBIB/CDRH Laboratory for the Analysis of Medical Imaging Systems in Rockville, Md., points out that non-uniformity is a major medical imaging consideration for both monochrome and color LCDs. All LCDs have some degree of non-uniform behavior across the screen, which results in patterns that can obscure abnormalities. When a radiologist interprets an image such as a mammogram, he or she may need to rely on and determine changes in optical density to make a diagnosis. Optical density is, in turn, associated with changes in luminance, so non-uniformity can misinform diagnosis.

"Initially, researchers thought that monochrome displays could achieve non-uniformity close to 10 percent, but very few monochrome displays achieve that goal," explains Badano. The phenomenon is a well-known issue among grayscale display systems, but non-uniformity problems become more severe with color.

"When a color filter is added to a monochrome display, it has a compounded effect on non-uniformity," continues Badano. In fact, the demonstrated non-uniformity of color displays is one of the reasons preventing their adoption in the medical imaging industry — until now.

Spatial noise in LCDs has two components, says Badano. The first relates to the large-scale non-uniformity of the backlight. Typically, backlight non-uniformity causes luminance changes near the borders of the display. This phenomenon actually causes few diagnostic issues.

The second cause of spatial noise can be more problematic for radiologists. Individual LCD pixels resemble a collection of small sub-pixels. Cell artifacts can cause higher frequency variations in the pixel luminance. "Noise can cause a problem when a radiologist examines fine detail in images such as 1 or 2 pixel-wide microcalcifications or spiculated borders of cancerous lesions," explains Badano.

Spatial noise can be considerably more noticeable than differences in grayscales displayed on an LCD. Translation?

Noise can interfere with diagnostic interpretation, making it more difficult to differentiate high resolution features of a medical image. "The actual effect of spatial noise on diagnostic interpretation is unknown," confirms Badano.

Research, however, indicates that both non-uniformity and noise are cause for concern. Noise does make it harder to distinguish subtle features at high spatial frequencies on a medical image from the background, which can increase the potential for both false negative and false positive interpretations.

Badano says the effect of noise may be more important in the color display environment because a color display introduces additional noise with its color filter. A color display system can have luminance errors over the entire display area, and there may be color variability across the display with the same color appearing differently depending on its location in the display.

### Overcoming non-uniformity & noise: Uniform Luminance Technology

To correct for non-uniformity and noise, Barco developed Uniform Luminance Technology. All new generation Coronis and Coronis Color Diagnostic Luminance displays incorporate the technology.

Uniform Luminance Technology is a three step solution. First, it assesses the spatial noise pattern of the display for all video levels. Appropriate correction values to compensate for the spatial noise are calculated for every display pixel and all video levels based on the initial characterization of noise patterns. Then, it digitally pre-compensates the image before sending it to the display panel. Correction data is inverse to the spatial noise, which means that spatial noise and the pre-

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compensated image cancel each other out. The end result is a noise-free image.

Uniform Luminance Technology is enabled by hardware contained within Barco displays, resulting in a process that is transparent to the end-user and available in real-time.

The end performance surpasses the clinical ideal of non-uniformity in the 10 percent range. Without Uniform Luminance Technology, luminance may vary by more than 40 percent. Barco's technology, however, brings luminance uniformity to a very respectable 95 percent. This may boost diagnostic accuracy and confidence among radiologists.

Although its benefits in the grayscale realm are impressive, Uniform Luminance Technology may have a more significant impact in the color display environment as it improves color uniformity and accuracy. Without Uniform Luminance Technology, color uniformity can vary tremendously depending on the position of the color on the display. Such variability can be detrimental in medical imaging applications that demand precise color reproduction such as fused PET-CT studies. Uniform Luminance Technology corrects the problem and minimizes the color variation over the display surface to the point where it is not visible to the human observer. Reducing color non-uniformity results in more accurate color reproductions across the entire display.

Uniform Luminance technology is associated with other benefits as well. Displays without Uniform Luminance Technology are completely compliant to DICOM GSDF only at the position where the display was characterized. The average distortion may exceed more than 25 JNDs (just noticeable differences) across 256 video levels.

Barco's Uniform Luminance Technology, however, brings a dramatic improvement to the picture. Coronis Color Diagnostic Luminance displays comply with DICOM GSDF across the entire display. Average distortion plummets to less than one JND. Once again, the results could be enhanced diagnostic accuracy and confidence.

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#### Other considerations

Badano of the FDA concludes with a final point to ponder. "Physicians may be tempted to use a lower quality, non medical-grade color display, but image quality on these displays does not typically compare to medical-grade displays. Medical-grade displays should provide superior calibration and reduced noise, among other features, when compared to non-medical grade systems," he says.

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#### Conclusion

Uniform Luminance Technology differentiates Barco's Coronis Color Diagnostic Luminance displays from other systems on the market. The new technology solves a common dilemma among imaging and IT specialists. That is, the embedded solution corrects and compensates for non-uniformity and spatial noise to optimize the color display system. Uniform Luminance Technology ensures absolutely minimal non-uniformity and spatial noise and complete compliance with DICOM GSDF. The potential for misreads may be lowered as noise and non-uniformity no longer cloud the medical images. Color is clearer and more accurate and consistent for the interpreting reader, enabling the radiologist to focus on his top priority — accurate interpretation of medical images.