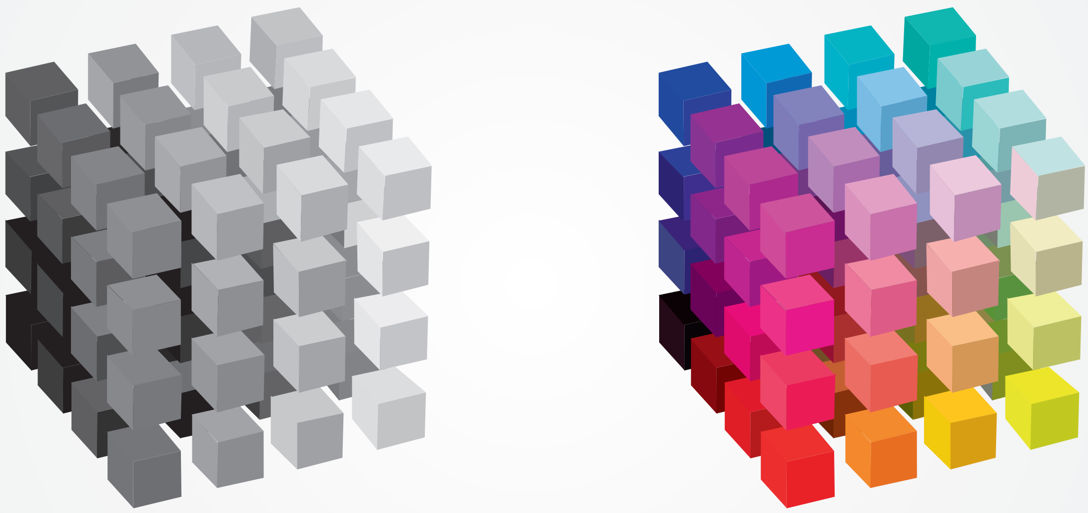
SteadyColor & SteadyGray

Technology highlight



As the pioneer and industry leader of medical calibration technology, Barco defined the image quality standard for diagnostic viewing applications with the SteadyColor™ color calibration technique. With our latest color display systems, QAWeb incorporates the vast color know-how Barco has developed over the past several decades into SteadyColor to further advance one of its core technologies.

SteadyGray™ uses the same color calibration technology to achieve a more constant and consistent gray appearance. SteadyGray ensures that all gray values are as close as possible to the tint of the selected white color, whether that is blue base, clear base, or some other preferred white tint.

Increasing use of color in medical applications

As the use of color in medical imaging continues to evolve, going beyond simple annotation to depicting more complex diagnostic information, medical displays must meet a higher standard for color in line with those used for medical grayscale displays.

Generations of medical color displays have provided some means to guarantee stable and calibrated DICOM grayscale images. The latest advances in medical imaging, however, mandate more advanced calibration technology to guarantee consistent color images in space and time. Recent technological breakthroughs with respect to color calibration will enable our new generation of diagnostic displays to achieve this goal, and enable radiologists to rely on the diagnostic value of color if present in the image.

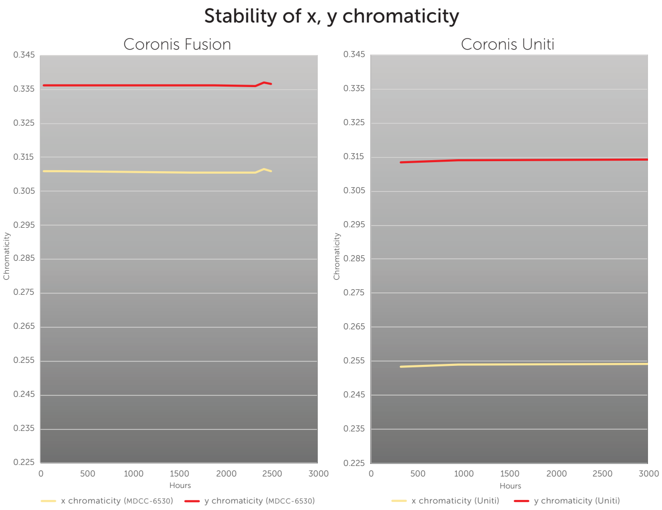


Fig 1: Color stability

Advanced medical displays have multiple sensors that continuously monitor and adjust display parameters to maintain picture consistency over long periods of time. In typical displays, most sensors can also measure a single luminance (black to gray), correcting deviations as needed. On Barco's advanced color display systems, precision sensors can also measure color on multiple levels. This information is then used by QAWeb to calculate data used with numerous 3D Look-Up Tables (LUTs) to perform the SteadyColor and SteadyGray calibration.

The clinical impact of SteadyGray calibration is two-fold:

1. Functional information, such as flow or metabolic activity, is often indicated by adding color to the gray image that shows morphology. Ordinary displays have a color tint on gray that varies with gray level (figure 7), making it hard to interpret small amounts of color. SteadyGray minimizes color variations of the grays, so that a small amount of intentionally added color can be easily seen when used to indicate functional information.
2. Displays that are grayscale only are factory selected for a certain color base (tint), typically either blue base or clear base. But this tint changes over time, varies from system to system, and varies with gray level. When the tint of gray displays varies throughout the enterprise, this can be a distraction to the radiologist who relies on a familiar appearance to compare the current case to those cases in their memory. By maintaining the preferred color base for white and all grays, a color display with SteadyGray offers a more consistent and familiar gray image than any grayscale display could.

DICOM calibration on previous generations of medical grayscale and color displays

Fig 2 and Fig 3 below clearly illustrate how SteadyColor compares to former DICOM calibration on earlier Barco medical color displays.

On previous generations of medical displays, only the grayscale JNDs were calibrated (see the black to white grayscale on the left in Fig 2). When properly executed, equal steps in Digital Driving Level (DDL) result in equal perceptual gray differences, as seen in the graphic. However, although all gray DDL's seem to generate perceptual equal steps, this is not the case for the red scale as it completely disappears as soon as the red becomes brighter. Some color JNDs in the red area are squeezed, while others are stretched over the available range. This phenomenon occurs for other colors as well.

Fig 3 shows how SteadyColor calibrates both gray and color values in adjacent steps, which are also much more equally distributed.

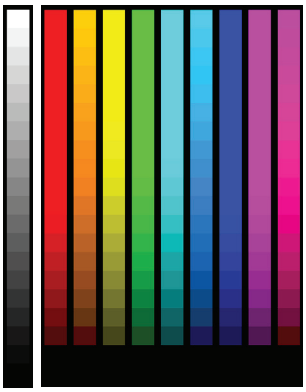


Fig 2: DICOM GSDF JNDs on grayscale & color displays - proper grayscale JNDs but color??

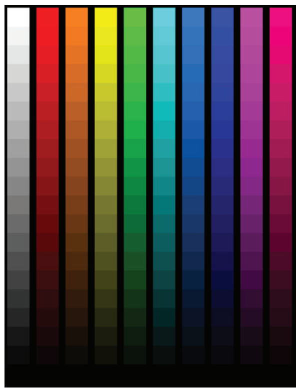


Fig 3: Color JNDs on SteadyColor calibrated displays - perfect grayscale & color JNDs

Maintaining image quality and DICOM-compliance under all lighting conditions

Radiologists expect the quality of their medical images to remain stable over time. While data stored in the computer archive is purely digital (and thus, stable), the perceived image on a display is not. Changing ambient lighting conditions in the reading room can influence the display's performance, the resulting image on screen, and consequently, the radiologist's ability to detect subtle information. SteadyColor technology automatically factors in the ambient lighting conditions during the calibration process to ensure accurate color JNDs.

New color sensors

As an essential component of Barco's color diagnostic displays, our sensors, including our patented color I-Guard, have become the industry-standard technology for monitoring image quality and DICOM consistency. All Barco's front sensors have been improved to measure much finer gradations of colors spread over the color gamut of the display.

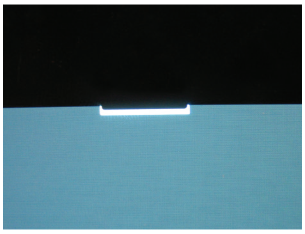


Fig 4: A color I-Guard discreetly embedded in the display.

Barco's calibration sensor (Fig 4) is an embedded optical precision colorimeter positioned at the front of the LCD screen, which captures precisely what the radiologist sees: the result of the complete image formation process of the LCD, including the graphic board, the LUT, the driving electronics, the backlight and the Liquid Crystal cells. I-Guard continuously monitors the light and color output of the red, green and blue contributions without disturbing the actual image display. It then communicates its readings to the controlling electronics, which make corrective actions to the LCD in real time.

3D color Look-Up Table

QAWeb uses the color sensors to perform a color characterization of the color gamut of the display by measuring a large combination of different colors that can be displayed on the screen. Then, SteadyColor uses an advanced algorithm to determine how the individual colors should be adjusted so that equal color-driving levels result in color JNDs. SteadyColor employs floating point calculations with nearly infinite resolution capabilities to calculate the JNDs, improving accuracy beyond what typical hardware calculations based on integers can provide due to their fixed bit length.

The resulting information is put in a hardware 3D LUT that enables the display to adjust color driving levels in real time so that the proper Luminance + Color appears at the front of the display. This is the same used in a traditional medical display implementing Grayscale Standard Display Function (GSDF). Here, the DDL are also converted in real time to the proper light output. As GSDF only defines luminance, a one-dimensional LUT can perform this less complex task.

The result can be observed in Fig 5 and Fig 6 below. Fig 5 shows the colors before the JND's are calibrated on a SteadyColor display, whereas Fig 6 shows the JNDs after calibration.

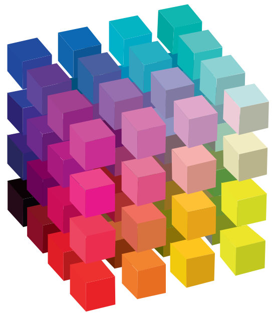


Fig 5: Before calibration

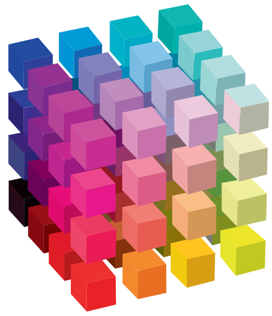


Fig 6: After SteadyColor

Ordinary gray has variation in chroma, e.g. purple tint in darker shades, yellow in brighter shades

SteadyGray has consistent chroma; tint of darker shades matches brighter shades up to white

Fig 7: SteadyGray has consistent tint