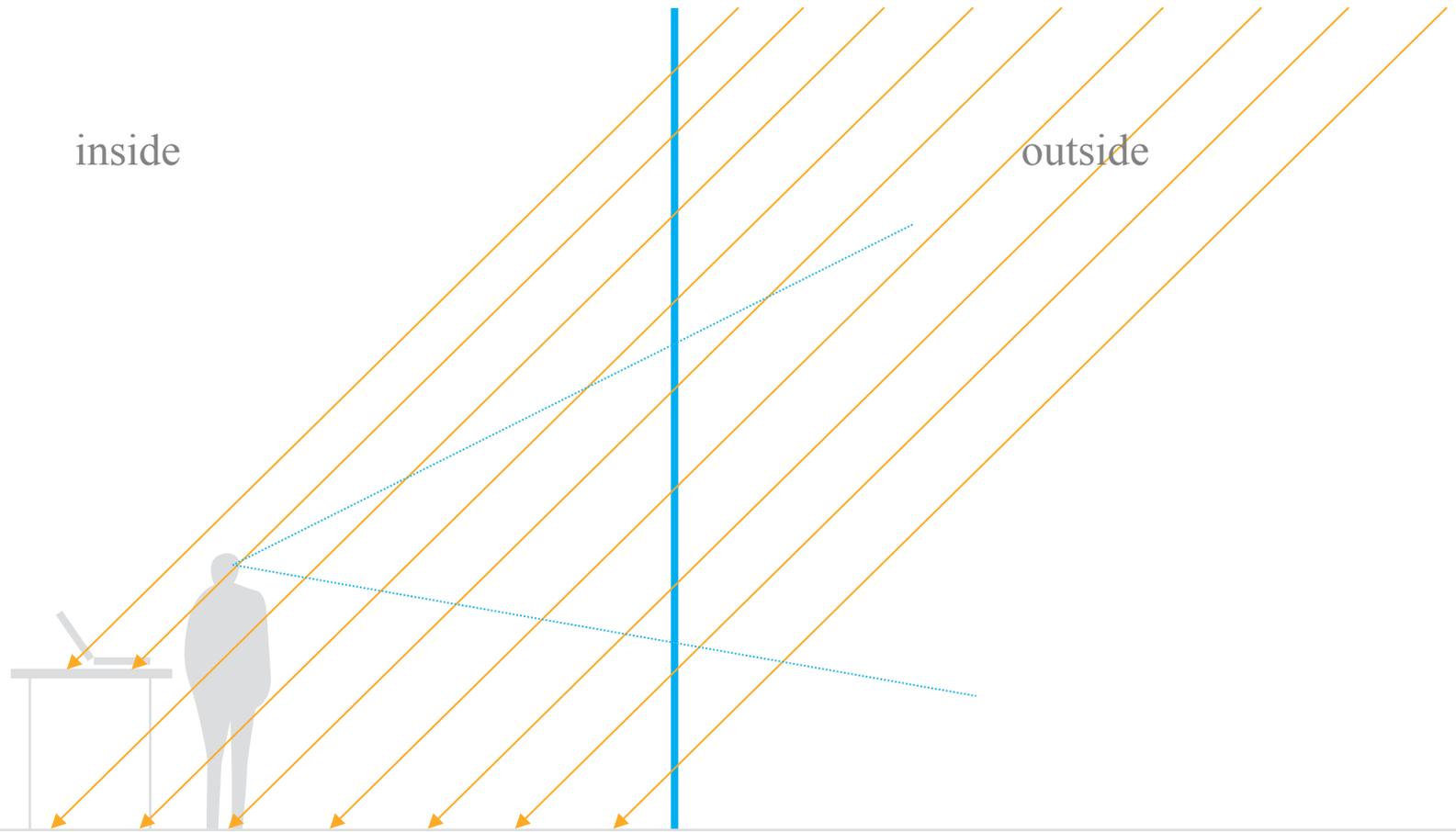


Investigating Daylight Reflections in the Built Environment

2017 International Radiance Conference
Galen Burrell

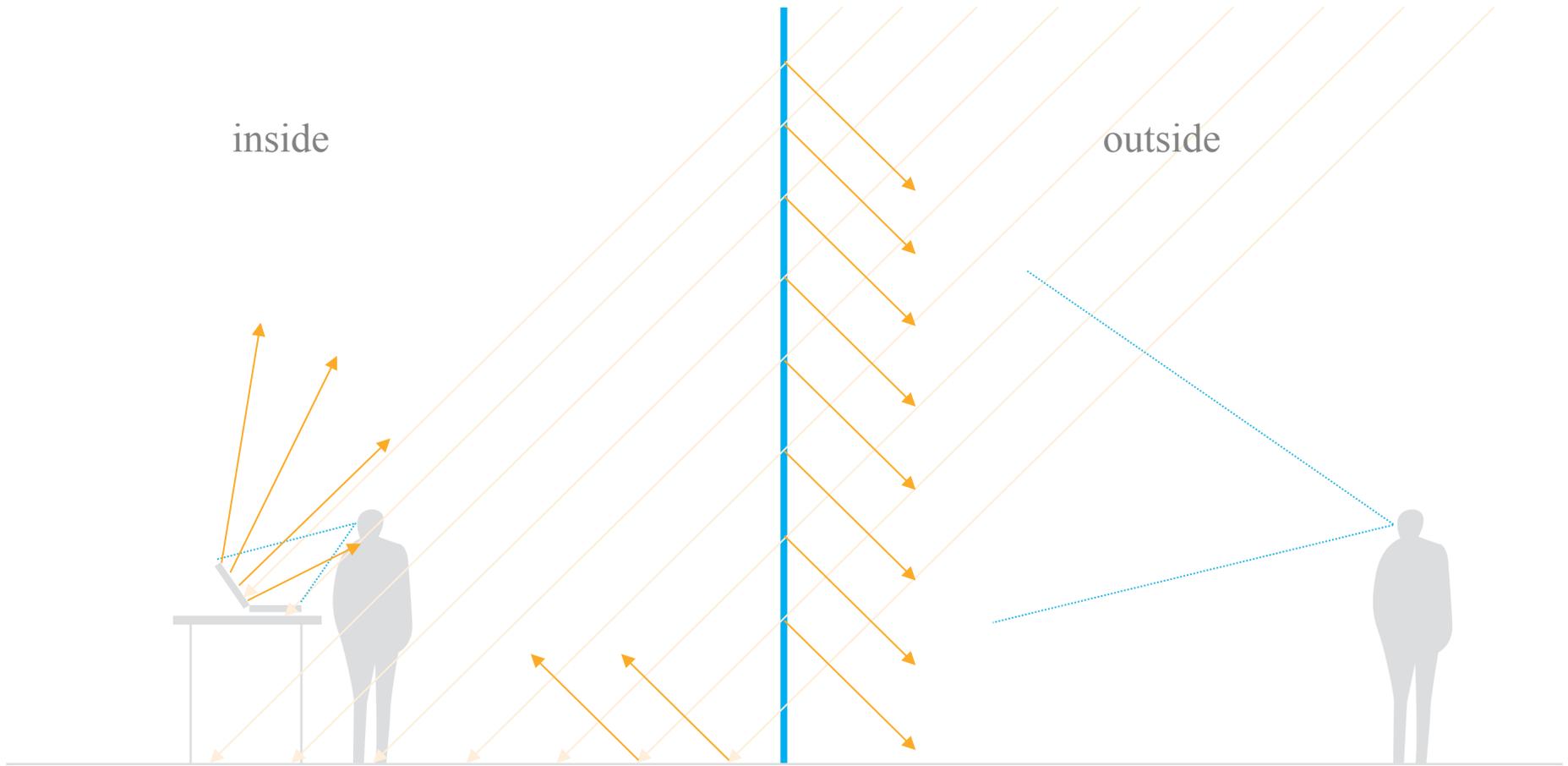
inside

outside



inside

outside



Sorry, not that kind
of reflections!



Outside...

CLEAR GLASS IGU

VLT = 79%

Rest = 14%

VNEI-63 IGU

VLT = 62%

Rest = 11%

LE54-GREEN IGU

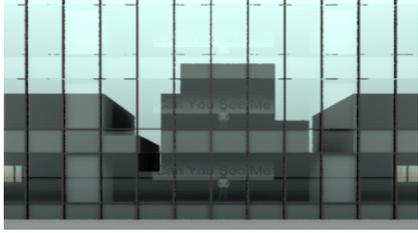
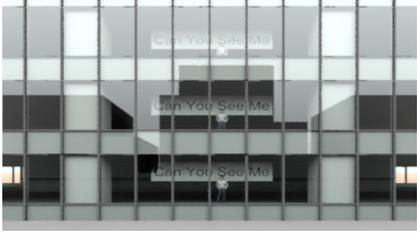
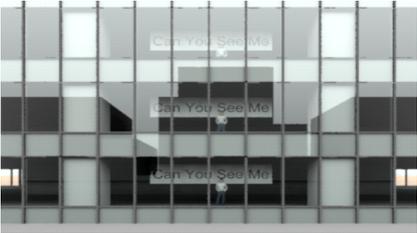
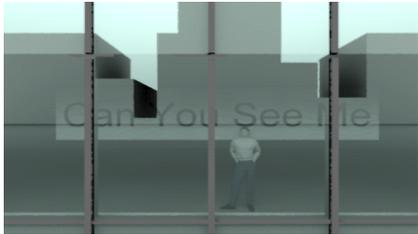
VLT = 42%

Rest = 8%

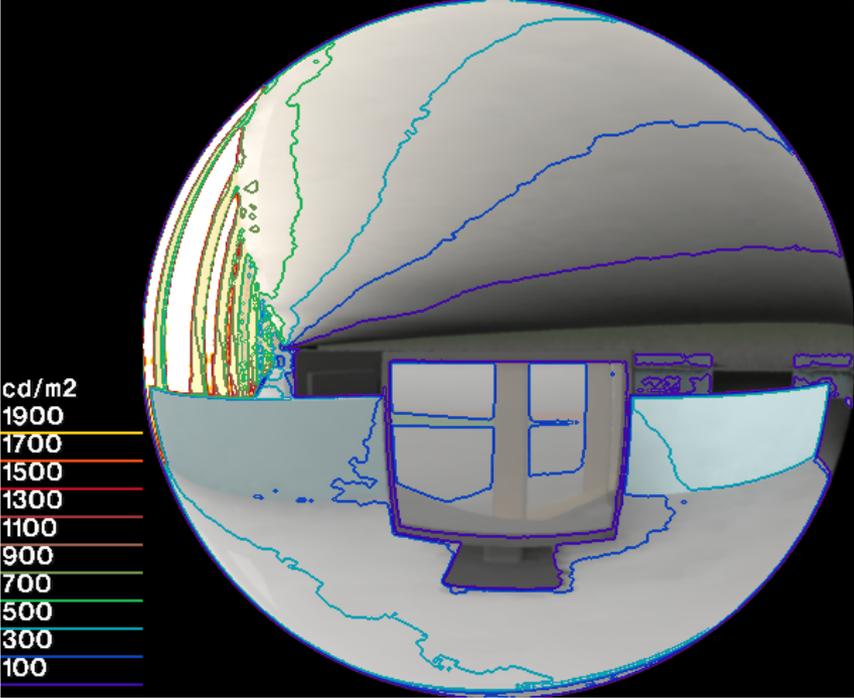
PPG-SB80 IGU

VLT = 47%

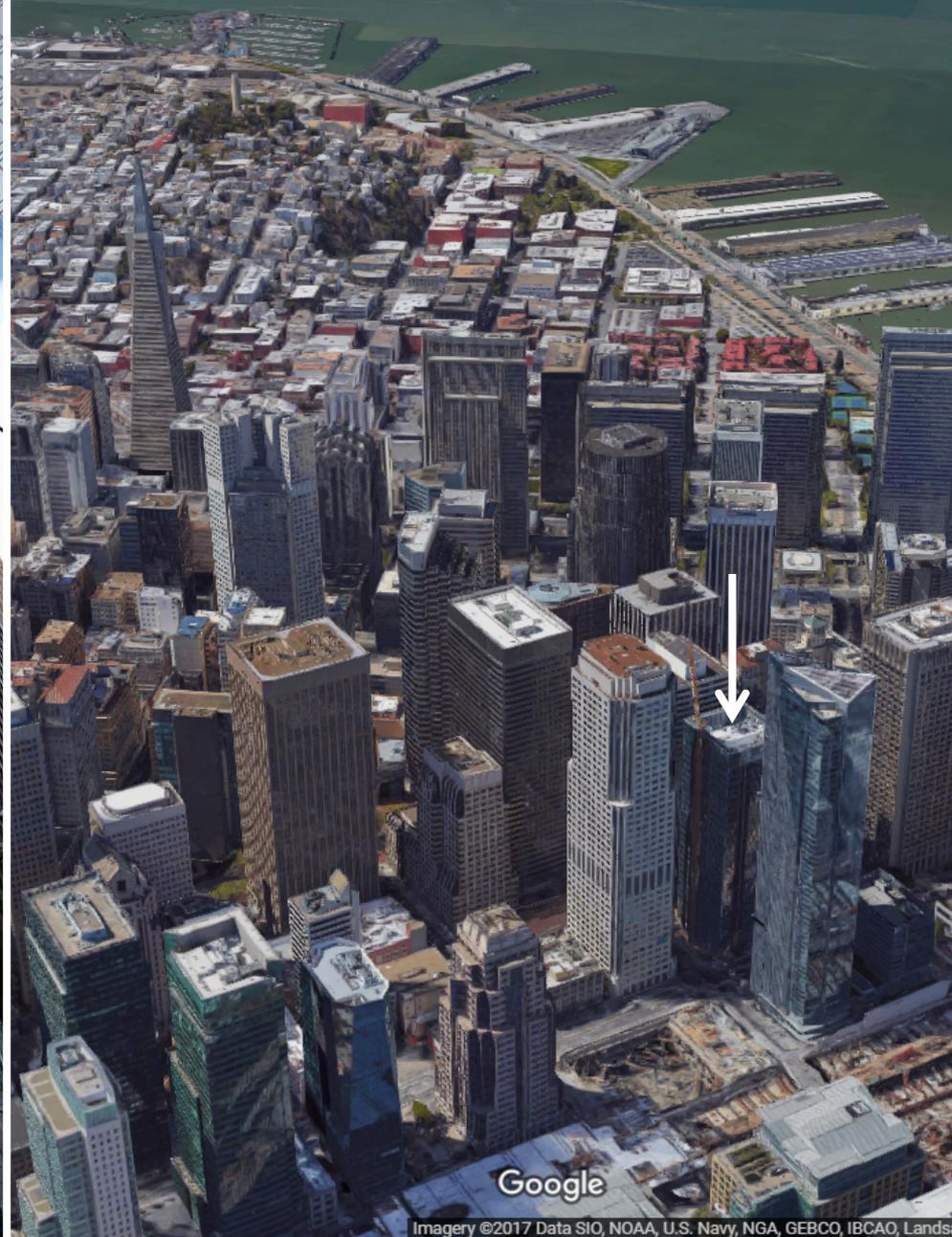
Rest = 33%



Inside...



Case Study #1:
350 Mission Street, San Francisco



Imagery ©2017 Data SIO, NOAA, U.S. Navy, NGA, GEBCO, IBCAO, Lands





Layers of Light







Three View Points



Corner



Millenium



Transbay

Three types of content



Ove Arup
(Greyscale)



Degas
(Low contrast color)



Kandinsky
(High contrast color)

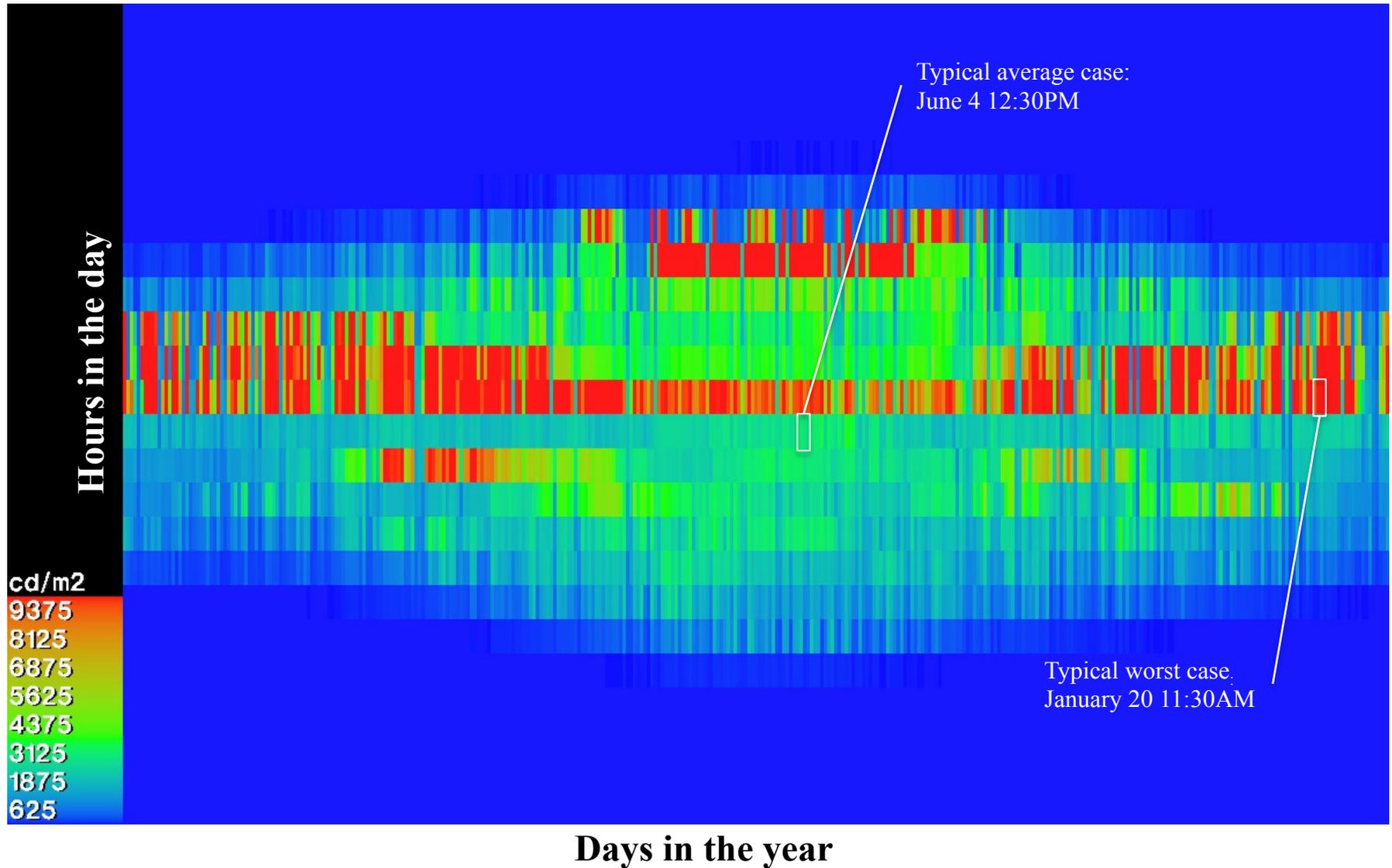
Three levels of screen brightness

1500 cd/m²

2500 cd/m²

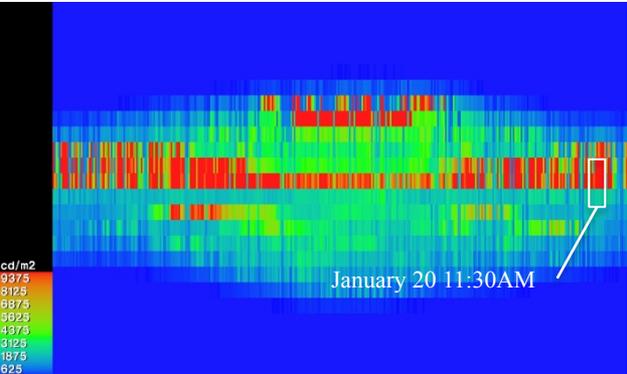
5000 cd/m²

Veiling Luminance - Annual Simulation

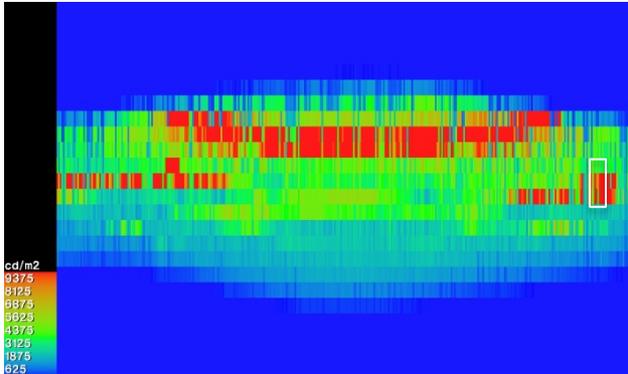


Typical Worst Case

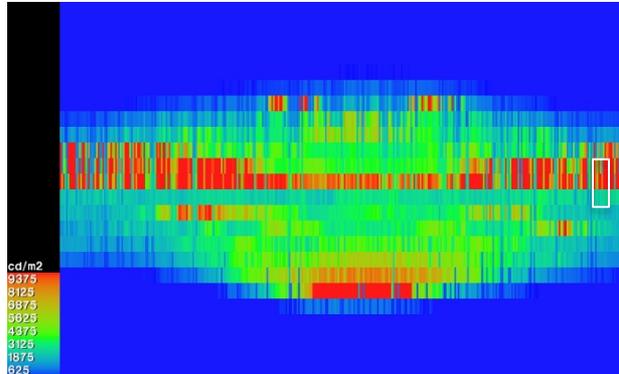
January 20, 11:30AM



Corner



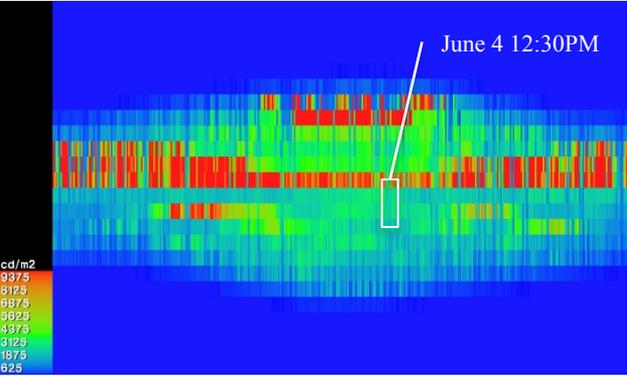
Millenium



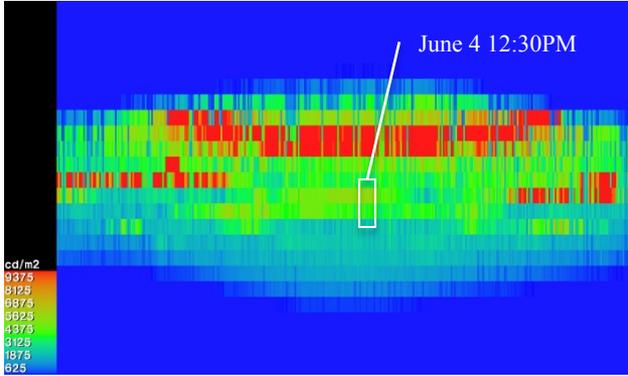
Transbay

Typical Average Case

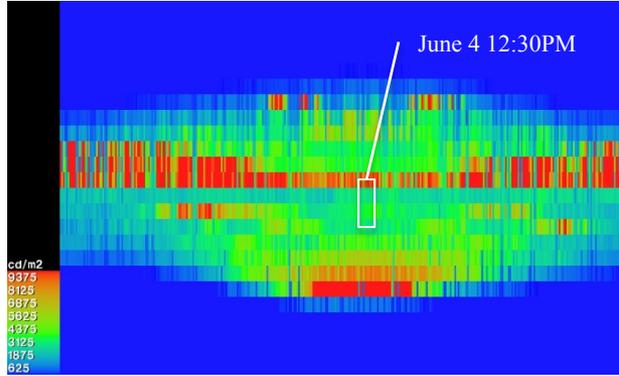
June 4, 12:30PM



Corner



Millenium



Transbay

Visualizations – Worst Case

January 20, 11:30AM



Date/
Time

Media Screen
Brightness

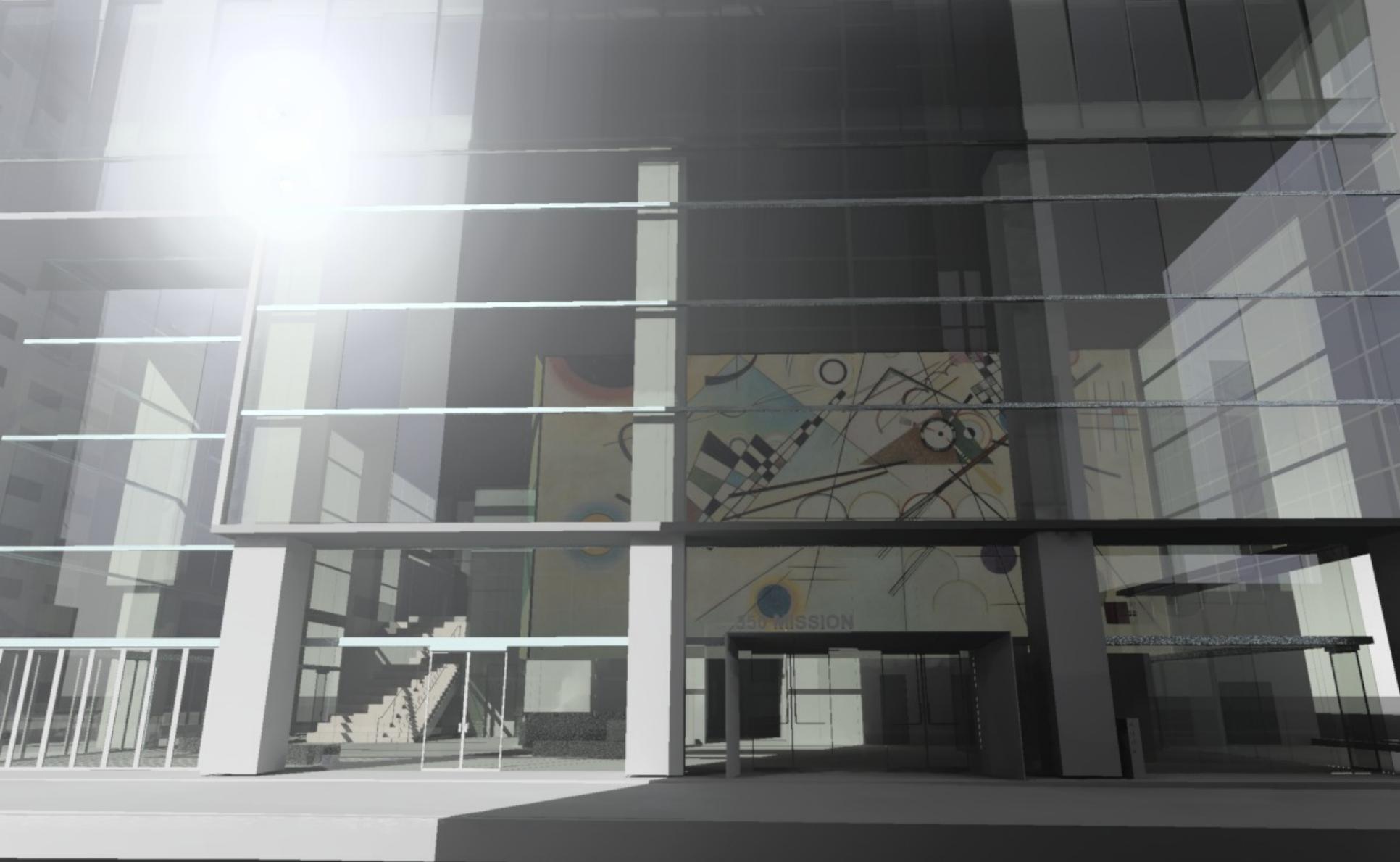


































Visualizations – Average Case

June 4, 12:30PM













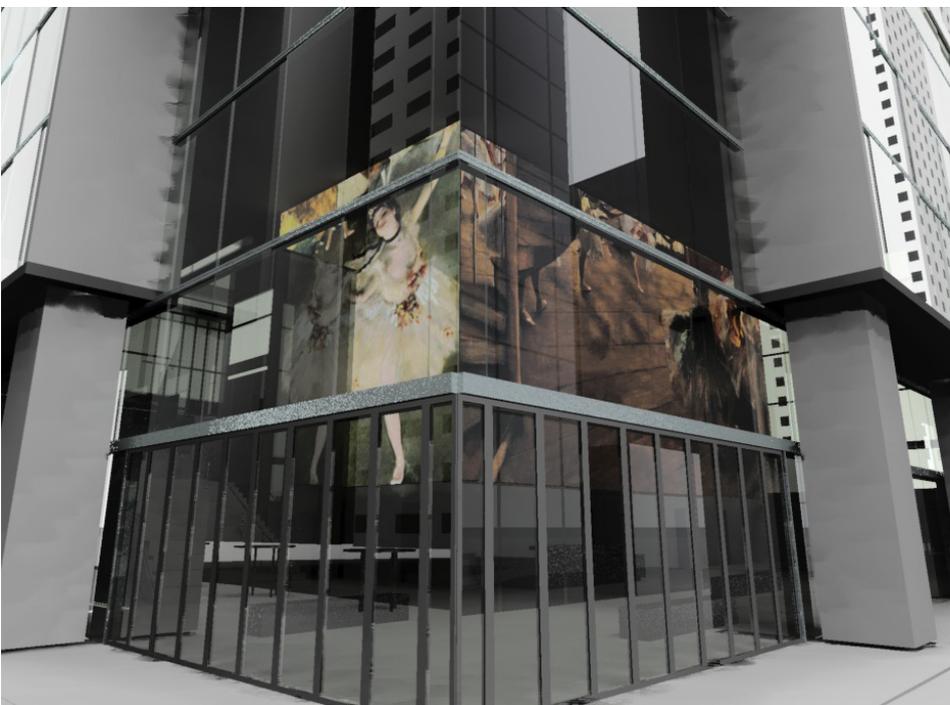




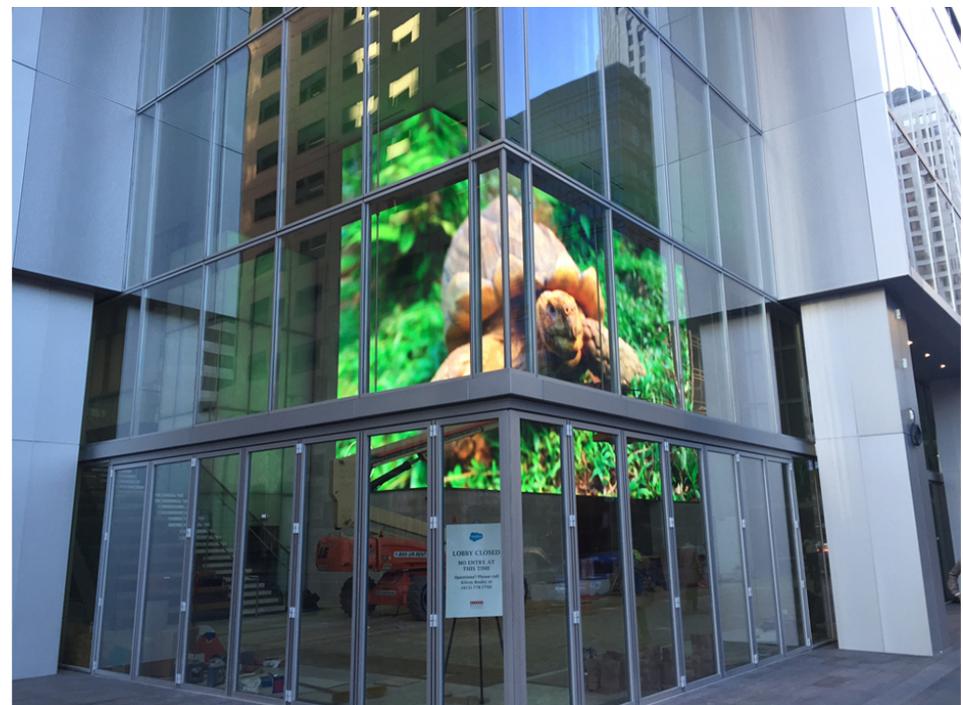


Conclusions

- Veiling reflection analysis indicates that views of the media screen through the façade may be challenged on the order of 2 hours per day.
- Under average conditions, the lowest screen brightness was judged to be sufficient by the Client and design team.
- Under worst case conditions, visibility for all but the highest brightest (5000 cd/m²) screen were challenged by veiling reflections.
- The Client selected the lowest brightness screen given their priority to achieve the best visual performance *inside* the building, with exterior visibility being secondary.



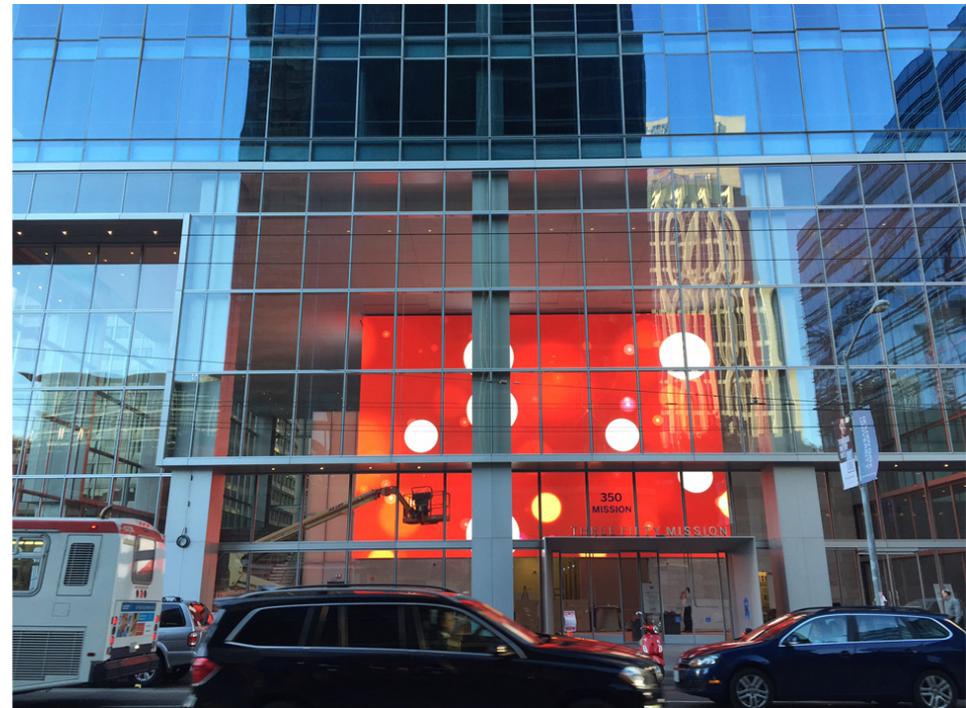
Radiance



Photograph



Radiance

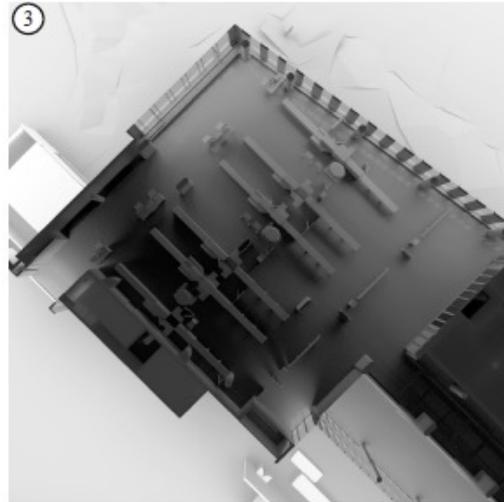


Photograph

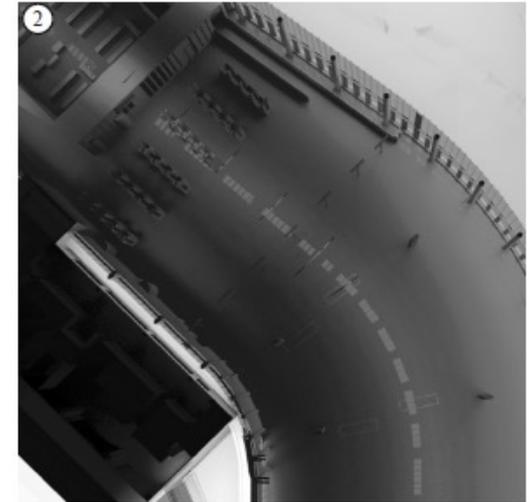
Case Study #2:
SeaTac International Arrivals Facility



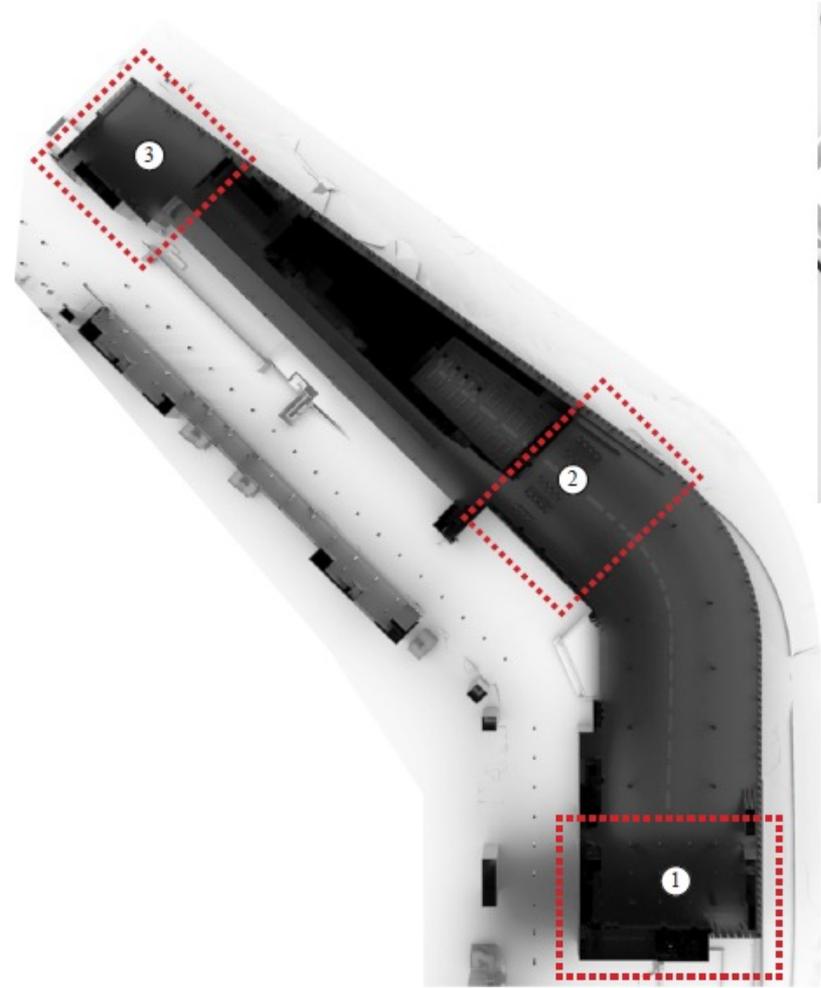
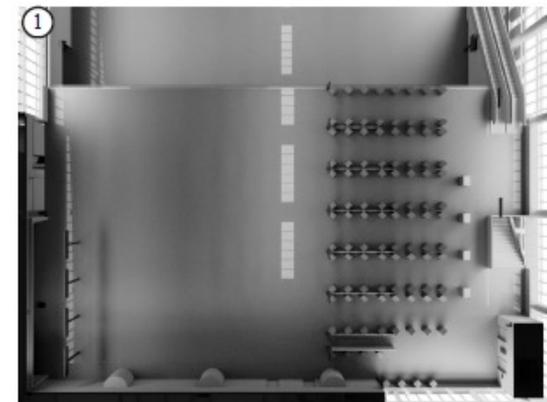
Location 3: Security Recheck

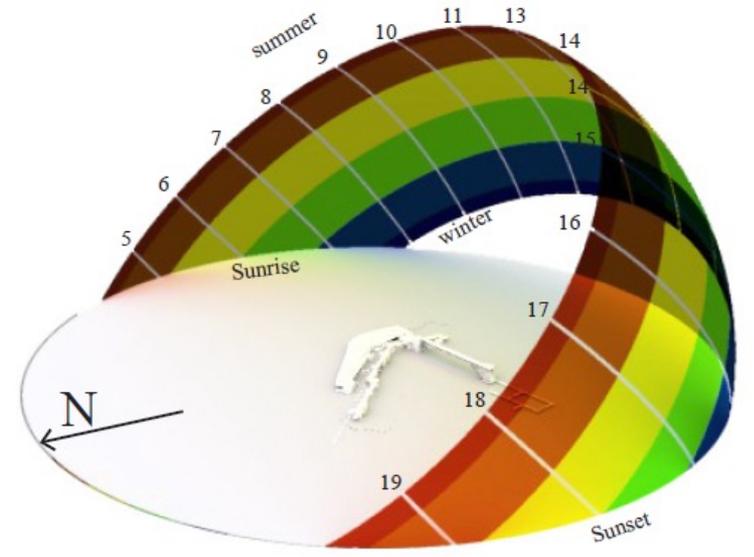
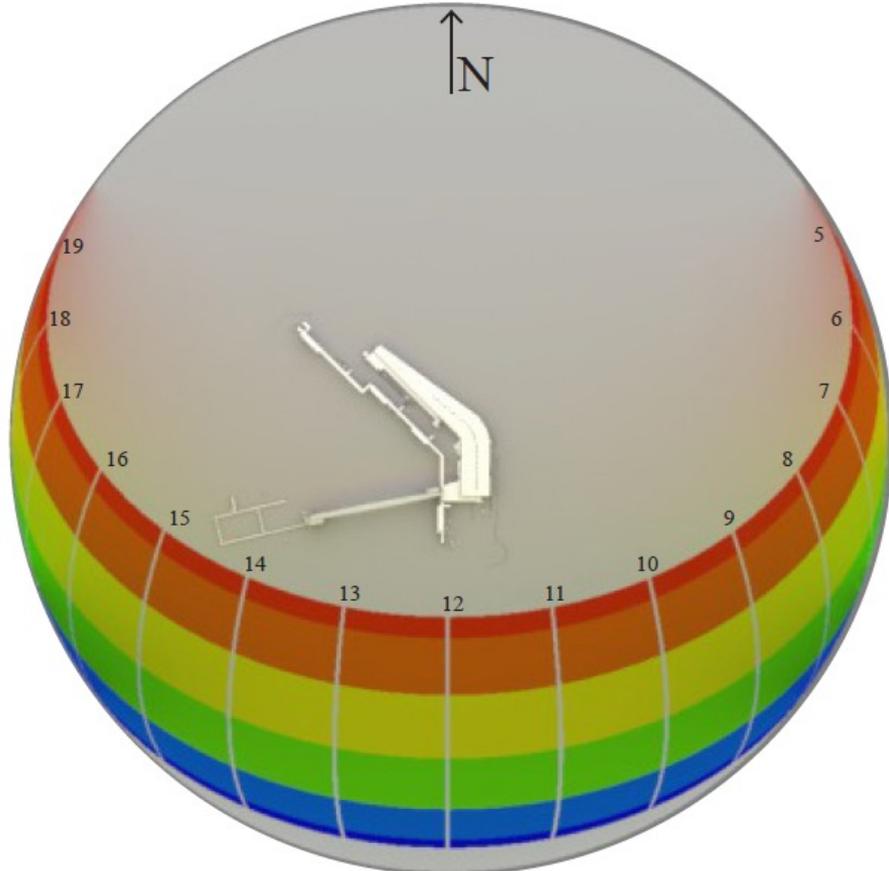


Location 2: Triage



Location 1: Automated Passport Control (APC)





June Sunpath

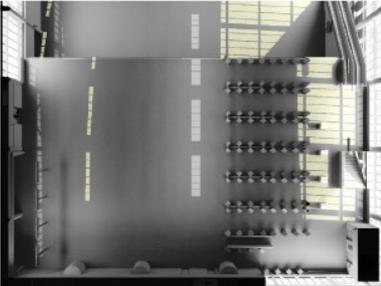
Note: All times listed assume local solar time. Daylight savings time has not been accounted for, so 1 hour should be added to march/september and summer times.



7:00 AM



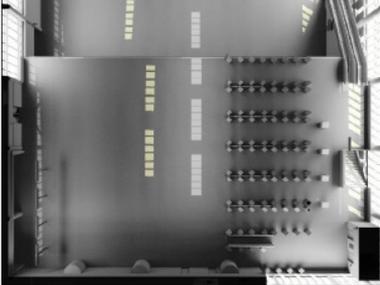
8:00 AM



9:00 AM



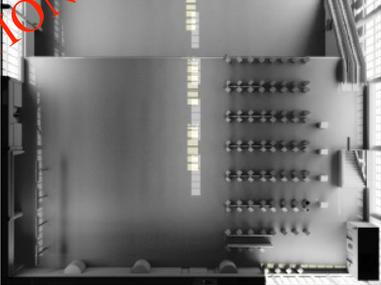
10:00 AM



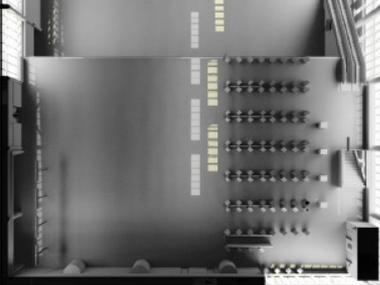
11:00 AM



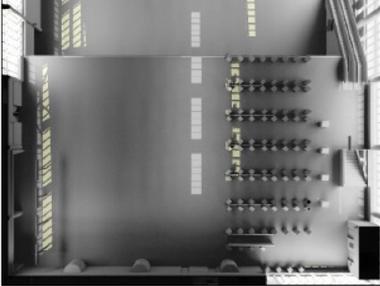
12:00 PM



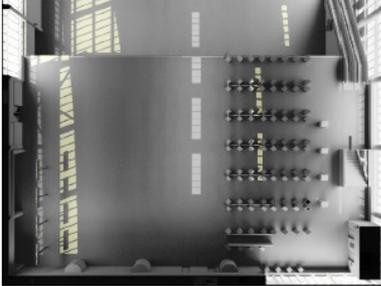
1:00 PM



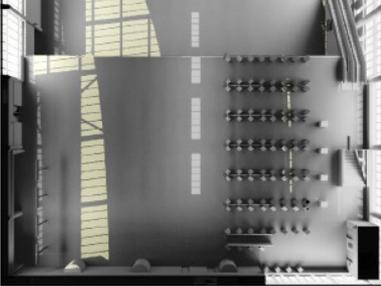
2:00 PM



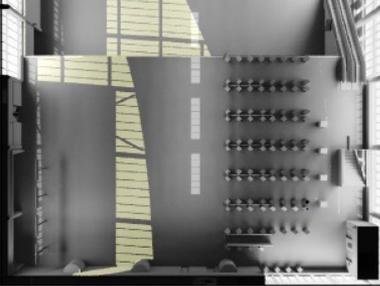
3:00 PM



4:00 PM



5:00 PM



6:00 PM

ANIMATION

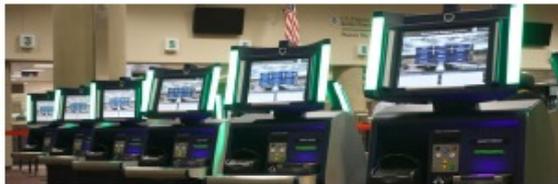
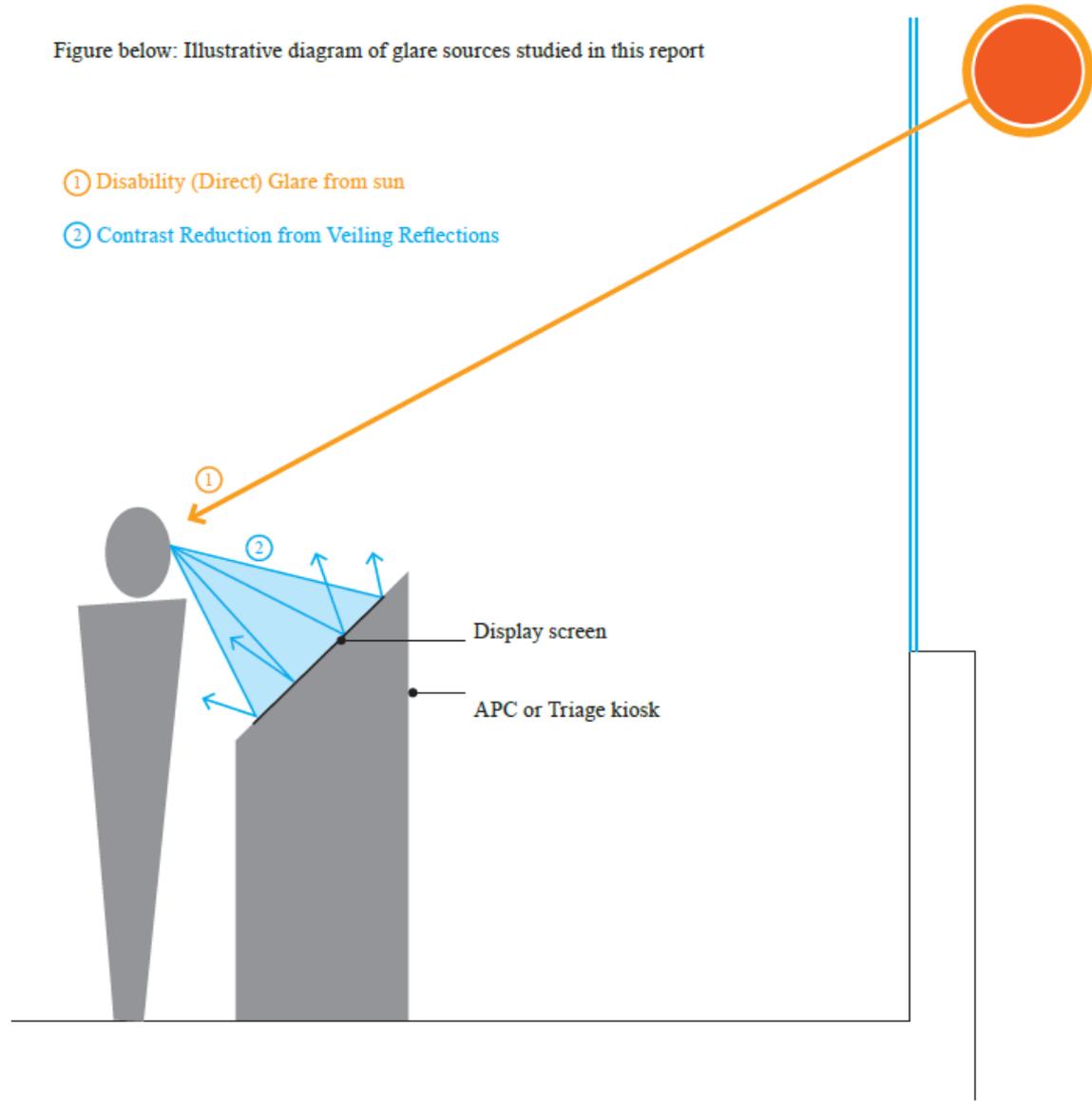
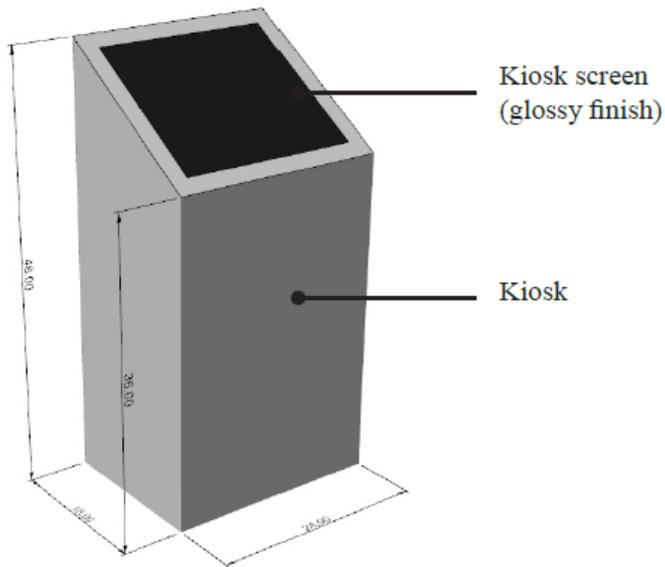


Figure below: Illustrative diagram of glare sources studied in this report

- ① Disability (Direct) Glare from sun
- ② Contrast Reduction from Veiling Reflections



Monitor Contrast

Monitor Contrast = $L_{\downarrow \text{white pixel}} / L_{\downarrow \text{black pixel}}$

Apparent Monitor Contrast = $L_{\downarrow \text{white pixel}} + L_{\downarrow \text{veiling reflection}} / L_{\downarrow \text{black pixel}} + L_{\downarrow \text{veiling reflection}}$

Monitor specification

Calculated with simulation

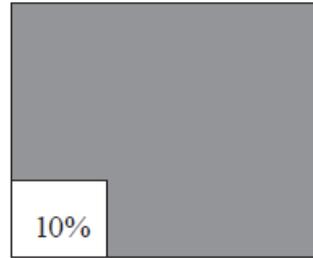
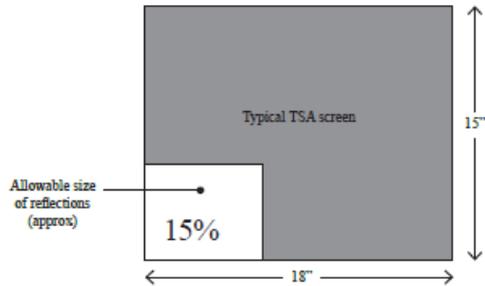
Recommended Contrast Ratios

Category A	Category B	Category C
100:1	25:1	5:1
Images show a full range of colors (or grays in black and white photographs) and have good shadow detail.	The range of colors is like that of Category A except the images are limited in shadows and details and have a flat two-dimensional appearance.	The images are composed of contrasting colors or black and white (no grays). They have little or no detail in the dark areas.
Examples: Portraits and landscapes	Examples: Cartoons and flatly lighted photographs of subjects with limited brightness range.	Examples: Printed test, charts, and other linework for use with slide and overhead projectors.

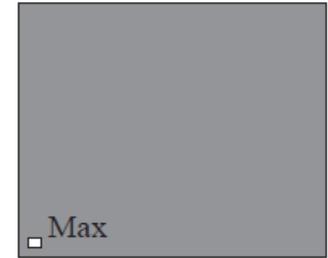
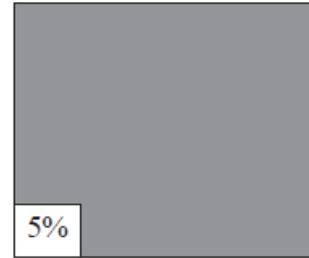
*Source:
Kodak Audiovisual Projection
Kodak Publication S-3
Revision 036-03-82
Page 10*

Sensitivity Study

This page shows the sensitivity of allowing varying percentages of veiling reflections on the display screens. The higher the percentage of screen area that is allowed to show reflected glare, fewer locations exceed the threshold.

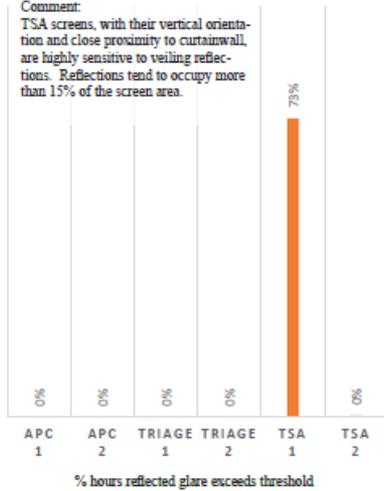


Current Assumption



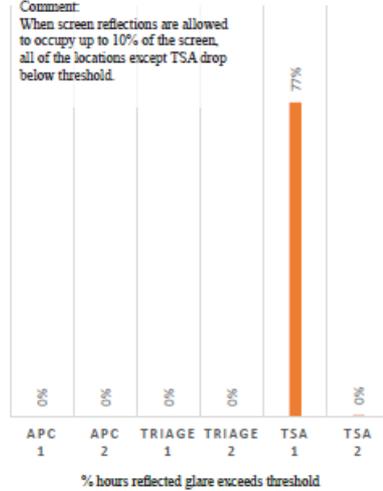
Comment:

TSA screens, with their vertical orientation and close proximity to curtainwall, are highly sensitive to veiling reflections. Reflections tend to occupy more than 15% of the screen area.



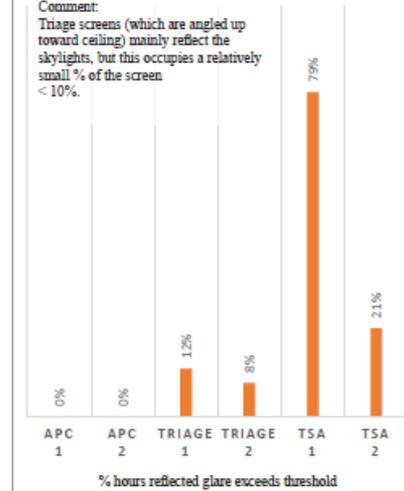
Comment:

When screen reflections are allowed to occupy up to 10% of the screen, all of the locations except TSA drop below threshold.



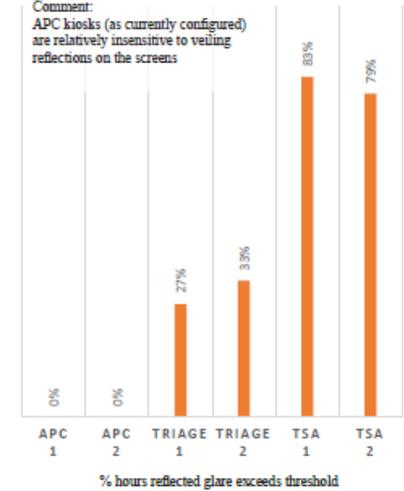
Comment:

Triage screens (which are angled up toward ceiling) mainly reflect the skylights, but this occupies a relatively small % of the screen < 10%.

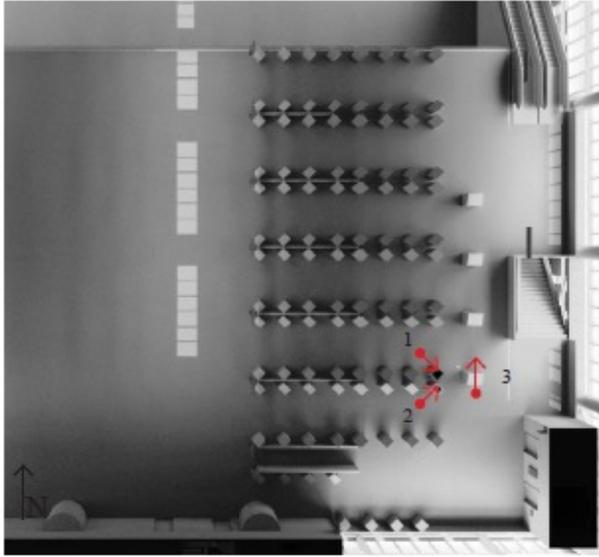


Comment:

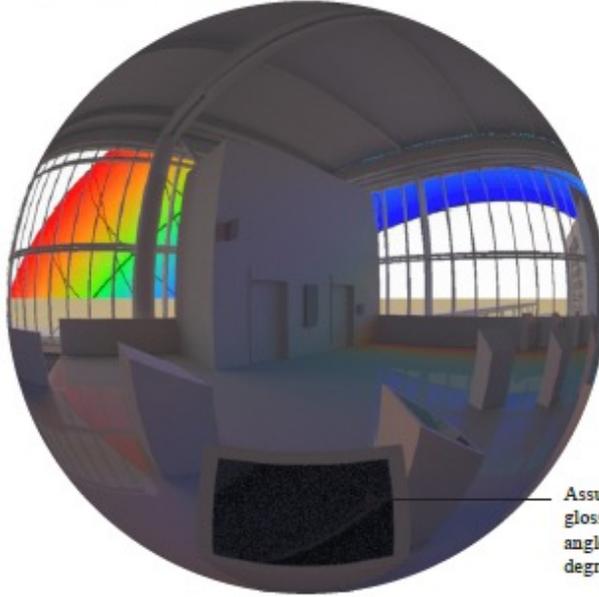
APC kiosks (as currently configured) are relatively insensitive to veiling reflections on the screens



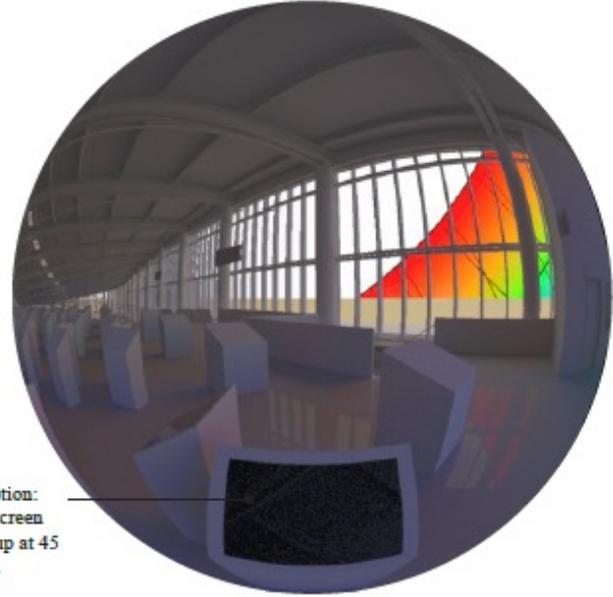
Viewpoint Plan



View 1: Looking Southeast

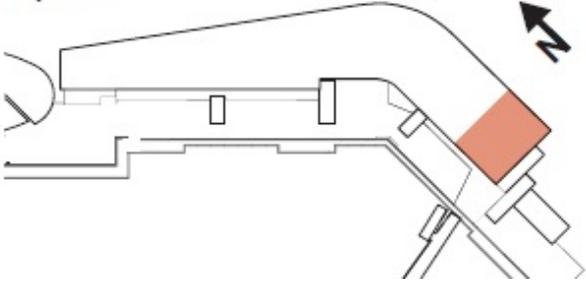


View 2: Looking Northeast

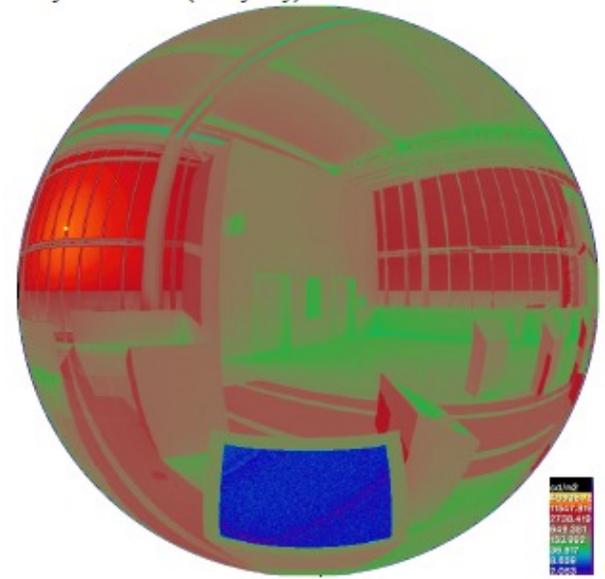


Assumption:
glossy screen
angled up at 45
degrees.

Key Plan

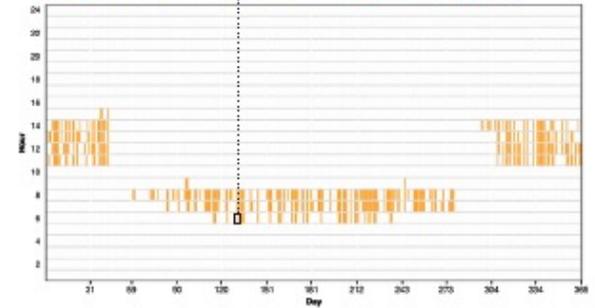


View 1: Looking Southeast
 May 9 6:00 AM (sunny sky)



Annual Glare Analysis

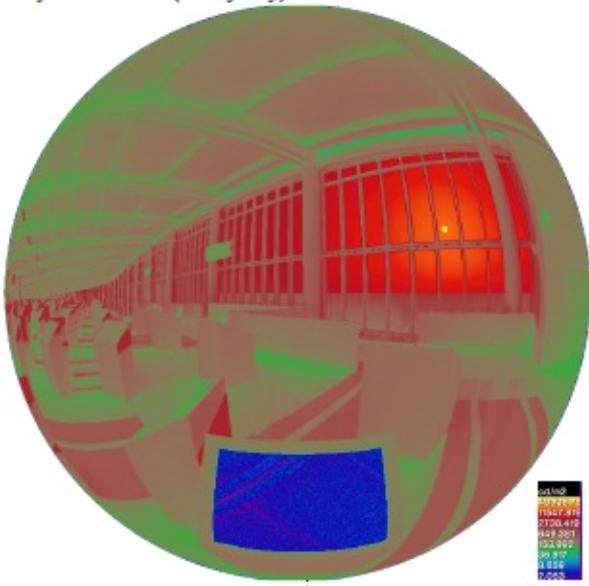
■ = Disability (Direct) Glare ■ = Veiling (Reflected) Glare



Disability Glare Reflected Glare Combined Glare
10% **0%** **10%**

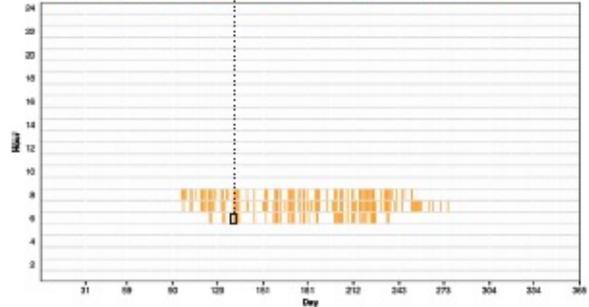
% of all daylight hours during the year

View 2: Looking Northeast
 May 9 6:00 AM (sunny sky)



Annual Glare Analysis

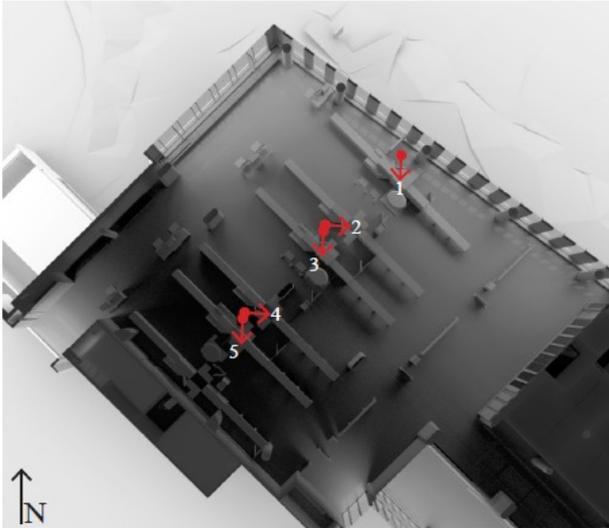
■ = Disability (Direct) Glare ■ = Veiling (Reflected) Glare



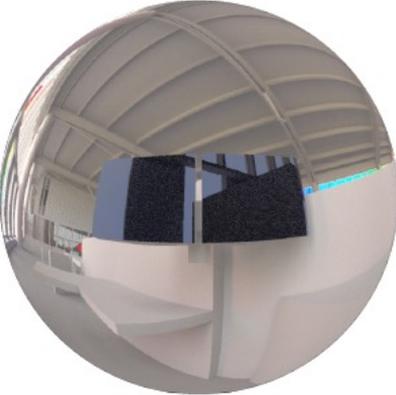
Disability Glare Reflected Glare Combined Glare
5% **0%** **5%**

% of all daylight hours during the year

Viewpoint Plan



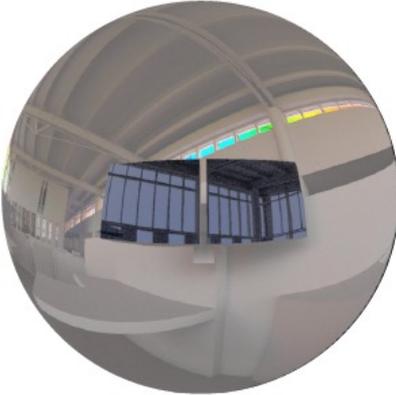
View 1: Looking Northeast



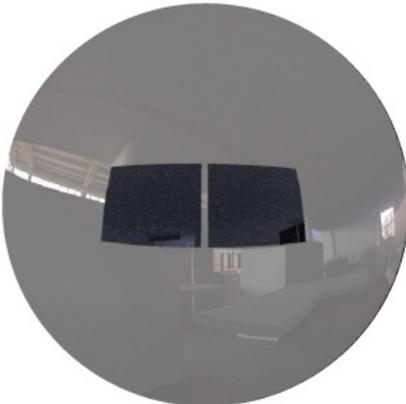
View 2: Looking Southwest



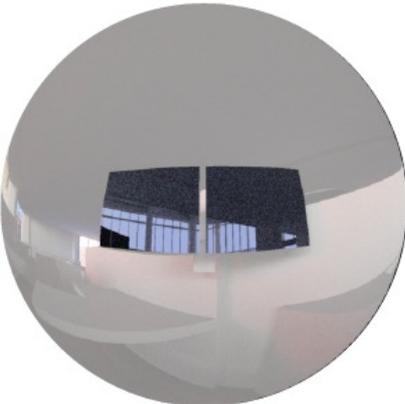
View 3: Looking Northeast



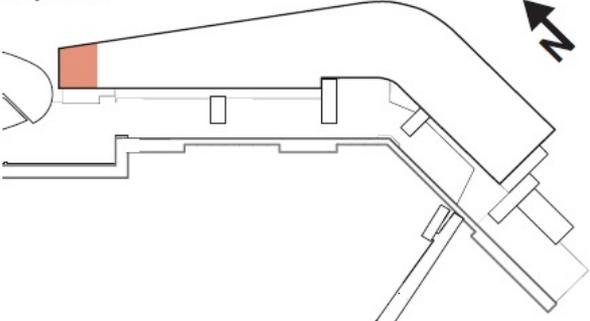
View 4: Looking Southwest



View 5: Looking Northeast

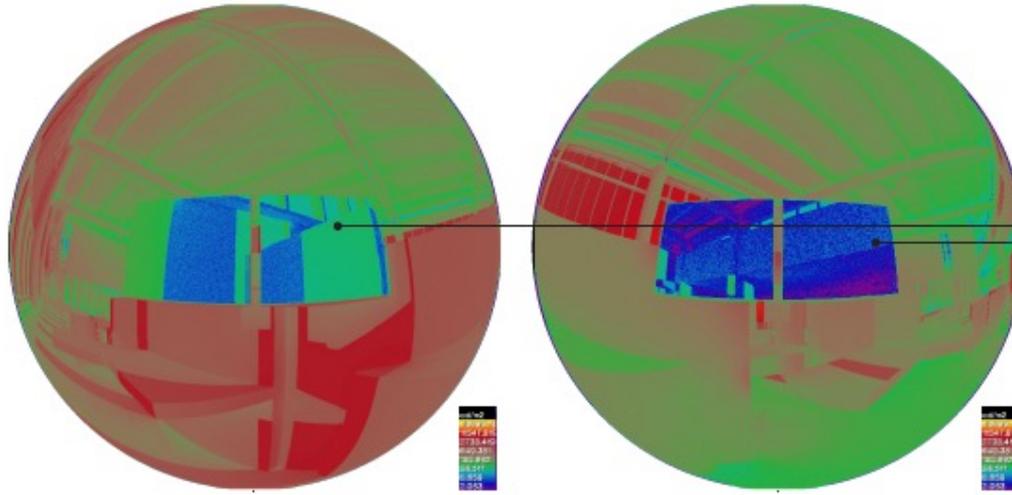


Key Plan

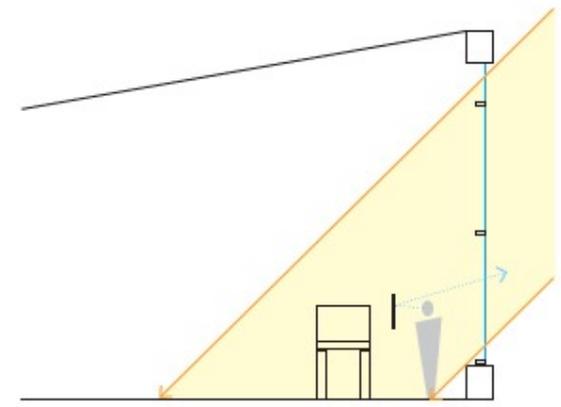
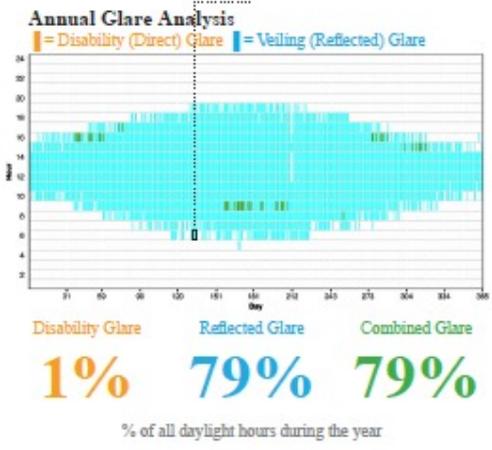


View 1: Looking Northeast
May 9 6:00AM (sunny sky)

View 2: Looking Southwest
May 9 6:00AM (sunny sky)

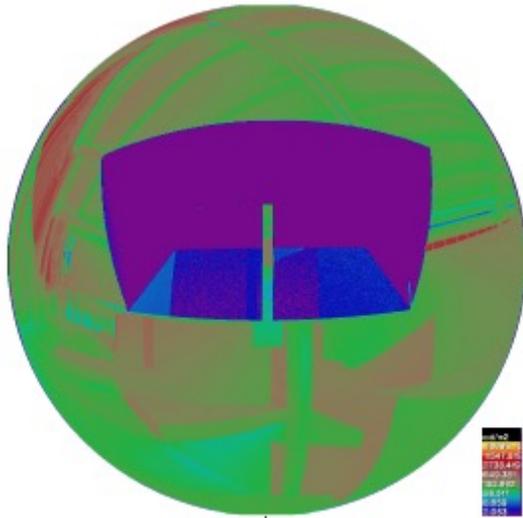


Reflections of skylight and glazing visible on screen

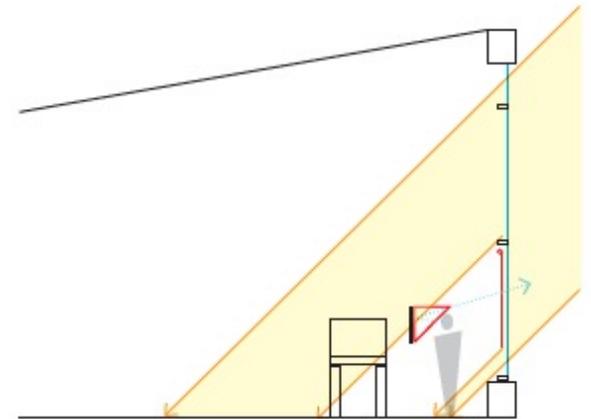
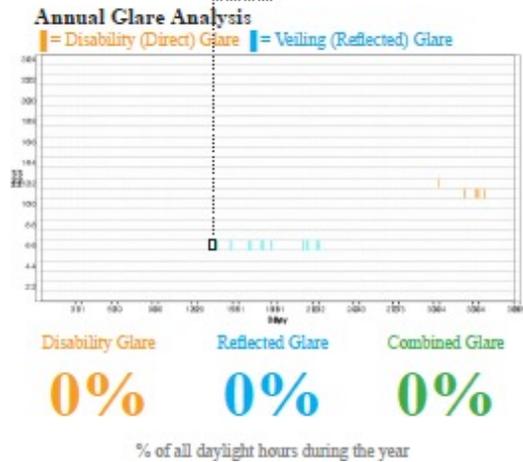
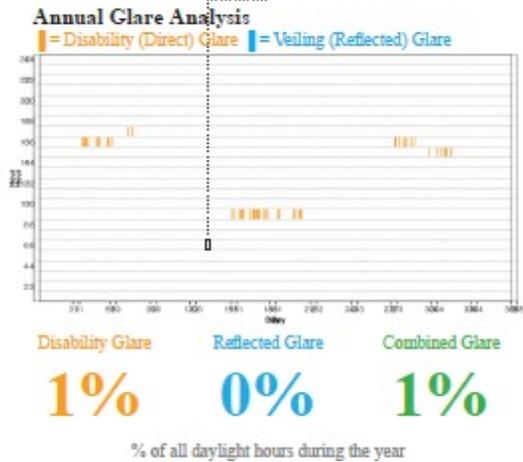
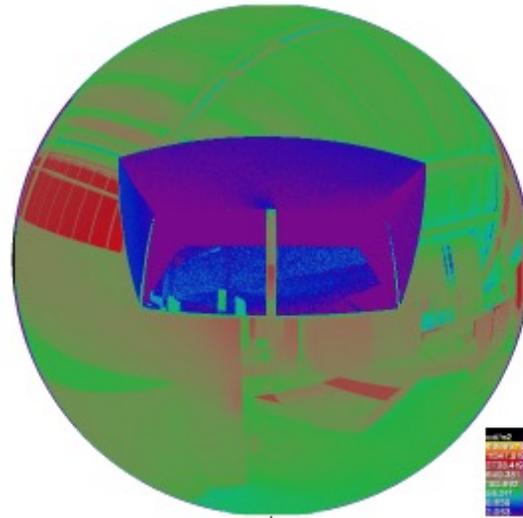


ARUP

View 1: Looking Northeast
May 9 6:00AM (sunny sky)

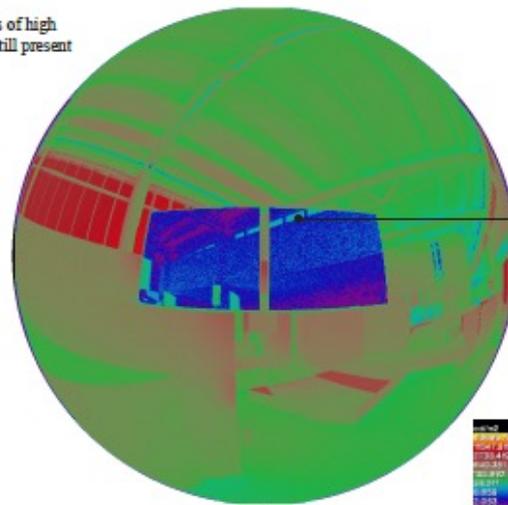
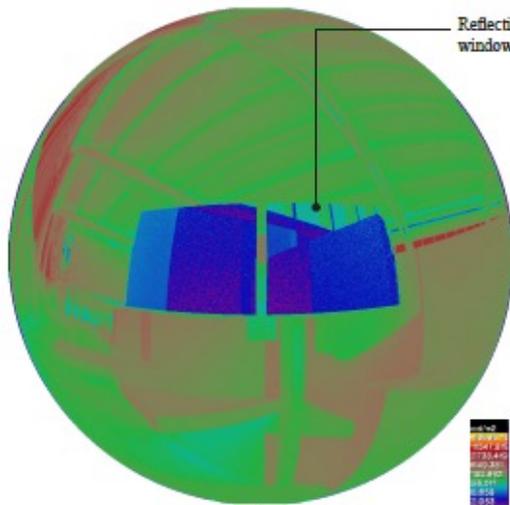


View 2: Looking Southwest
May 9 6:00AM (sunny sky)



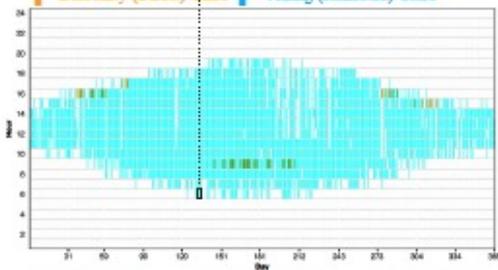
View 1: Looking Northeast
May 9 6:00AM (sunny sky)

View 2: Looking Southwest
May 9 6:00AM (sunny sky)



Annual Glare Analysis

■ = Disability (Direct) Glare ■ = Veiling (Reflected) Glare



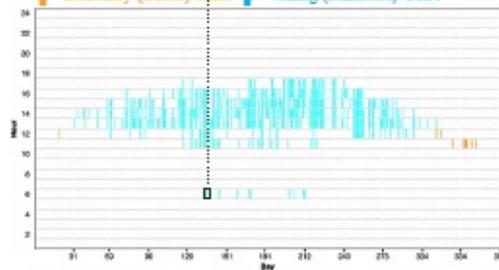
Disability Glare Reflected Glare Combined Glare

1% **68%** **69%**

% of all daylight hours during the year

Annual Glare Analysis

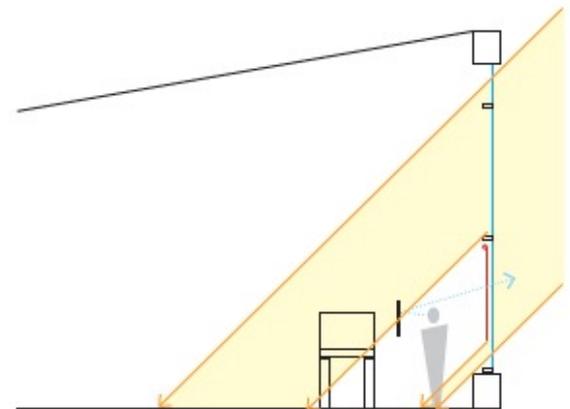
■ = Disability (Direct) Glare ■ = Veiling (Reflected) Glare



Disability Glare Reflected Glare Combined Glare

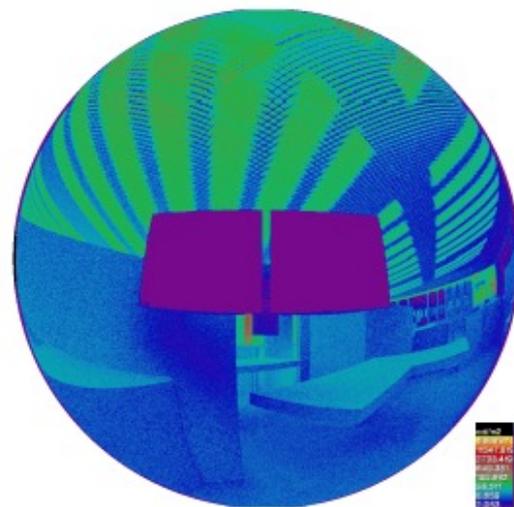
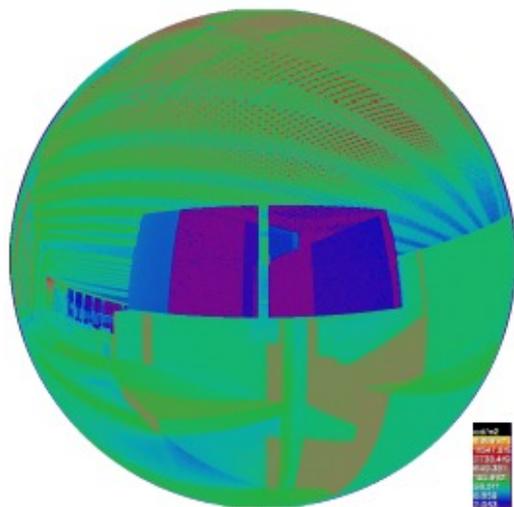
0% **13%** **13%**

% of all daylight hours during the year



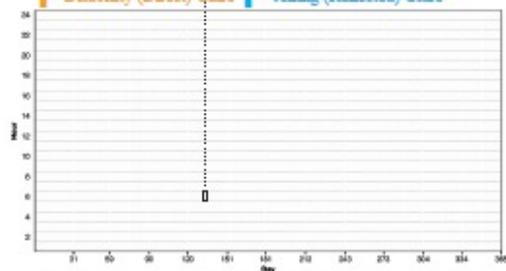
View 1: Looking Northeast
May 9 6:00AM (sunny sky)

View 2: Looking Southwest
May 9 6:00AM (sunny sky)



Annual Glare Analysis

■ = Disability (Direct) Glare ■ = Veiling (Reflected) Glare

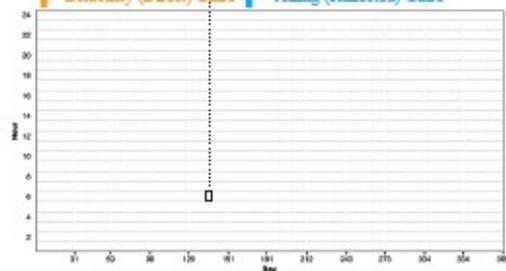


Disability Glare 0%
Reflected Glare 0%
Combined Glare 0%

% of all daylight hours during the year

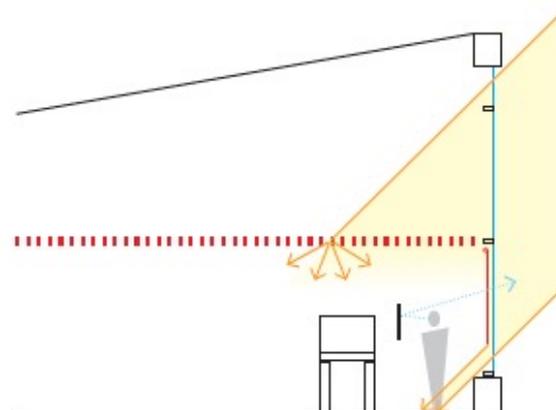
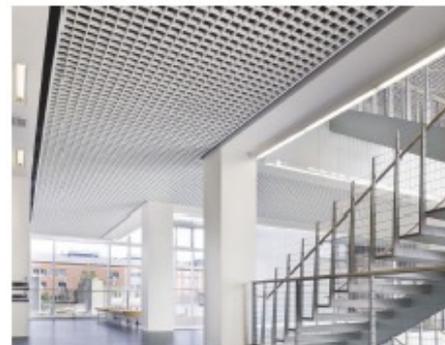
Annual Glare Analysis

■ = Disability (Direct) Glare ■ = Veiling (Reflected) Glare

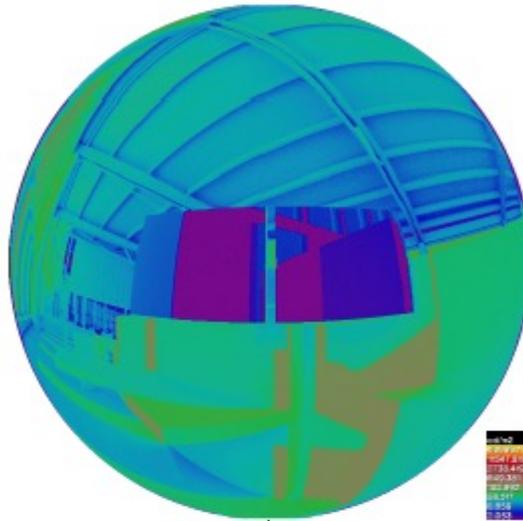


Disability Glare 0%
Reflected Glare 0%
Combined Glare 0%

% of all daylight hours during the year

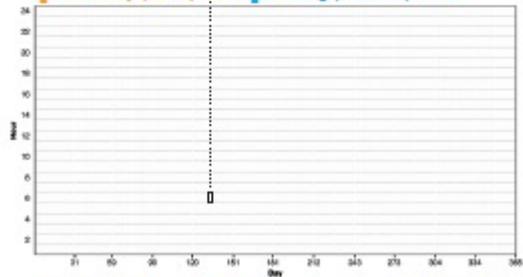


View 1: Looking Northeast
May 9 6:00AM (sunny sky)



Annual Glare Analysis

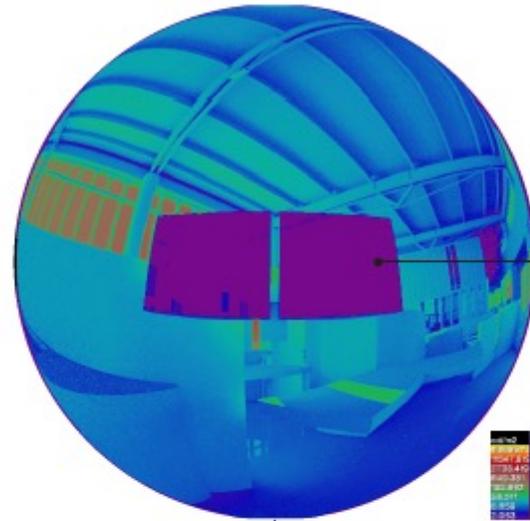
■ = Disability (Direct) Glare ■ = Veiling (Reflected) Glare



Disability Glare Reflected Glare Combined Glare
0% **0%** **0%**

% of all daylight hours during the year

View 2: Looking Southwest
May 9 6:00AM (sunny sky)

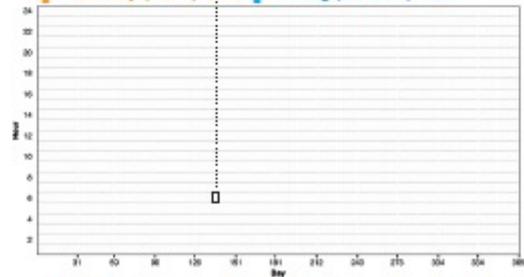


Screen reflections are close to zero



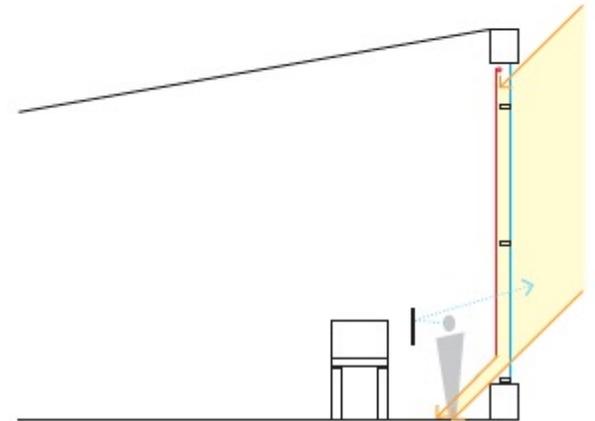
Annual Glare Analysis

■ = Disability (Direct) Glare ■ = Veiling (Reflected) Glare



Disability Glare Reflected Glare Combined Glare
0% **0.1%** **0.1%**

% of all daylight hours during the year



Thank you!