VeriLUM®

Video Display Calibration
And Conformance Tracking

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This User Guide describes VeriLUM® Version 5.02.0007 .

Revision Date: April, 2012

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Preface

VeriLUM® is a tool for ensuring consistent color and grayscale video display performance. Our goal is to make it easy and efficient to judge when a video display system is continuing to function normally or needs adjustment or replacement.

Luminance and chromaticity measurements using VeriLUM® require a photometer with the VeriLUM® logo. This is a Chroma 5 photometer manufactured by Xrite, Inc.

VeriLUM® supports PC workstations using Microsoft Windows operating systems XP, Vista, and 7.

An unconditional 30-day money back guarantee protects you against the possibility that VeriLUM® does not work with your display and video card combination. In addition, at no cost, you can download VeriLUM® software from our website (www.image-smiths.com), then install and configure it. This will give you added confidence that VeriLUM® will work with your system prior to your purchase of a VeriLUM® photometer. Without a VeriLUM® photometer you will not be able to make luminance and chromaticity measurements.

VeriLUM® can be used for **acceptance testing, visual checks, gamma correction, and conformance tracking** of a video display system.

VeriLUM® software can be installed on as many workstations as desired. No additional licenses or fees are required.

1.0 Getting Started

1.1 SYSTEM REQUIREMENTS

VeriLUM® requires a personal computer with Microsoft Windows Operating System (XP, Vista, or 7). In addition, the video display system must be capable of at least 1024 X 768 pixels with a minimum of 256 colors (24- or 32-bit true color is highly recommended) and the video driver must address downloadable gamma ramps on the video card. Administrator privileges are required to install VeriLUM®.

1.2 INSTALLING VeriLUM®

NOTE: Always install the VeriLUM® software before plugging in the USB photometer.

VeriLUM® software is shipped on a CD. Double-click the VeriLUM_Install.exe icon with the left mouse button. The installation script will verify the minimum system requirements, create the necessary folders and icons, install the program files and ancillary files, and update the registry.

Note that the default install folder in the installer is C:\VeriLUM . This is different than previous versions of the installer where the install folder was C:\Program Files\VeriLUM . If you want to use C:\Program Files\VeriLUM as the install folder you can specify it in the installer at run time.

This User Guide is included on the CD in Adobe Acrobat PDF format. Print as many copies as you need or use it in soft-copy display mode.

Also, the VeriLUM® software can be downloaded from the IMAGE Smiths, Inc. website: www.image-smiths.com .

**** MS Windows Vista and MS Windows 7 Install Notes ****

Special considerations are necessary when installing VeriLUM® on PCs using the Microsoft Windows Vista or Microsoft Windows 7 operating systems.

The default install folder is VeriLUM and resides at the root of the system volume.

When the VeriLUM installer finishes, navigate to the VeriLUM install folder and right-click on the folder. Choose the Security tab and ensure that All Users have Full Control permissions for the folder.

In addition, look for the program file named VeriLUMnc.exe in the install folder for VeriLUM. Right-click on the filename VeriLUMnc.exe and click on the Compatibility tab. Turn on the check box for "Windows XP (Service Pack 2)" compatibility. Also turn on the checkbox for "Disable Desktop Composition". If you do not check the "Disable Desktop Composition" box then VeriLUM will not correctly display the SMPTE Pattern, the VeriLUM Pattern, and

luminance patches. Apply these settings. Then click on “Show settings for all Users” and turn on the same two check boxes for All Users and apply these choices. Click on OK to return to the compatibility tab and then click on OK to return to the install folder. Exit the install folder.

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1.3 RUNNING VeriLUM®

[Note: VeriLUM® uses the left mouse button exclusively. Thus all references to clicking imply left mouse button clicks.]

After installing the VeriLUM® software, connect a VeriLUM® pod to any available USB port. Plug and Play should automatically detect the Xrite Chroma 5 Calibrator and load the driver.

*** 64-bit Architecture Note ***

The VeriLUM® installer application installs 32-bit drivers for the USB port Chroma 5 photometer. If you have a 64-bit architecture PC then you must update the USB driver for the photometer. After the installer completes and after you have plugged in the photometer, create a folder on the C:\ hard drive and copy the file Chroma_signed_USB_drivers.zip from the VeriLUM Install CD to the folder you created. This is important since Windows 7 requires you to have “ownership” of the folder into which you extract the files from the zipped file. Otherwise you will get an Access Denied message when you try to use the files to update the USB drivers. If Windows 7 indicates that the files are encrypted, then decrypt the extracted files (if the filenames are in green then they are encrypted). After you plug in the VeriLUM photometer, use Device Manager to Update the USB drivers by pointing to the 64-bit drivers you extracted from the zipped file.

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Click on Start/Programs/VeriLUM .

Normally the VeriLUM® Main Screen appears as shown in **Figure 1**

However, the first time VeriLUM® is run, a Define Configuration Screen appears (see **Figure 2**).

1.4 CONFIGURING VeriLUM®

It is extremely important to properly configure VeriLUM®. You must first define your workstation desktop in Windows and then configure VeriLUM® to reflect that definition. The Configuration dialog box has two buttons in the upper right-hand corner that are used to select the display device being used and to specify the desktop display configuration.

Figure 2A shows how to use **SELECT DISPLAY DEVICE** to specify whether your display is a CRT or an LCD/LED and whether it is grayscale or color.

Figure 2B shows how to use **MONITOR CONFIGURATION** to indicate to VeriLUM® that there are special considerations which apply to the video cards and displays. In many cases you do not need to click on any buttons in this screen other than **OK**; that is, VeriLUM® automatically detects the display configuration. However, Windows permits complexity in the desktop arrangement. For example, it is possible in Windows to have a mix of color and grayscale displays, non-uniform rows and columns, and a mix of portrait and landscape modes. Using the Monitor Configuration options to properly convey a complex desktop configuration may require some experimentation.

VeriLUM® can only address one type of video card. If your system has more than one type of video card installed then you must toggle off calibration on the displays associated with the additional video cards. To do this, highlight the words “Display n” and then click once on the radio button “Toggle On/Off Calibration on this Display”.

An additional application is provided to address a second type of video card. It is named VeriLUM_Plus_Install.exe. You should install VeriLUM® **only** or install **both** VeriLUM® **AND** VeriLUM® Plus. The default install folder for VeriLUM_Plus is C:\VeriLUM_Plus. You must apply the same security permission settings to this folder and apply the same compatibility mode checkbox and disable the desktop composition checkbox settings for the VeriLUMnc.exe program as described in Section 1.2 above.

In the Configuration Screen for VeriLUM® Plus toggle off calibration on the displays being calibrated by VeriLUM® and in VeriLUM® toggle off calibration on the displays being calibrated by VeriLUM® Plus.

In the Configuration Screen you can indicate how the minimum and maximum luminance values enter into the gamma correction scheme. The measured values can be used; a set of target values can be specified; or you can use the measured maximum and specify a target value for the contrast ratio (i.e. the ratio of maximum to minimum luminance). Most users choose to use the measured values.

For CRTs, a percent surround value can be specified to account for veiling glare. This value is used to define the surround for all luminance measurements; in particular, all luminance measurements used in determining the DICOM Part 14 gamma correction lookup table. The default value is 20%. For LCD or LED displays this value is set to zero.

When you click **OK** the VeriLUM® application will exit to complete initialization and the VeriLUMOnOff application will be launched. VeriLUMOnOff is a task bar application that provides easy access for enabling and disabling the gamma correction. In addition, there is a button for running VeriLUM® without the pod being attached. Note that when the gamma model has been chosen as the luminance response model for calibration VeriLUMOnOff permits a user to specify a different gamma to be used and the choice takes effect without re-measuring the characteristic curve of the display.

1.5 UNINSTALLING VeriLUM®

To remove VeriLUM®, use the Control Panel Add/Remove Programs function. All files and icons and registry entries created as a part of the install process will be removed. Files created during the operation of the VeriLUM® software will not be removed. In particular, the VeriLUM.Pref file will remain in the install folder. Manually deleting these files and the install folder is recommended.

If it is desired to re-define the desktop in Windows it is not necessary to un-install and re-install VeriLUM®. You can delete the VeriLUM.Pref file from the VeriLUM® install folder and then run VeriLUM®. The Configuration Screen will then create the file VeriLUM.Pref.

If you redefine the Windows desktop display devices then you **MUST** delete the VeriLUM.Pref file before you reconfigure the desktop in Windows. Otherwise VeriLUM® will incorrectly address the display devices.

FIGURE 1. VeriLUM® Main Screen

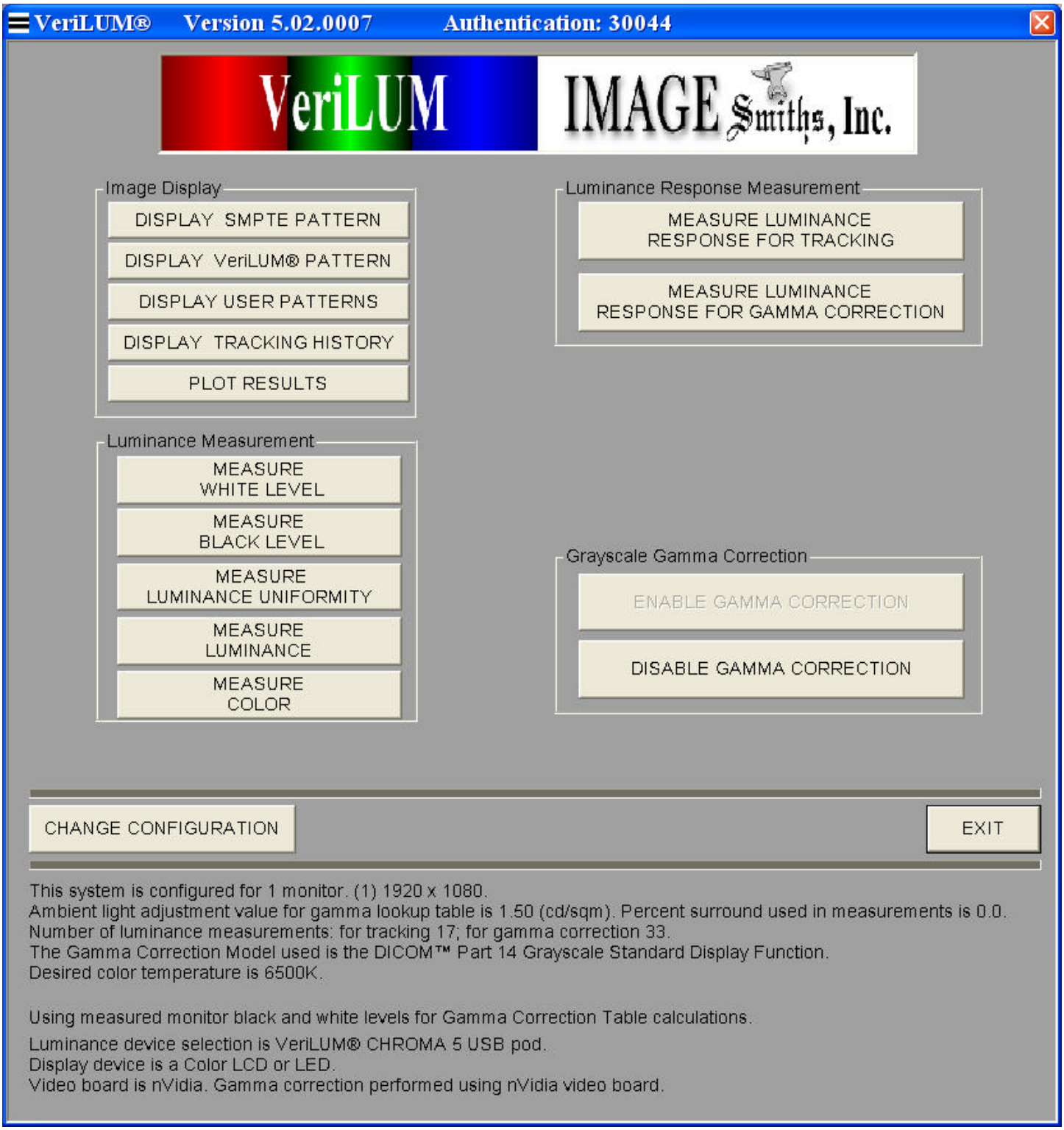


Figure 2. VeriLUM® Configuration Screen

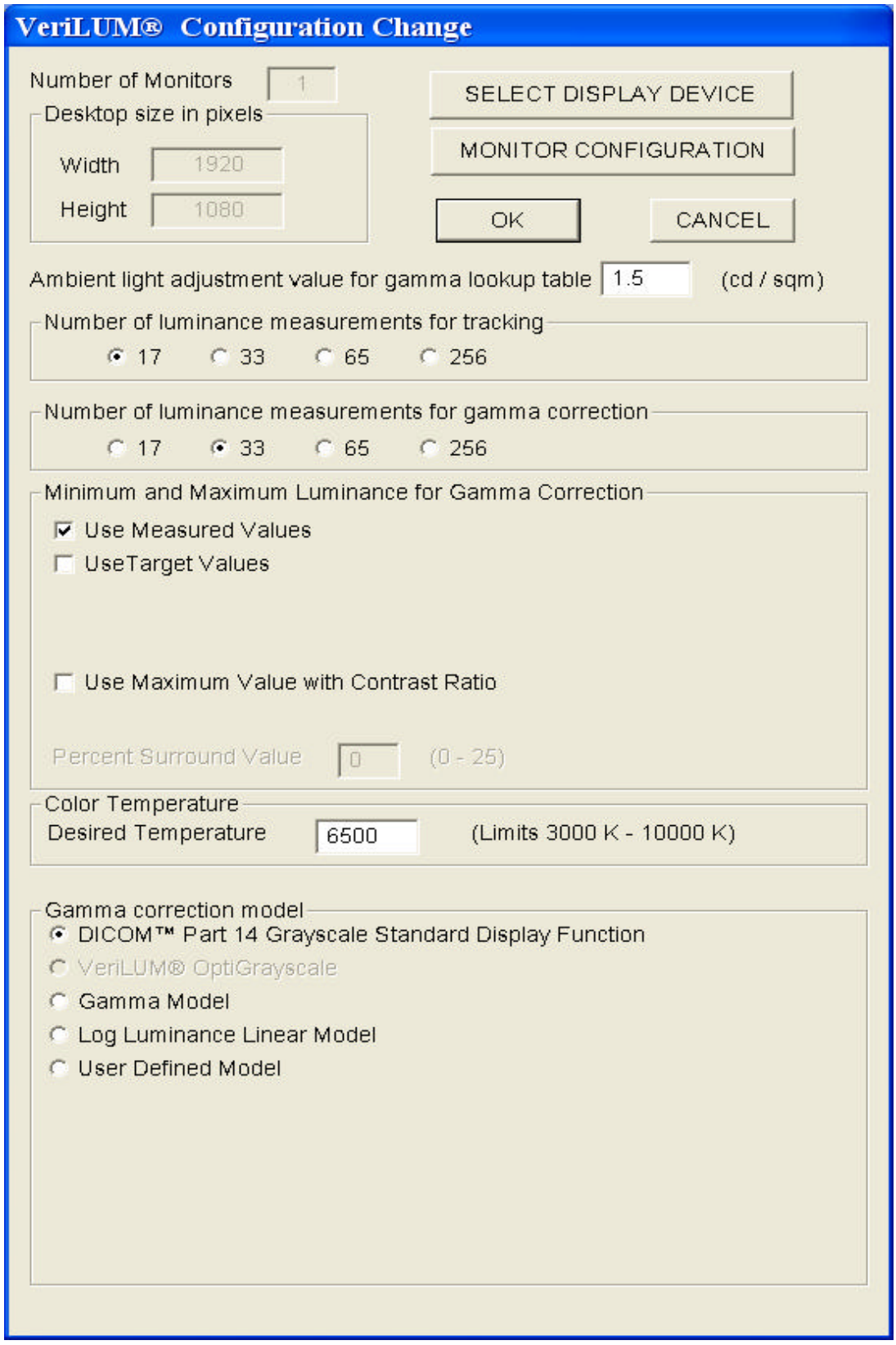


Figure 2A. VeriLUM® Display Device Screen

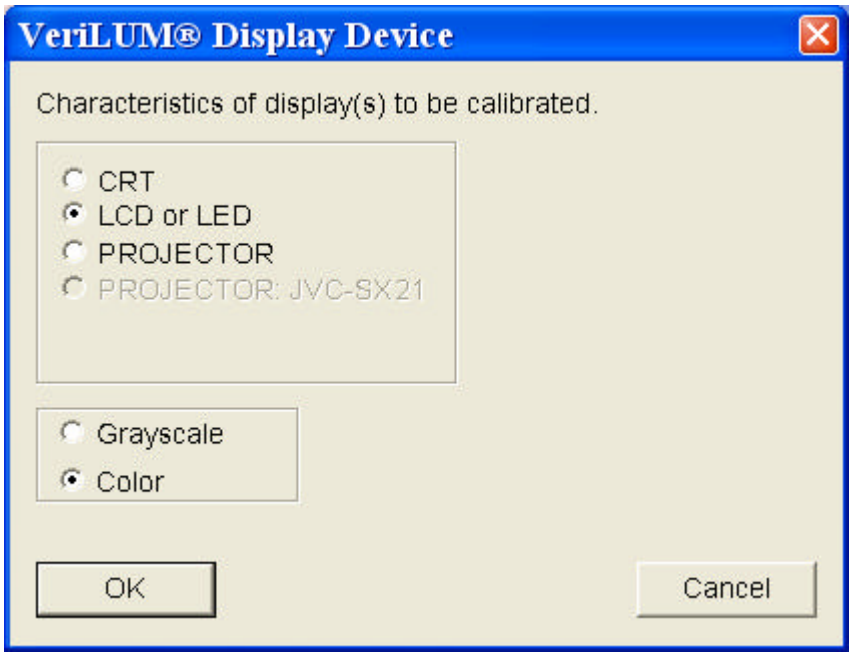
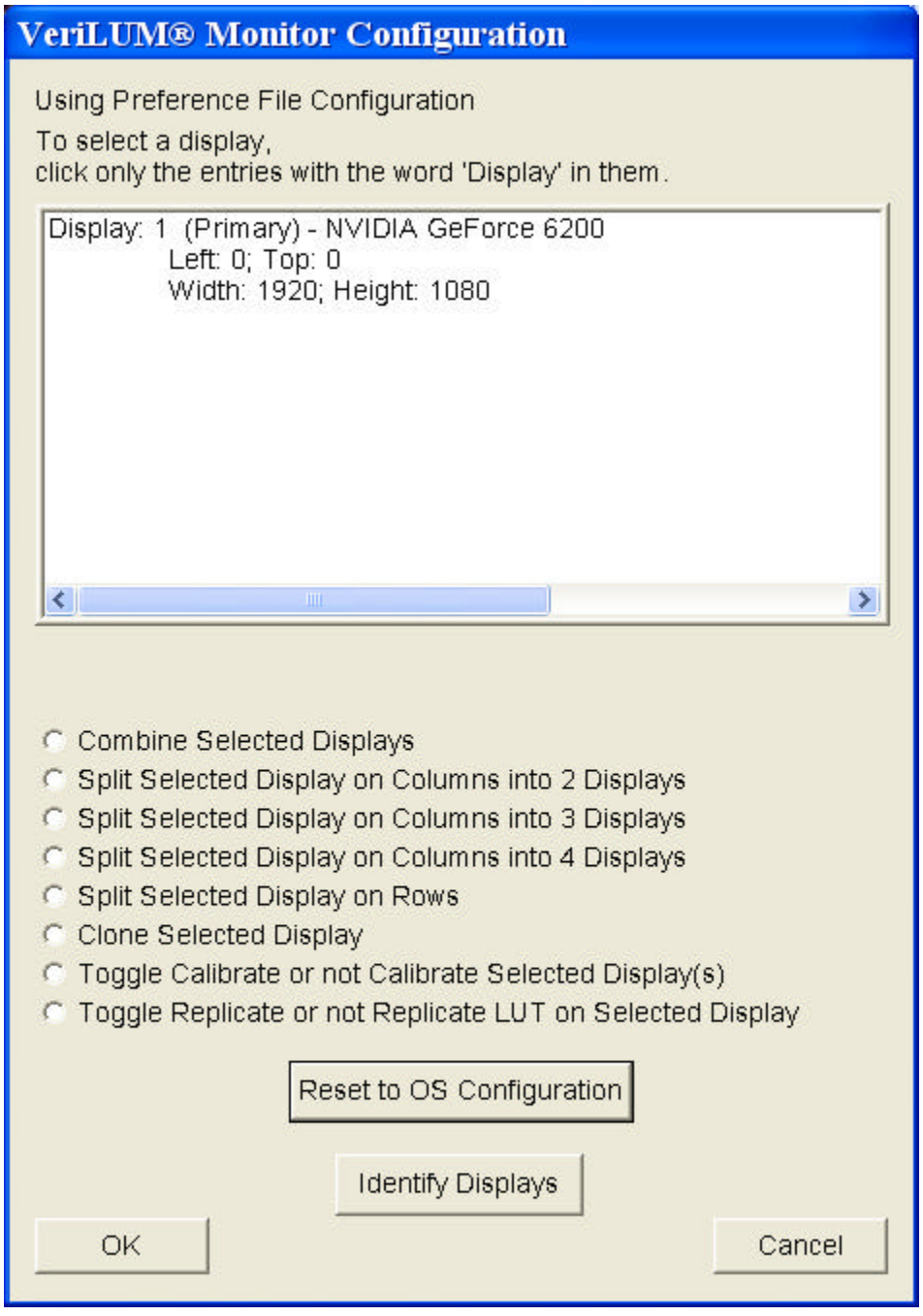


Figure 2B. VeriLUM® Monitor Configuration Screen



2.0 OPERATING VeriLUM®

VeriLUM® addresses three major operational requirements for video display quality assurance: Acceptance Testing; Calibration to a Luminance Response Model; Conformance Tracking.

2.1 USING VeriLUM® FOR ACCEPTANCE TESTING

2.1.1 DISPLAY SMPTE PATTERN

The SMPTE pattern serves a multitude of purposes. For acceptance testing it is useful to help determine whether there is video stability and general geometric and luminance fidelity. Gross distortions such as wavy lines, rectangular areas where square areas are expected, flicker, smearing and so forth should all be rectified before further testing is performed. If problems are observed which are not correctable with information supplied by the video card vendor, video display vendor, or system integrator, then a repair call is warranted.

Click **CONTINUE** to return to the VeriLUM® Main Screen.

2.1.2 DISPLAY VeriLUM® PATTERN

The VeriLUM® pattern also has many uses. For acceptance testing it is used to assess geometric linearity and focus.

Measure the horizontal and vertical diameters of the large circle centered in the display. Adjust the geometry to equalize these diameters. The diameters of the smaller circles in the four corners and the center can also be measured to ensure that the circles do not appear strongly elliptical.

There are five objects used to determine whether the focus is adequate. Each object consists of four squares and each square has alternating white and black lines in a horizontal or vertical direction. The focus objects are in the four corners of the display and in the center. Each object should be inspected to determine whether the video display system is capable of resolving “one on; one off” objects. If the lines are indistinguishable, or wavy, or smeared, then the focus or astigmatism may need to be adjusted. This usually requires trained maintenance personnel with specialized equipment.

Click **CONTINUE** to return to the VeriLUM® Main Screen.

2.1.3 MEASURE BLACK LEVEL and MEASURE WHITE LEVEL

These measurements provide an indication of the minimum and maximum luminance at which the video display system is operating. If a specification for these levels has been

defined by the workstation vendor, then this is a quick way to see whether the video setup was accomplished correctly. If there are multiple displays on a workstation and the black and white levels are quite different among the displays, then it will be very difficult to display an image on the different displays and achieve the same look-and-feel. Use these functions to ensure that the black and white levels are set at about the same value for all the displays.

2.1.4 MEASURE LUMINANCE UNIFORMITY

This function measures the white level in the center and four corners of the display and indicates the percentage deviation of the corner luminance value from the center luminance value. In the absence of some other specification, the percentage deviation should not exceed plus or minus 15%.

The correlated color temperature of the white patches is displayed as well.

2.1.5 MEASURE LUMINANCE

A general luminance measurement function is provided. Place the VeriLUM® pod where you want to measure the luminance. Measurements are made and displayed in one second intervals. Hit the Space Bar on the Keyboard to capture the luminance reading. The reading will be written into a date-time-stamped file, and stored in the folder where VeriLUM® was installed.

This is especially useful when VeriLUM® is being run on a laptop computer and a measurement of the luminance of some external self-luminous light source is desired (for example, a film viewbox).

In addition to the luminance value (Y) the 1931 CIE x- and y-chromaticity values are displayed as well as the 1976 CIE u'- and v'-chromaticity values.

2.1.6 MEASURE COLOR

Some users want to completely characterize a display device by measuring the red, green, blue, and gray at every driving level. A text file containing the measured values is written to the install folder for VeriLUM®. These files can be imported into a spreadsheet or graphing program.

2.2 USING VeriLUM® FOR CALIBRATION TO A LUMINANCE RESPONSE MODEL

Click **MEASURE LUMINANCE RESPONSE FOR GAMMA CORRECTION** and follow the on-screen instructions for placing the luminance pod and measuring the characteristic luminance response of the video display.

When the measurements are completed a gamma correction table is written to a file in the folder in which VeriLUM® was installed. This gamma correction conforms to the model specified in the Configuration Screen dialog box.

The model choices are: DICOM Part 14 Grayscale Standard Display Function; a Gamma Model with specified gamma value; or a User Defined Model specified by a data file. Use a gamma value of 0 to indicate that you want to calibrate and perform conformance checking to the natural gamma of the display.

Note: See section 3.2 for a description of the data file format for specifying a User Defined Model.

The gamma correction lookup table is loaded onto the video board after the table is calculated.

With gamma correction enabled the effect of perceptual linearization (DICOM® Part 14) can be seen immediately by clicking **DISPLAY SMPTE PATTERN** . You should be able to see clearly the 5% square in the 0% surround and the 95% square in the 100% surround. The perceived luminance in the other percentage squares should increase linearly as your eye moves from the 0% square around to the 100% square in a clockwise direction. Do not be confused by the optical illusion at the two 50% squares. The luminance appears to be different only because there is a 40% square to the left of one of the 50% squares and there is a 60% square to the right of the other 50% square.

Press the SPACEBAR to toggle the gamma correction on and off. This is a way to visually demonstrate the effect of the gamma correction.

You can also click **DISPLAY VERILUM PATTERN**. When DICOM® Part 14 perceptual linearization has been applied you can see clearly the complete content of this pattern. There are squares of increasing luminance arrayed left to right across the display. There are also smaller squares within these squares and the pixel values of these smaller squares are obtained by adding and subtracting from the pixel value of the surrounding square an amount equal to one percent of the grayscale range. Again, press the SPACEBAR to toggle the gamma correction on and off.

The purpose of the VeriLUM® pattern is to see whether a one percent change in driving level is visible across the whole range of pixel values in an image. You can judge visually whether the DICOM Part 14 objective has been met. That is, whether equal changes in driving level produce equal changes in perceived luminance over the whole range of driving levels.

When a model other than the DICOM® Part 14 Grayscale Standard Display Function is used, the features of the VeriLUM® and SMPTE patterns that are visualized are model dependent.

If the perceptual linearization effect is not as strong visually as you expected it to be or is too strong (as judged by the visibility of the 5% square in the 0% surround of the SMPTE pattern), then click **CHANGE CONFIGURATION** and enter a different value for the Ambient Light Adjustment Value. The default value is 1.5 cd/m^2. Increase this value if the workstation is located in a room with brighter ambient light (adjustment values as high as 2.5 cd/m^2 are sometimes needed). Decrease this value if the workstation is located in a room with very low ambient light. Gamma correction must be re-done after a change is made in the Ambient Light Adjustment Value.

Click **DISPLAY USER PATTERNS** to see the effect of the gamma correction on your favorite bitmap or DICOM images. Use the SPACEBAR to toggle on and off the gamma correction lookup table. You display bitmap images by selecting the file type BMP and you display DICOM files by selecting the file type DCM.

Click **ENABLE GAMMA CORRECTION** to have the gamma correction table loaded then and at system startup and when each user logs onto the system.

Click **DISABLE GAMMA CORRECTION** to have a linear ramp loaded into the gamma correction table then and at system startup. This means that the "natural gamma" of the display will be operable instead of a luminance response model gamma correction.

2.3 USING VeriLUM® FOR CONFORMANCE TRACKING

Click **MEASURE LUMINANCE RESPONSE FOR TRACKING** and follow the on-screen instructions to perform luminance measurements and compute and display the VeriLUM® Display Index, Effective Ambient Offset, White Level, Black Level, Correlated Color Temperature, and the luminance and chromaticity values for the Red, Green, and Blue primaries.

A display window presents the current and prior values of these parameters. Click **PRINT** to print the results on the default Windows printer. Click **HISTORY PLOT** to display all of the tracking results since the last calibration. Click **JND PLOT** to display a graph of the JNDs per luminance interval calculated from the tracking luminance measurements. A determination is made as to how well the individual values of the JNDs per luminance interval correlate with the expected JNDs per luminance interval. A rating of Excellent, Good, Fair, or Poor is assigned. Click **OK** to return to the VeriLUM Main Screen.

The VeriLUM® Display Index and the Effective Ambient Light parameter have the following interpretations:

> The Display Index is a number between 01 and 10. The closer the Display Index is to 01 the closer the video display system is to matching the luminance model specified in the Configuration Screen.

The Effective Ambient Light indicates the offset that gave the best estimate of the Display Index.

In all cases the Display Index, Effective Ambient Light, White Level, and Black Level are tracked over time and a significant change in any one of these parameters serves as a warning that something has changed in the video display system and investigation is warranted.

For example, if the Display Index varies by 02 or more index points over time then some significant change has occurred. Of course the cause may be simply that some user has altered the brightness or contrast settings for the display. Before calling for repair of the display a new calibration should be performed, including setting the black level and the white level, and the SMPTE and VeriLUM® patterns should be displayed and visually inspected.

3 TECHNICAL NOTES

3.1 LUMINANCE MEASURING DEVICE SPECIFICATIONS

The VeriLUM® photometer is manufactured and calibrated by Xrite, Inc. and is quality controlled by IMAGE Smiths, Inc.

Calibration: Traceable to a National Institute of Standards and Technology (NIST) source.

Accuracy: Luminance +/- 2%; Chroma: +/- 0.004

Repeatability: Luminance +/- 1%; Chroma +/- 0.002

Luminance Range: 0.05 - 1000 cd/m^2

3.2 USER DEFINED LUMINANCE MODEL DATA FILE FORMAT

The User Defined Model data file consists of an ASCII text file with the number N of data points indicated on line 1. The next N lines contain X and Y data values separated by a comma. The X and Y values are normalized and both are between 0.0 and 1.0. Two sample files are included to illustrate the format.

The file GAMMA_195.MOD contains 65 data points representing a normalized model for the luminance response Y = X**1.95. The X value ranges from 0.0 to 1.0 in increments of 1/64. The Y values are computed at the 65 X values and range from 0.0 to 1.0. The model is used by multiplying Y by the difference between the maximum and minimum luminance measurements and then adding the minimum luminance level.

The file EXPONENTIAL_250.MOD contains 65 data points representing a normalized model for luminance response given by Y = (exp(2.5X) – 1.0) / (exp(2.5) – 1.0).