

Procedure for Verifying Lighting System Calibration at The New York Times Headquarter Building

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Scope:

This memorandum presents a procedure for verifying that the lighting controls manufacturer has properly calibrated the response of control system for the overhead lighting at the NY Times building. Proper calibration of the lighting control system in this building means adjusting the output of the overhead lighting system so that the following criteria are satisfied:

- 1) The average illuminance over a representative portion of the workstation task surface is at least 90% of the target design level (450 lux is 90% of the target 500 lux level¹) *and*
- 2) The overhead lights in the vicinity of the workstation are *significantly dimmed* (or OFF) if the average illuminance is $> 125\%$ (650 lux) of the target level.

Equipment Needed:

1. Lutron commissioning cart with Cambell Scientific data acquisition system and laptop computer (Figure 1)
2. Portable illuminance meter in current calibration
3. Digital camera with wide-angle lens (fisheye preferable)
4. Tripod
5. Measuring tape
6. Optional: Luminance meter (1 degree field-of-view recommended)



Figure 1. Photometric measurement apparatus for measuring and recording the average illuminance at the work surface. The Campbell Scientific data acquisition system and laptop are shown on cart in the background.

¹ The target light level for this project is 500 lux unless specified otherwise.

Conditions Required for Verification

1. Shades installed, addressed and communicating with the headend system
2. Shade sensors installed, addressed and communicating with the headend system
3. Solar tracking working
4. Brightness mode enabled and verified
5. Dimmable light fixtures installed and addressed
6. Daylight configuration zones established or calibrated
7. Furniture system installed

Procedure

With shading system in automatic mode:

1. The commissioning agent shall use Lutron's lighting commissioning cart to measure the average illuminance at the workstation surface. The commissioning cart takes a 3 x 3 (9-points) workplane illuminance measurement using a square gig that is 13 in. (0.3 m) on a side.
2. The commissioning agent will set the gig at the primary task location to measure the average illuminance for each verified workstation. Nearby obstructions to workplane illuminance will be temporarily removed to allow unobstructed measurement of the workplane illuminance.
3. The commissioning agent shall set the data acquisition system to record the 9 illuminance measurements once a minute for no less than 10 minutes per workstation.
4. The exact locations of the 9 illuminance measurements (i.e. the gig) relative to the furniture system (and the luminous environment at time of measurement) will be photographically documented using the tripod-mounted digital camera.
5. The commissioning agent will *visually note* whether the overhead lighting in the vicinity is visibly dimmed or OFF. A handheld luminance meter may be used to determine this².
6. If the commissioning agent is unable to determine whether the overhead lighting is dimmed, it may be necessary to reset the setpoint level for the local daylight configuration zone to a lower value (say 350 lux) and re-measure.

Shading System Override

With the local shade overridden, repeat the above six steps. If the shading system auto mode has the local shade deployed, then entirely retracting the shades will constitute overriding the shade controls. If the shading system auto mode has the local shade retracted, then the commissioning agent shall override the shade to a "reasonable" setting based on the commissioning agent's best judgement.

Initial Sampling

For the first floor to be verified, it is recommended that the floor be densely sampled (25 – 35% of the total workstation locations). An initial analysis of the verification data from

² LBNL is measuring the brightness of the fixture used at NY Times to determine the utility of using a luminance meter to determine unambiguously whether the light is dimmed or not and to what level.

this floor will allow more intelligent sampling for the rest of the floors of the building. For example, it may be possible to verify once every other floor rather than every floor, reducing the verification time by 50%.

Verification Sampling Density

Using the above technique, we believe it is practical for the commissioning agent to verify correct system performance at approximately 10 - 25% of the total number of workstations.

Database Considerations

The verification team should record all measured data and observations about local conditions at time of verification using the same data collection system currently used by Lutron to calibrate the lighting system.

The spatial coordinates of all measurements should be recorded using a convenient local coordinate system (some combination of workstation location or room number).

Analysis of Data

When analyzing the data to determine which workstation locations pass or fail the performance criteria, it may be desirable to determine average workplane illuminance using a truncated set of data. For example, if an unobstructed workplane illuminance measurement is not practical, it may be appropriate to throw out one or two “outlier” illuminance points. Determining whether or not it is appropriate to discard some points in calculating the average illuminance will be easier after the first floor is verified and the initial data inspected.

Verification of Lighting System Commissioning with High Dynamic Range Photographs

LBNL is tasked with developing the procedure for verifying that Lutron has properly commissioned the lighting control system. Proper commissioning of the lighting control system in this building means satisfying the following criteria:

- 3) that the illuminance at the task surface is at least 90% of the target design level (450 lux is 90% of the target 500 lux level) and
- 4) that the overhead lights are significantly dimmed (or OFF) if the illuminance is 125% (650 lux) of the target level.

LBNL proposed a verification procedure to the NY Times staff that consists of using Lutron's lighting commissioning cart to measure the task surface illuminances at 20-25% of the total number of workstation locations on each floor. To satisfy the second criterion above, LBNL proposed visually noting whether the overhead lighting was dimmed or not. Finally, LBNL proposed using a standard camera to document the location of the commissioning cart photometric grid relative to the furniture in each workstation. Previous work has demonstrated the value of photographically recording the location of photometric measurement apparatus because it greatly simplifies re-verification and provides a photographic archive that is extremely useful for re-commissioning.

NY Times staff suggested the following revision to the above process. NYT was concerned that the lighting system be able to satisfy these criteria even if the local roller shades were overridden by the occupants. It was originally envisioned that verification of the lighting control system performance would take place after the roller shade system was properly commissioned and operating in automatic mode. Verifying lighting system performance additionally when the roller shade system is overridden (there could be more than one override condition) requires additional measurements using the commissioning cart, which could significantly increase the verification time per workstation. Furthermore, recording the measurements becomes messier since there could be several "scenes" for each workstation location and it would be important note by hand all the various conditions.

Effort was spent testing whether the latest HDR imaging setup with the Canon 5D could be used in place of the standard photographic documentation originally proposed for verification. To test out our system in a physically constrained environment with multiple sources of light, we used a 6 x 8 office that one of our researchers work in. As seen in the attached images, there were several sources of lighting:

1. Ambient only (some stray daylight through clerestory)
2. With table lamp dimmed to an arbitrary level (this simulates daylight from a window)
3. With overhead light on (full) and table lamp at same setting as (2).
4. With overhead light on (full) and table lamp on at a different setting.

With this simple setup we could permute the lighting over various conditions roughly corresponding to those expected at the NY Times verification. For example, (3) and (4)

above could represent the lighting control system response to the roller shades in auto mode or overridden.

The following images show the same four HDR images processed through Photosphere to extract luminance of 1) the whole image, 2) the keyboard only and 3) the computer screen only. The graph shows all these luminance statistics for each of the lighting conditions. Note that this is a very useful way to compare lighting conditions. The keyboard luminance under the condition (3) is 67.8 while the keyboard luminance under (4) is 89.5. This would allow the verifier to quantify in detail the difference in photometric distribution as a result of, for example, overridden roller shades.



Figure 1. Four HDR images of workstation under four lighting conditions:
Top Left: Ambient light only
Top Right: Plus table lamp (uplight and downlight)
Bottom Left: Overhead light plus table lamp (uplight and downlight)
Bottom Right: Overhead light plus table lamp (uplight only)

These are screen captures taken from Photosphere with the luminance of the whole image selected and measured.

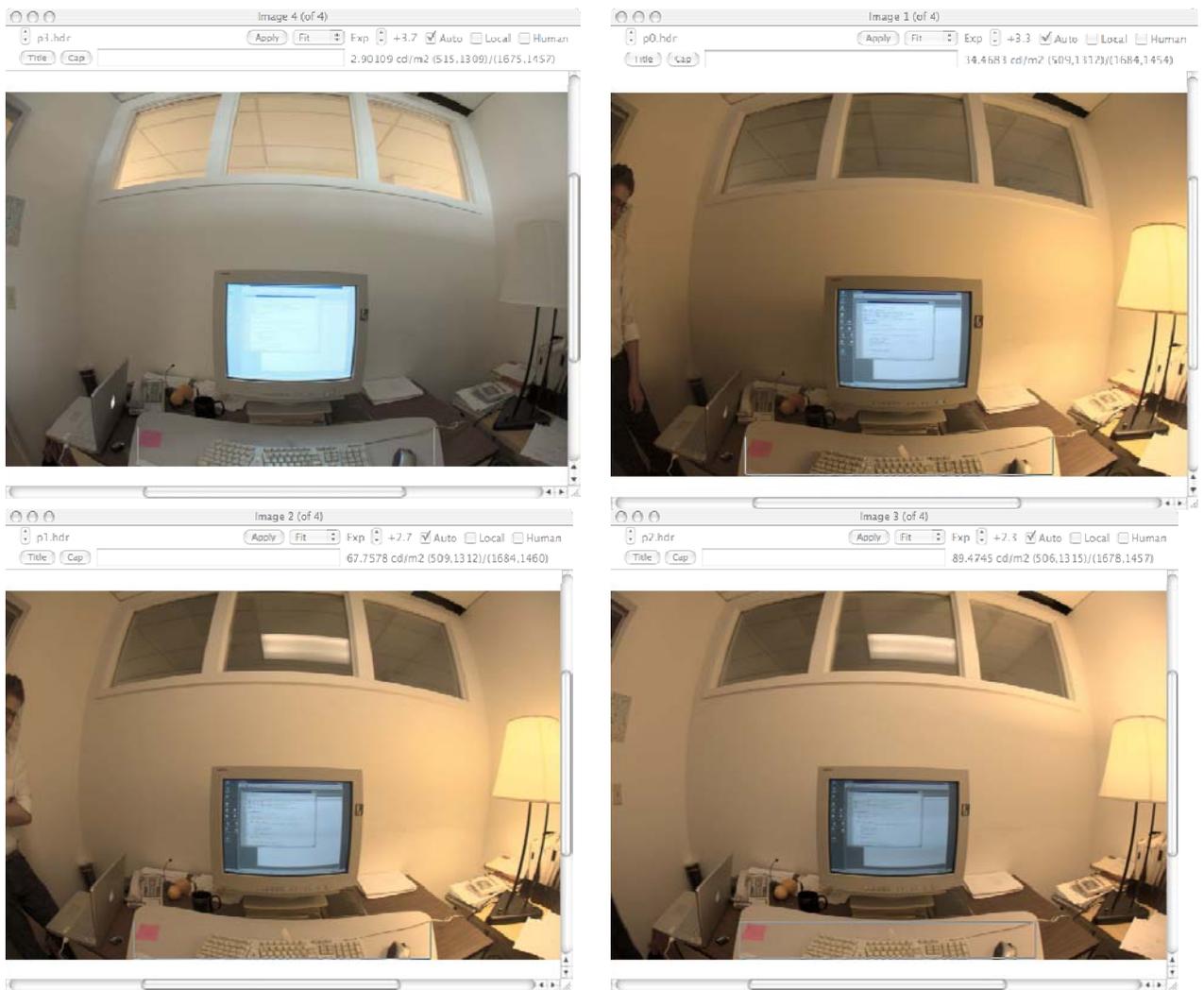


Figure 2. Four HDR images of workstation under four lighting conditions:

Top Left: Ambient light only

Top Right: Plus table lamp (uplight and downlight)

Bottom Left: Overhead light plus table lamp (uplight and downlight)

Bottom Right: Overhead light plus table lamp (uplight only)

These are screen captures taken from Photosphere with the luminance of the keyboard selected and measured.



Figure 3. Four HDR images of workstation under four lighting conditions:
 Top Left: Ambient light only
 Top Right: Plus table lamp (uplight and downlight)
 Bottom Left: Overhead light plus table lamp (uplight and downlight)
 Bottom Right: Overhead light plus table lamp (uplight only)

These are screen captures taken from Photosphere with the luminance of the computer screen selected and measured.

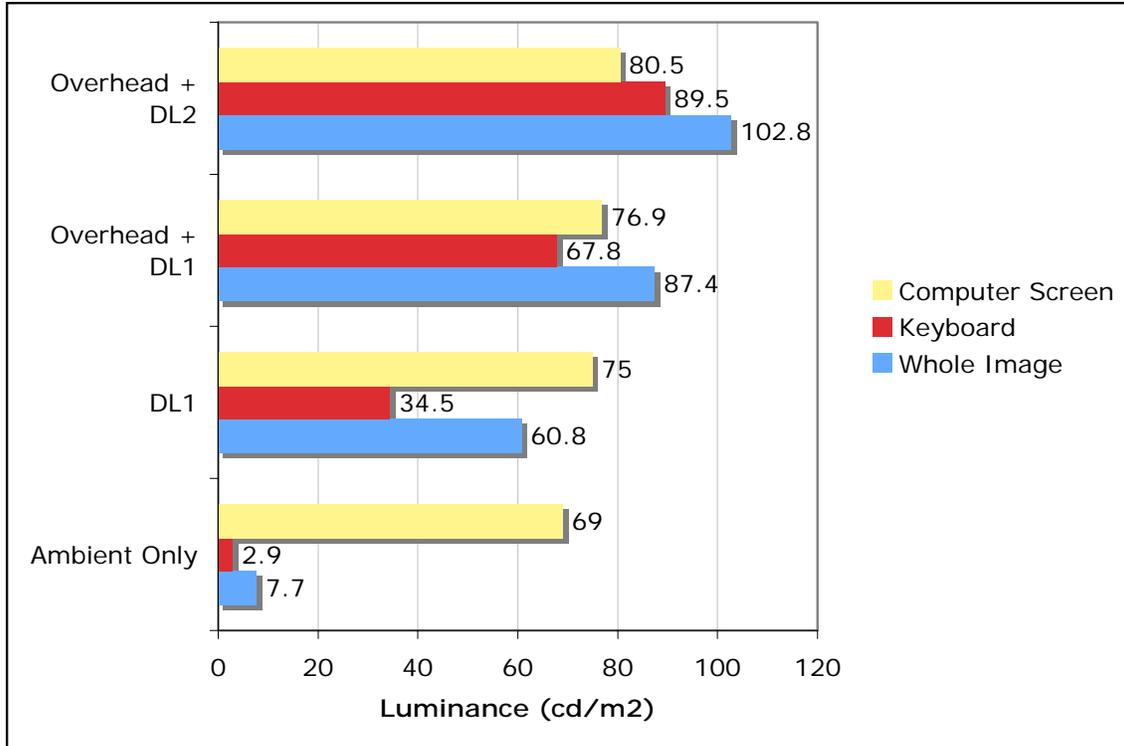


Figure 4. Luminance of the 1) computer screen only, 2) keyboard only and 3) whole image for each of the four lighting scenes measured. Notice that this allows quantification of particular luminances of interest.

To complete the verification process while meeting NY Times needs, we propose that the verification team using HDR imaging simultaneously with the Lutron commissioning cart when performing all verification measurements. The HDR viewpoint would be set to the occupant’s preferred viewing direction with the photometric grid of the commissioning cart entirely in the field-of-view. [Conceptually, imagine replacing the keyboard luminance that we actually measured with a hypothetical luminance capture that includes the commissioning grid itself]. The additional time required to make HDR measurements instead of the originally suggested standard photographs is not significantly longer especially since the commissioning cart will be set to record minute-by-minute data for about 15 minutes per workstation anyway. By being efficient in how the verification process is done, higher quality data can be collected without a significant increase in verification time.