A Comparative Discussion

Using Radiance, DAYSIM and Physical Models in Architectural Practice

8th International Radiance Workshop, Harvard GSD
2009_10_22

Presented by: Kevin Van Den Wymelenberg, University of Idaho, Integrated Design Lab - Boise

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Special thanks: Mehlika Inanici, PhD

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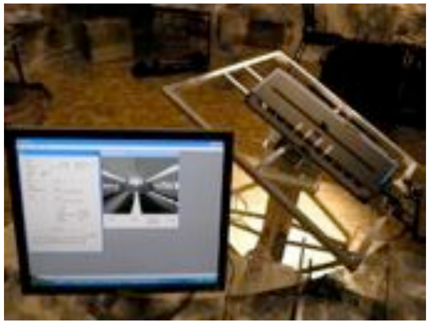
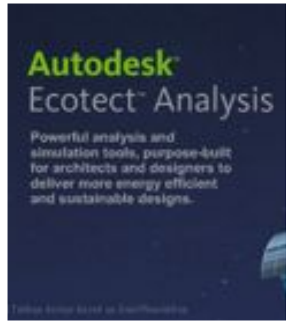
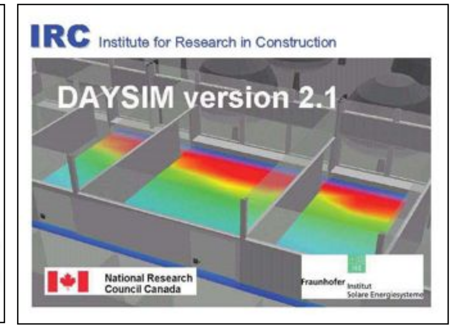
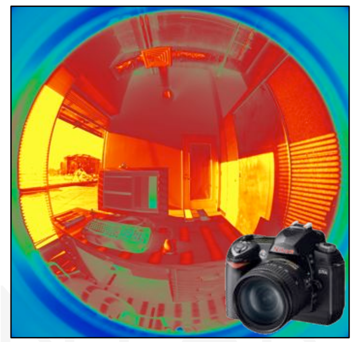
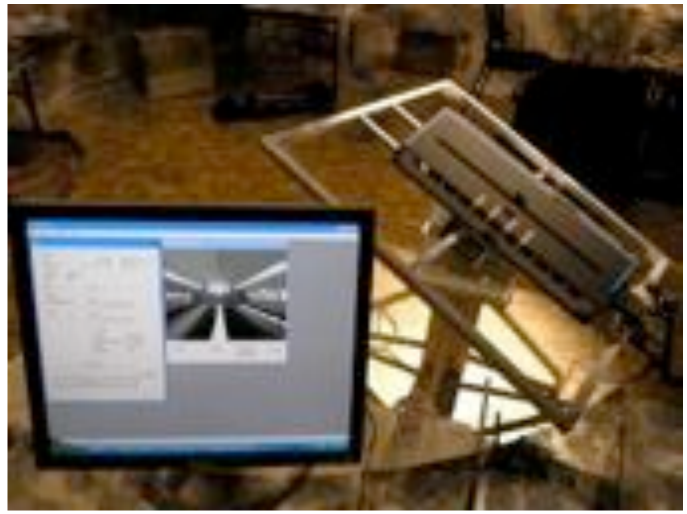








DAYLIGHTING TOOLS



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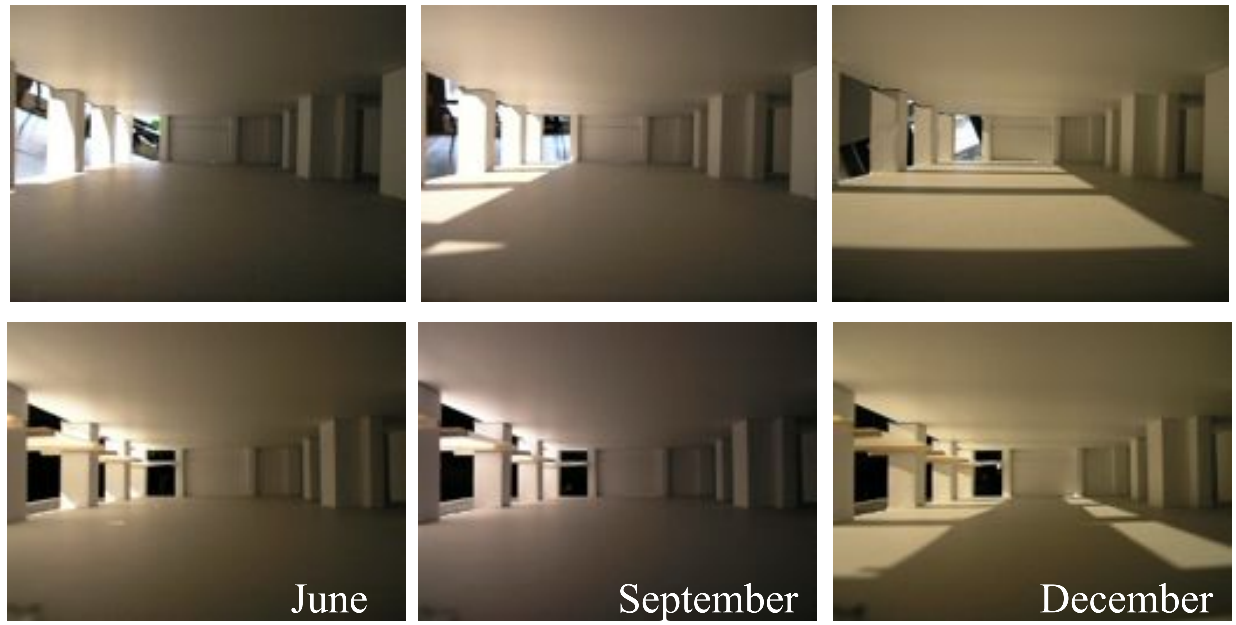
HELIODON Design Analysis

No Shading - 12 PM

With Shading - 12 PM



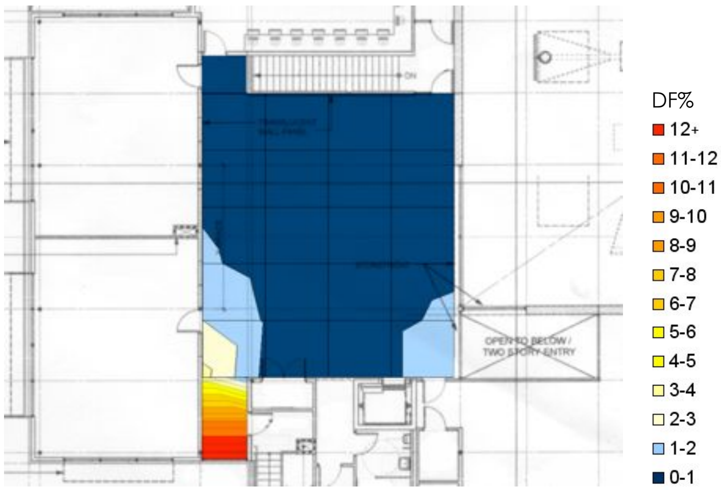
PHYSICAL MODELING HELIODON

Li-Cor 210 sa

Easy HDRs

OVERCAST SKYBOX Design Analysis

RAINIER VISTA BOYS & GIRLS CLUB- Seattle, WA (IDL- Puget Sound)



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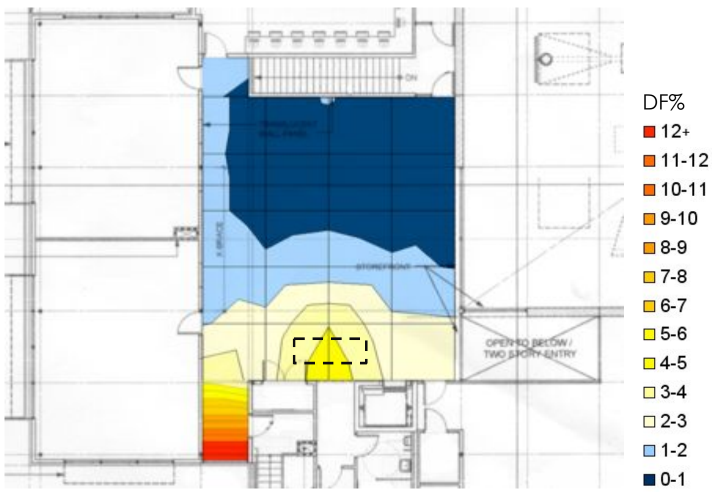
PHYSICAL MODELING OVERCAST SKYBOX

Baseline: No skylights

RAINIER VISTA BOYS & GIRLS CLUB- Seattle, WA (IDL- Puget Sound)



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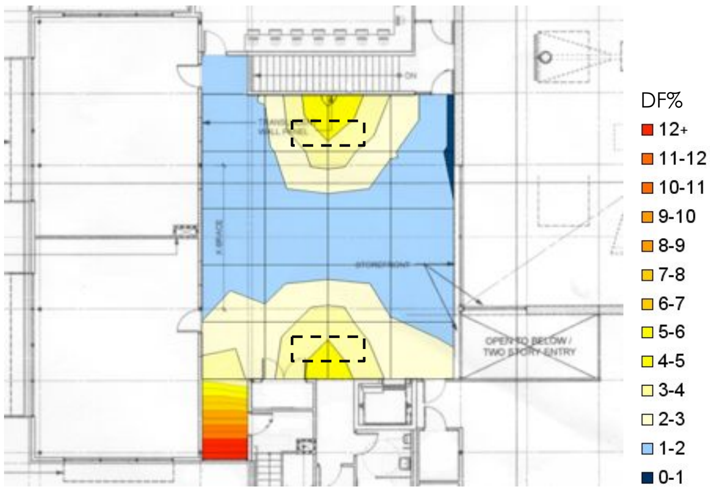
INTEGRATED DESIGN LAB

PHYSICAL MODELING OVERCAST SKYBOX

Modification 1: Two skylights- One in stairwell

RAINIER VISTA BOYS & GIRLS CLUB- Seattle, WA (IDL- Puget Sound)



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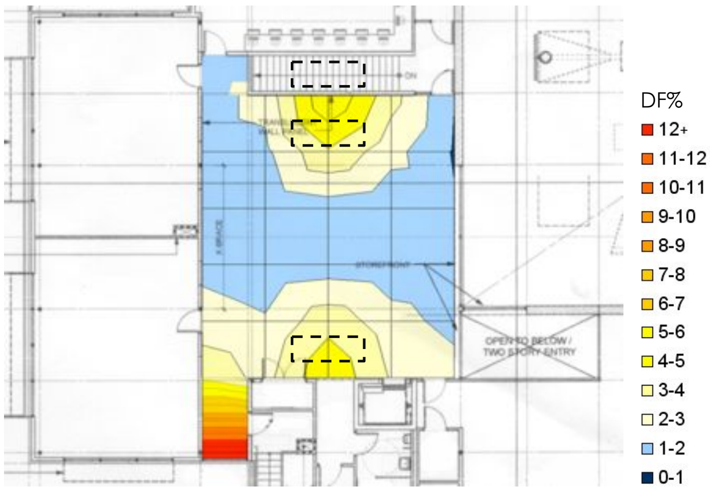
PHYSICAL MODELING OVERCAST SKYBOX

Modification 2: Two skylights- Both in Learning Center

RAINIER VISTA BOYS & GIRLS CLUB- Seattle, WA (IDL- Puget Sound)



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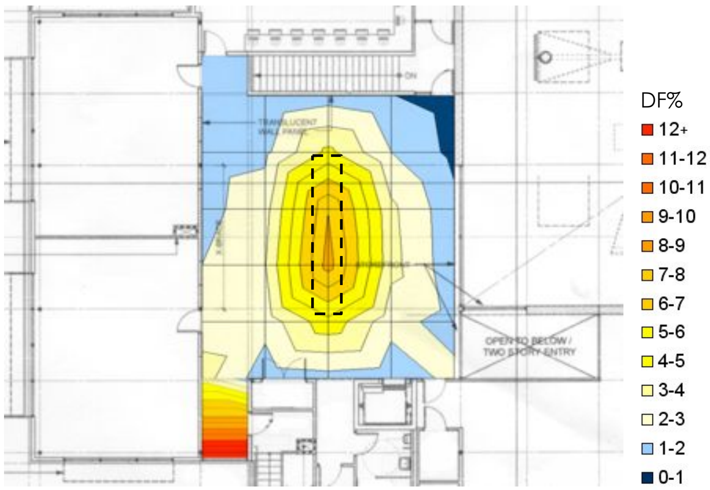
PHYSICAL MODELING OVERCAST SKYBOX

Modification 3: Three skylights- Two in Learning Center and one in stairwell

RAINIER VISTA BOYS & GIRLS CLUB- Seattle, WA (IDL- Puget Sound)



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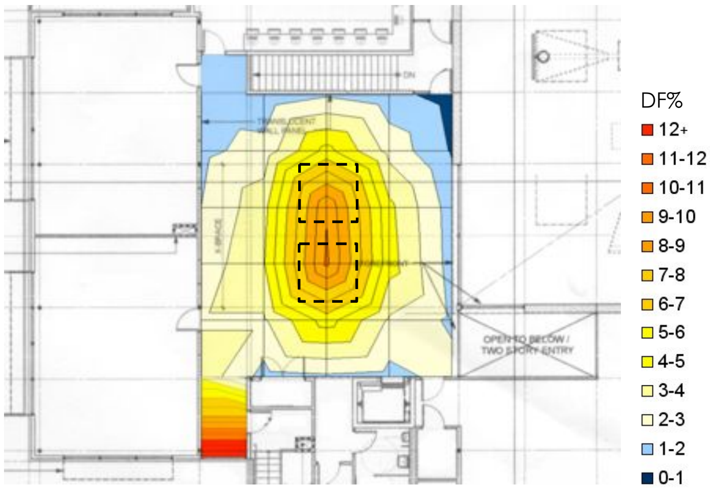
PHYSICAL MODELING OVERCAST SKYBOX

Modification 4: One skylight- Elongated rectangle

RAINIER VISTA BOYS & GIRLS CLUB- Seattle, WA (IDL- Puget Sound)



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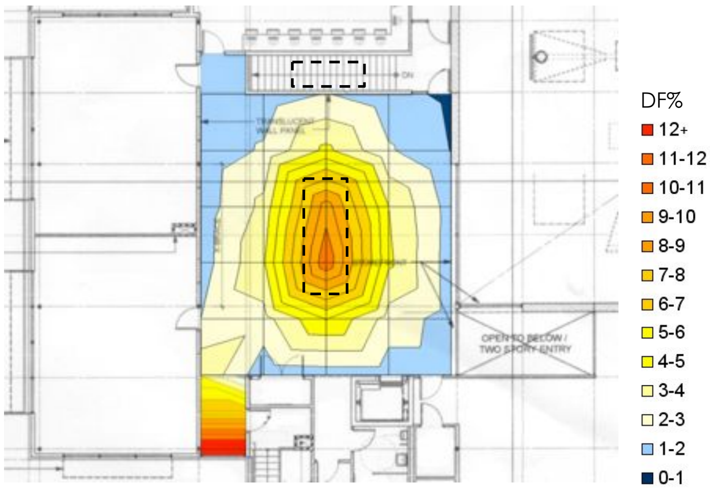
PHYSICAL MODELING OVERCAST SKYBOX

Modification 5: Two skylights- Large squares

RAINIER VISTA BOYS & GIRLS CLUB- Seattle, WA (IDL- Puget Sound)



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PHYSICAL MODELING OVERCAST SKYBOX

Modification 6: Two skylights- Large 6’ x 16’ rectangle and skylight at stairwell

North Mall Office Building – Salem, OR

YGH, Portland, Boise 2001 TESTS

PHYSICAL MODELING ~ Confidence

Garden City Head Start – Boise, ID

McKibben & Cooper Architects, Boise 2002 TESTS

PHYSICAL MODELING ~ Confidence

Federal Way Youth Development Center

Weinstein A|U

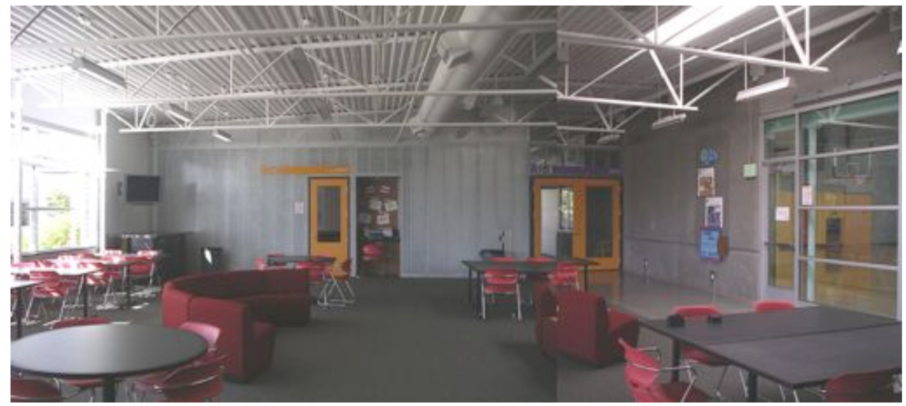
2003 TESTS

PHYSICAL MODELING ~ Confidence

Federal Way Youth Development Center

Weinstein AIU

2003 TESTS



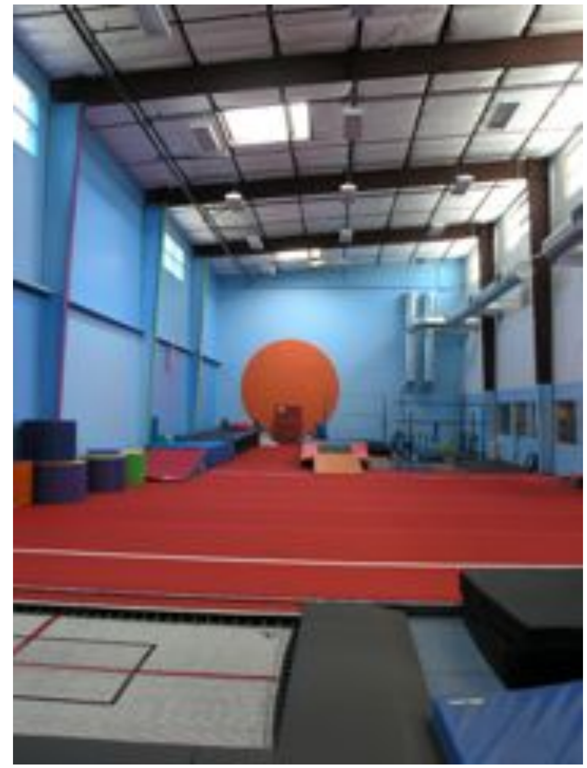
PHYSICAL MODELING ~ Confidence

CSI Recreation – Twin Falls, ID

CTA Group, Boise 2004 TESTS

Tumble Time Gymnasium – Boise, ID

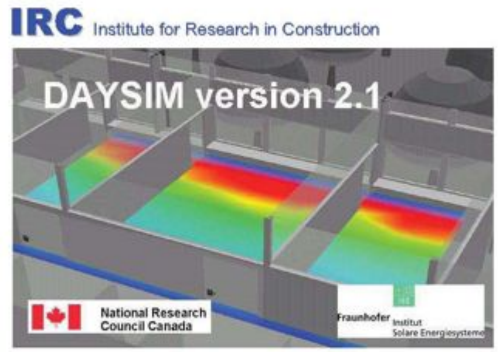
Cole + Poe Architects, Boise   2004 TESTS



PHYSICAL MODELING ~ Confidence

Radiance

Synthetic Imaging System



DIGITAL SUITE ANALYSIS

2006 – Ecotect – Radiance – Daysim – HDR Photography

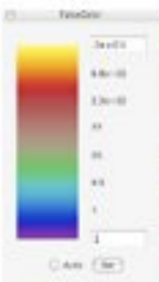
April 20th, 2007 - 8:30 AM Sun Time
Banner Bank - Case 4

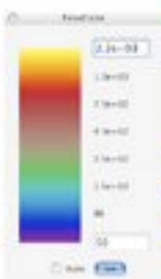
Blinds=Down-Optimized
Lights=Off
Sky=Clear

Camera=Nikon D70s
Lens=Nikkor 10.5mm

F-Stop=22
OverExp=1 sec
UnderExp=1/5000 sec
WB=Daylight

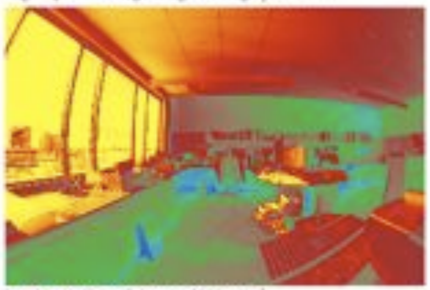
Luminance
Mean:Max Contrast=1:99



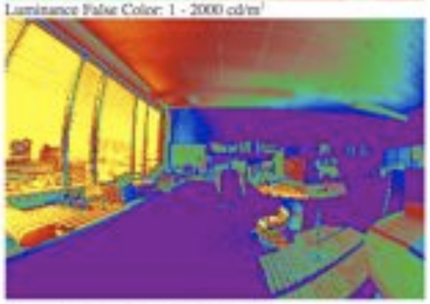


Photographic Baseline

High Dynamic Range Image: Photograph Baseline



Luminance False Color: 1 - 2000 cd/m²

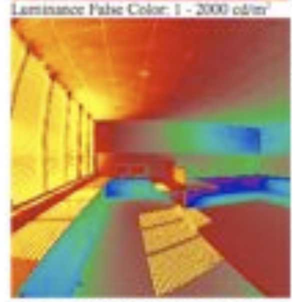


Luminance False Color: 50 - 2200 cd/m²

Rendered Baseline Proces

High Dynamic Range Rendering - HS

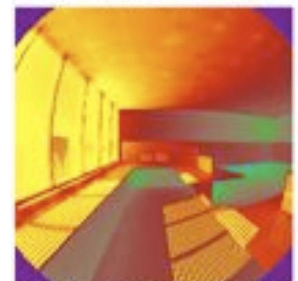
Luminance False Color: 1 - 2000 cd/m²



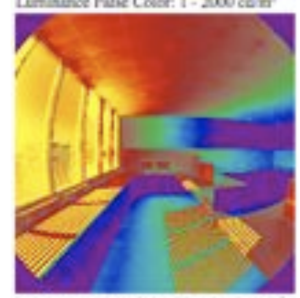
Luminance False Color: 50 - 2200 cd/m²

Rendered Baseline - Final

High Dynamic Range Rendering - HS

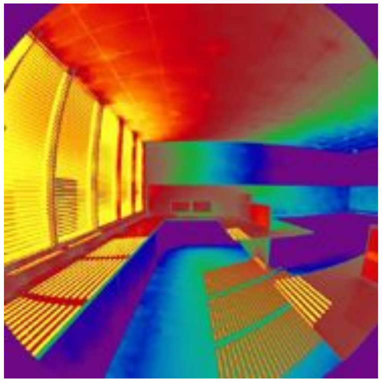


Luminance False Color: 1 - 2000 cd/m²

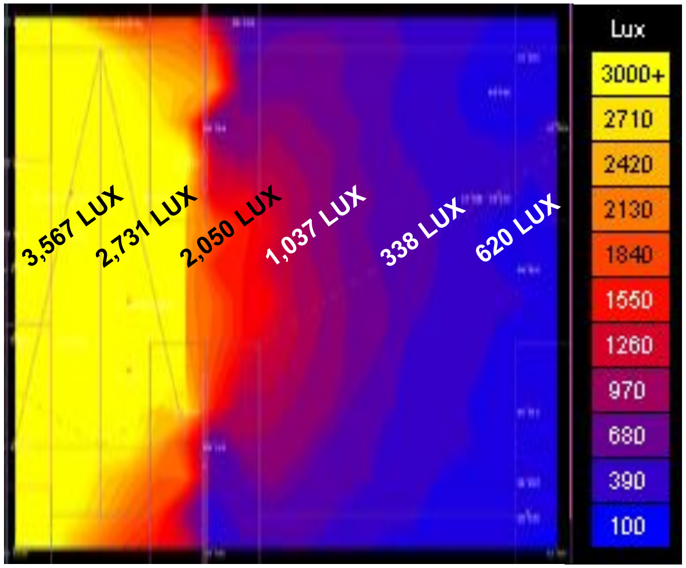


Luminance False Color: 50 - 2200 cd/m²

HDR Rendering



Luminance False Color: 50 - 2200 cd/m2

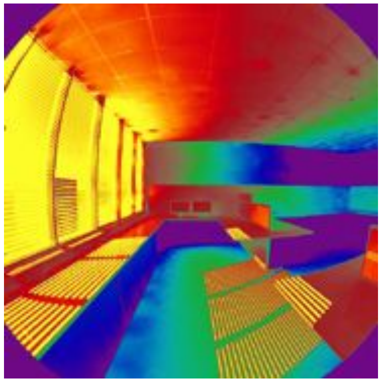


Workplane Illumination (lux)

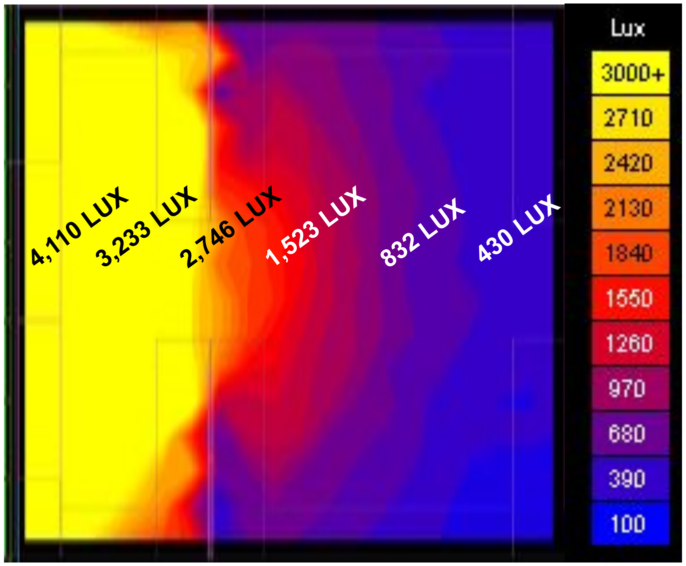
DIGITAL MODELING

Baseline: Banner Bank configuration

HDR Rendering



Luminance False Color: 50 - 2200 cd/m2

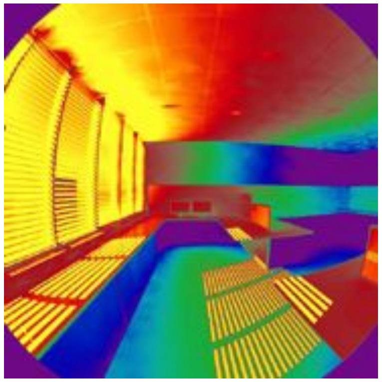


Workplane Illumination (lux)

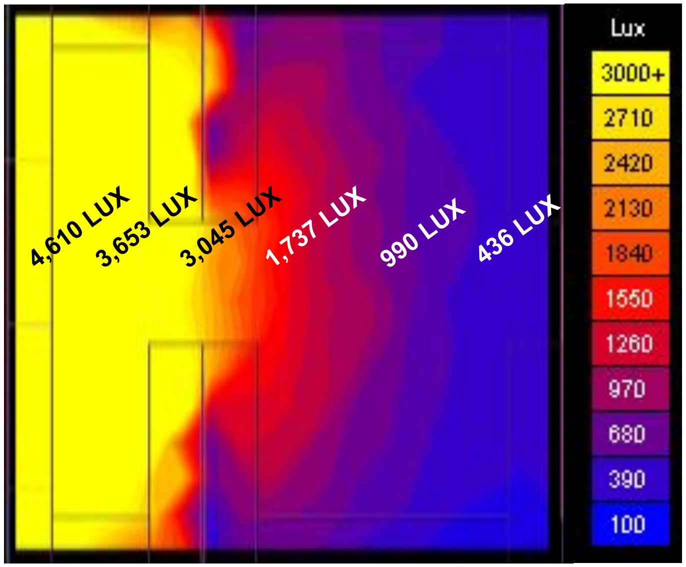
DIGITAL MODELING

Improved Glazing (SB70xlsp/SP)

HDR Rendering



Luminance False Color: 50 - 2200 cd/m2



Workplane Illumination (lux)

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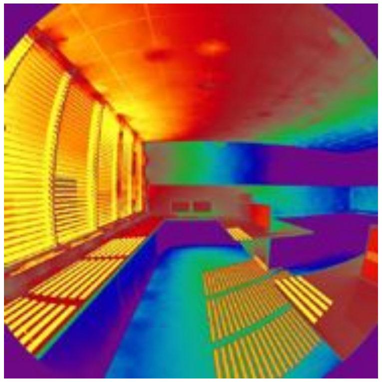
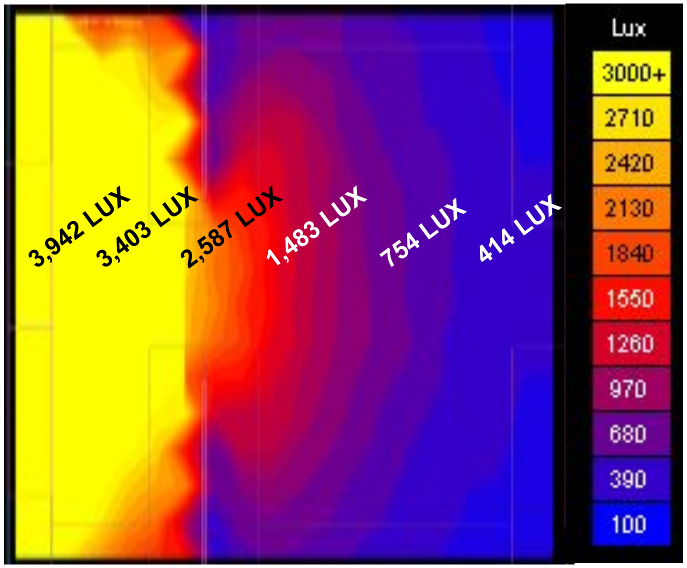
DIGITAL MODELING

3" Inverted Louver Blinds

HDR Rendering



Luminance False Color: 50 - 2200 cd/m2



Workplane Illumination (lux)

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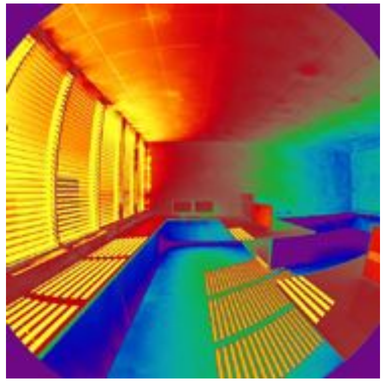
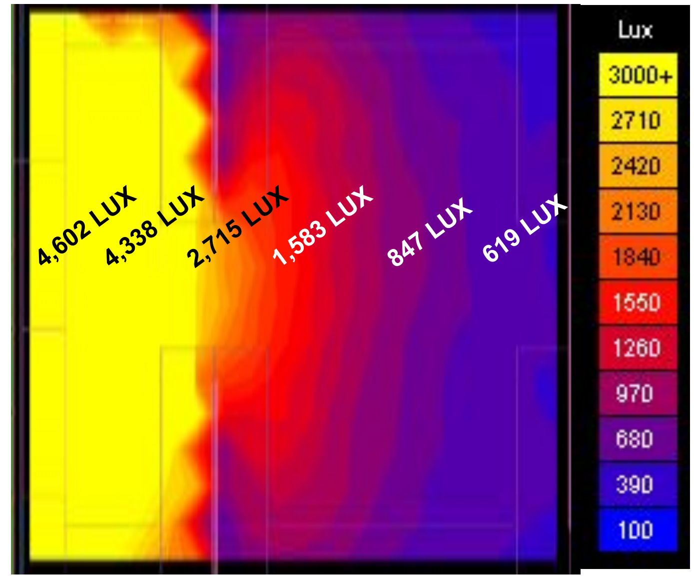
DIGITAL MODELING

Triple Pane Glazing (SP/70xl/SP)

HDR Rendering



Luminance False Color: 50 - 2200 cd/m2

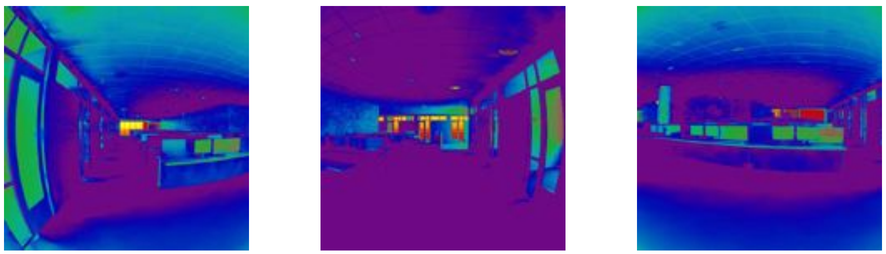


Workplane Illumination (lux)

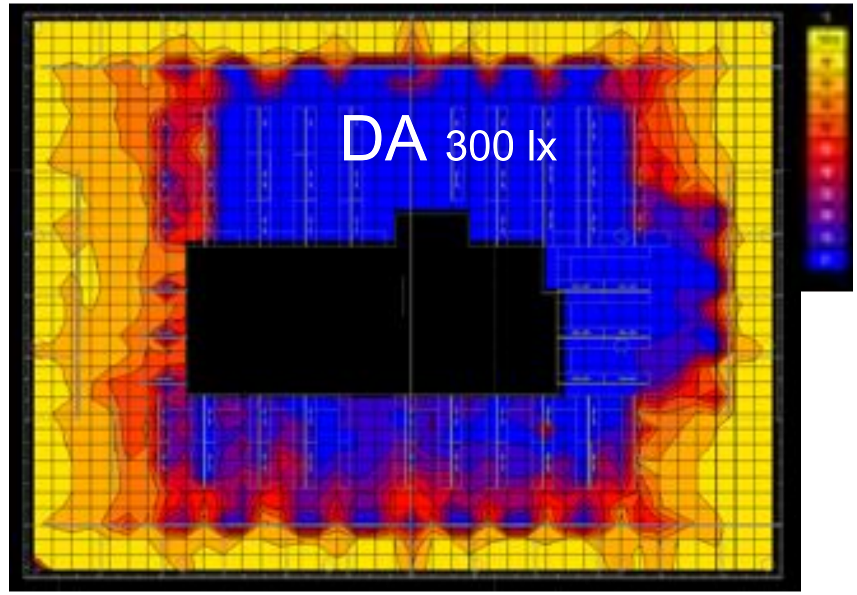
DIGITAL MODELING

Light Brown Modular Walls

HDR Rendering



Luminance False Color: 50 - 2200 cd/m2



Daylight Autonomy- % of time above 300 lux

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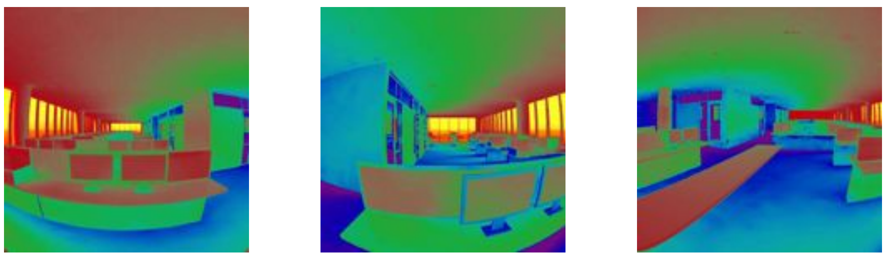
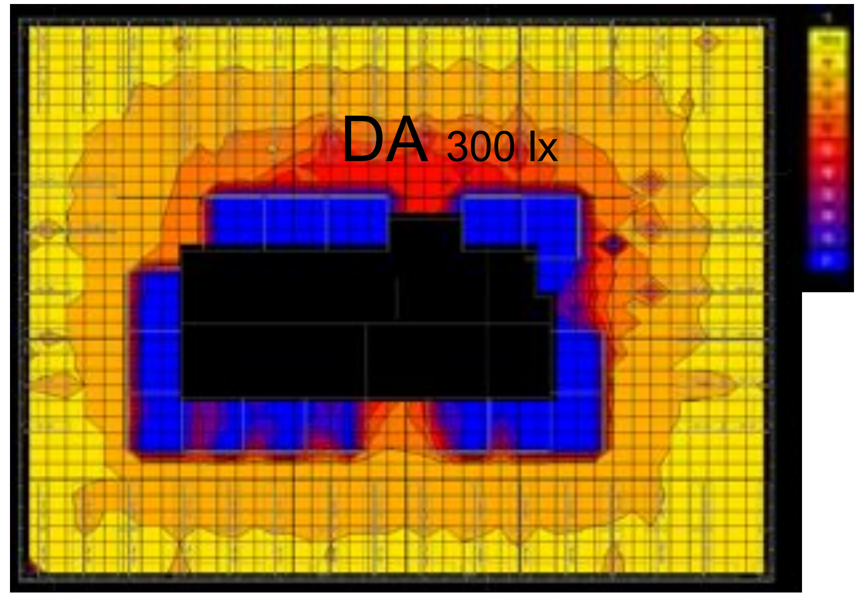
DIGITAL MODELING

Baseline- Perimeter Hard Wall Offices

HDR Rendering



Luminance False Color: 50 - 2200 cd/m2

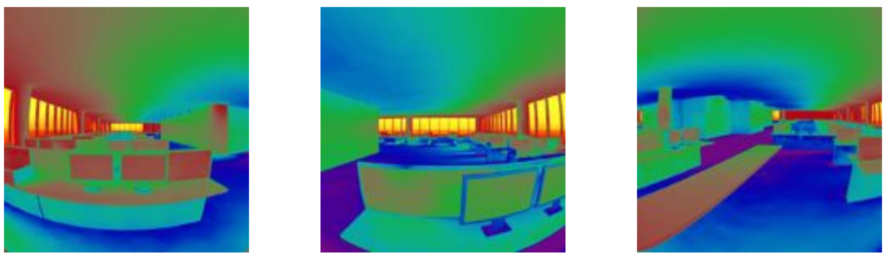


Daylight Autonomy- % of time above 300 lux

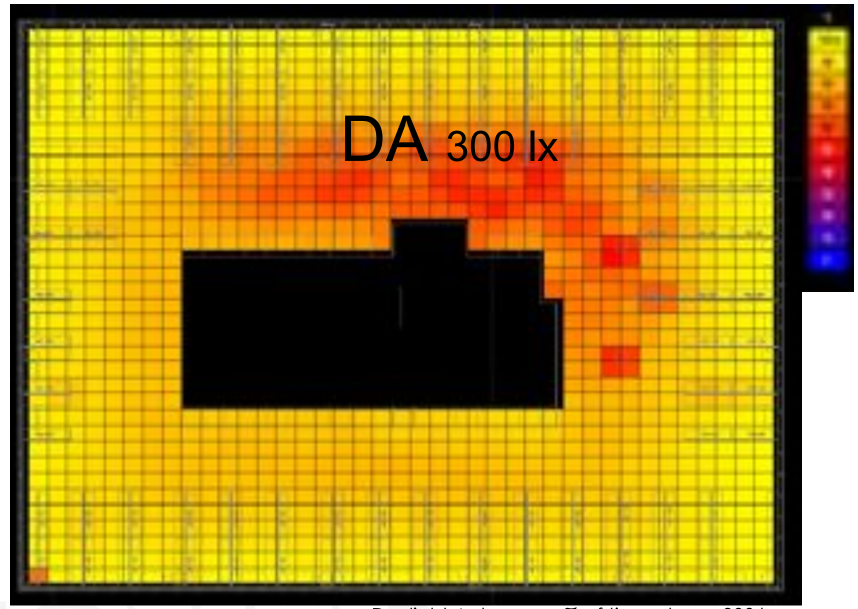
DIGITAL MODELING

Perimeter Open Office Plan

HDR Rendering



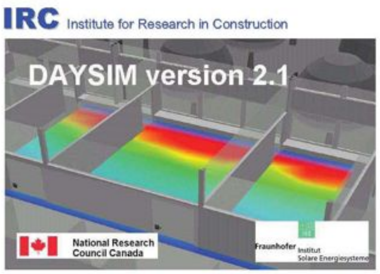
Luminance False Color: 50 - 2200 cd/m2



Daylight Autonomy- % of time above 300 lux

DIGITAL MODELING

Seventh Floor Skylights



Radiance
Synthetic Imaging System

INTEGRATED DESIGN LAB

HYBRID DIGITAL/PHYSICAL ANALYSIS

VOCATIONAL EDUCATION BUILDING

DAYLIGHTING STUDIES FOR:
CTA Group- Boise, ID

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University of Idaho College of Art and Architecture

BETTERBRICKS bottom line thinking on energy

IDAHO POWER

SECOND FLOOR

FIRST FLOOR

SHOP SECTION

SHOP SECTION

PROJECT INTRODUCTION

This project includes analysis of two large open spaces for vocational education. The space too the North has an approximately 35' ceiling height allowing for specialty equipment. Dissecting the two spaces is a hallway leading from the classroom portion on the West end with access to the large spaces along its length and terminating at the East entrance. The south space is composed of an open auto shop through the center and a spray shop at the East end. The roof is articulated in a cascading fashion from high in the north to low in the south to allow for clerestory lighting.

VOCATIONAL EDUCATION BUILDING

V. 1 DIGITAL MODEL ANALYSIS
6.05.09
V.2 DIGITAL MODEL ANALYSIS
6.19.09
V.3 DIGTIAL MODEL ANALYSIS
7.15.09
V.1 PHYSICAL MODEL ANALYSIS
9.08.09
V.4 DIGITAL MODEL ANALYSIS
9.09.09
V.2 PHYSICAL MODEL ANALYSIS
9.22.09

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VOCATIONAL EDUCATION BUILDING

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9.22.09

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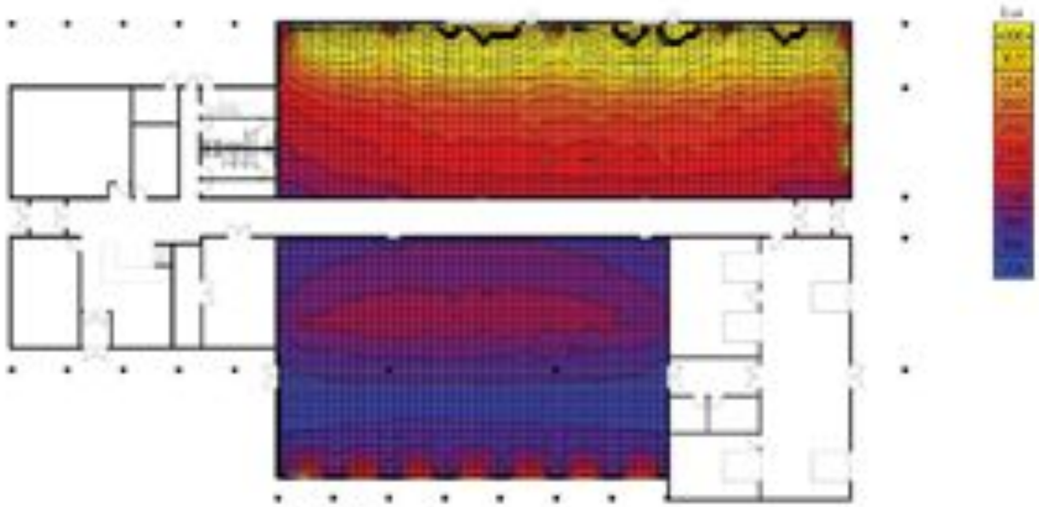

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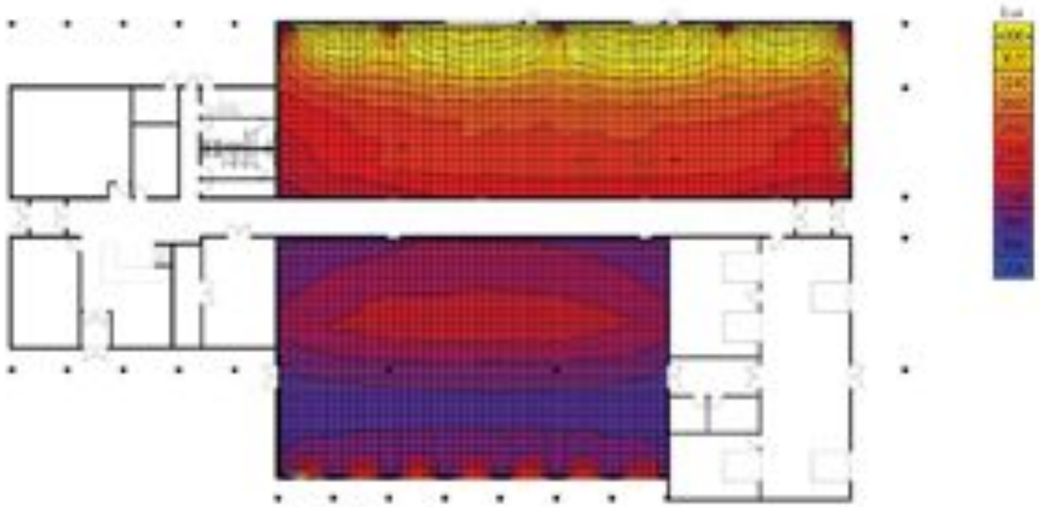
ANALYSIS DATA

JUNE 21

Overcast - 12:00

The above floor plan graphically shows the amount of daylight hitting a work plane at 30 inches. The values for the daylight are in the units of Lux (a measure of the apparent intensity of light hitting or passing through a surface). One footcandle is equivalent to 10.67 Lux. Values along the 30 foot high North facade are relatively high due to the large amount of glazing.

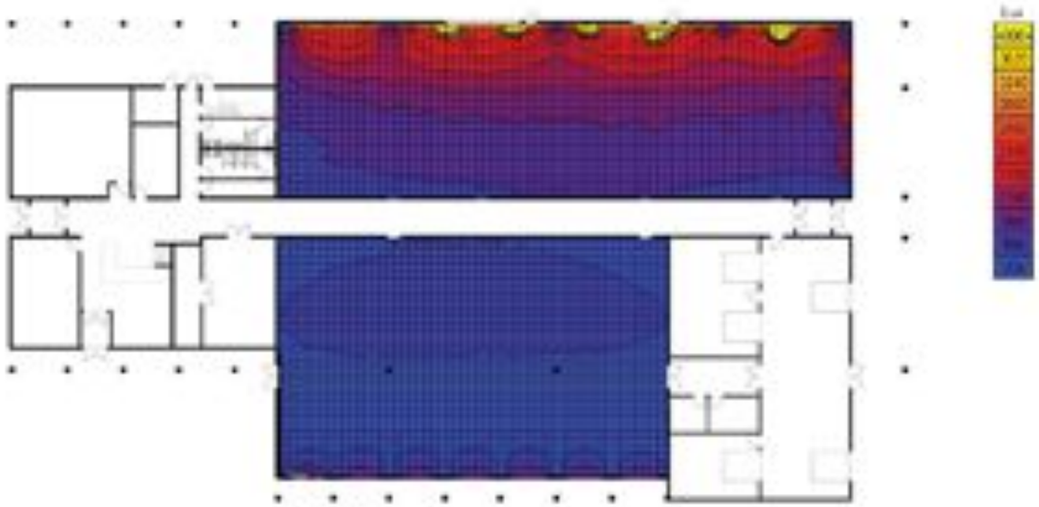


ANALYSIS DATA

SEPTEMBER 21

Overcast - 12:00

Values along the 30 foot high North facade are relatively high due to the large amount of glazing.



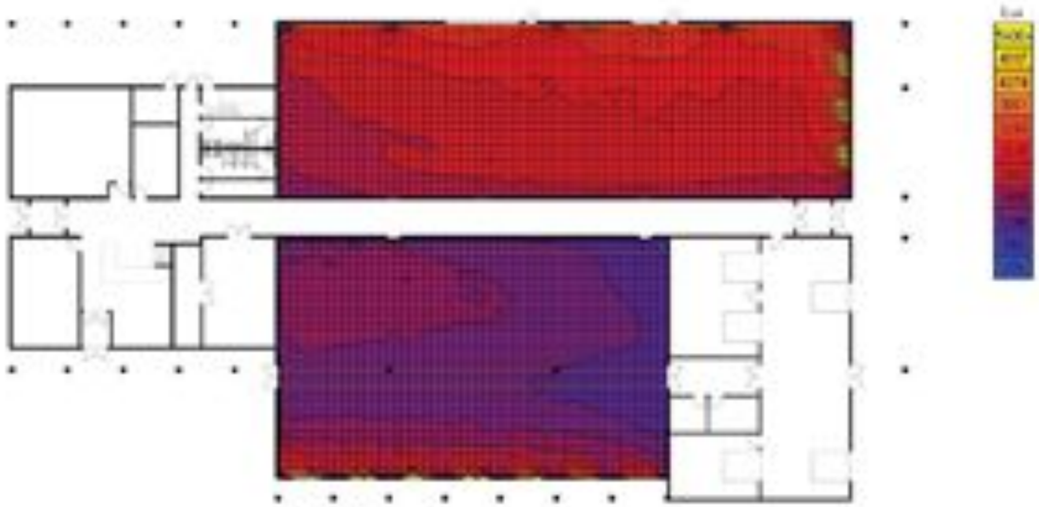
INTEGRATED DESIGN LAB

ANALYSIS DATA

DECEMBER 21

Overcast - 12:00

Even in the worst case scenario light levels are never below 200 Lux during this time and are appropriate for the tasks that will be conducted within these spaces. However light levels are still relatively high along the North facade.



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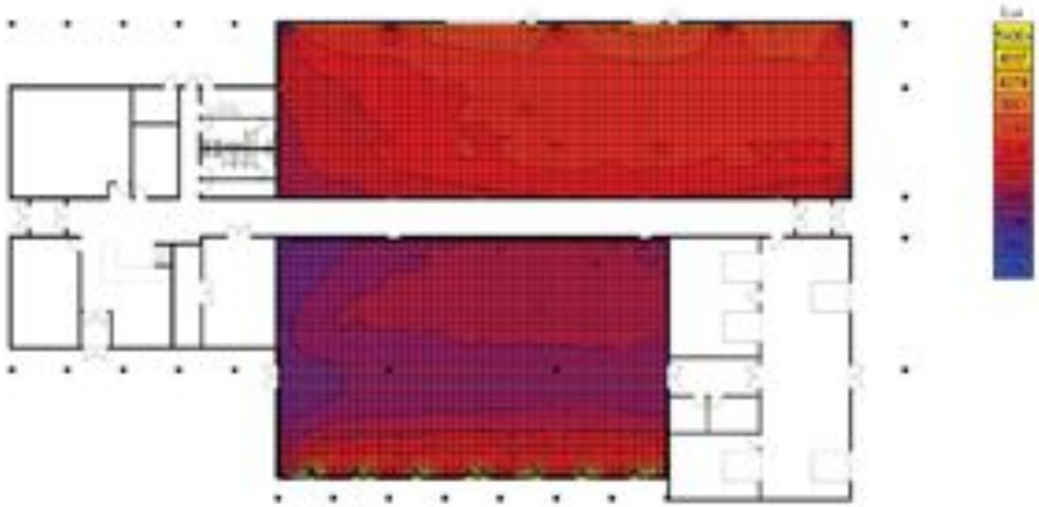
ANALYSIS DATA

SEPTEMBER 21

Clear Sky No Sun - 09:00 - Meets LEED V3.0 Requirements for these two spaces.

LEED V3.0 - Demonstrate 75% or more of all regularly occupied spaces areas achieve daylight illuminance levels of a minimum of 25 footcandles (fc) and a maximum of 500 fc in a clear sky condition on September 21 at 9 a.m. and 3 p.m.



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ANALYSIS DATA

SEPTEMBER 21

Clear Sky No Sun - 15:00 - Meets LEED V3.0 Requirements for these two spaces.

LEED V3.0 - Demonstrate 75% or more of all regularly occupied spaces areas achieve daylight illuminance levels of a minimum of 25 footcandles (fc) and a maximum of 500 fc in a clear sky condition on September 21 at 9 a.m. and 3 p.m.

Daylight Autonomy

Useful Daylight Illuminances

INTEGRATED DESIGN LAB

ANALYSIS DATA

Daylight Autonomy is defined as the percentage of the year that a certain location exceeds a certain minimum daylight threshold during a given set of hours. Therefore 80% of the year 300lux was achieved from 09:00 till 20:00.

Useful Daylight Illuminances (UDI) determines when daylight levels are 'useful' for the occupant, i.e. neither too dark (<100 lux) nor too bright (>2000 lux). Therefore <10-20% of the year light was 'useful'. This low percentage is due to the late occupancy times as well as the high values in the northern space and the lower levels in the southern space.

VOCATIONAL EDUCATION BUILDING

V. 1 DIGITAL MODEL ANALYSIS
6.05.09
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9.08.09
V.4 DIGITAL MODEL ANALYSIS
9.09.09
V.2 PHYSICAL MODEL ANALYSIS
9.22.09

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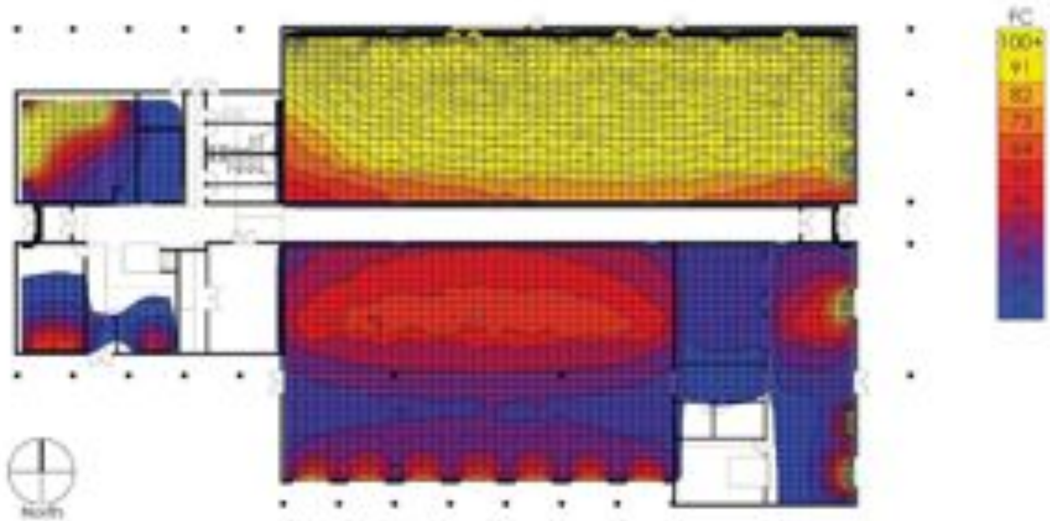


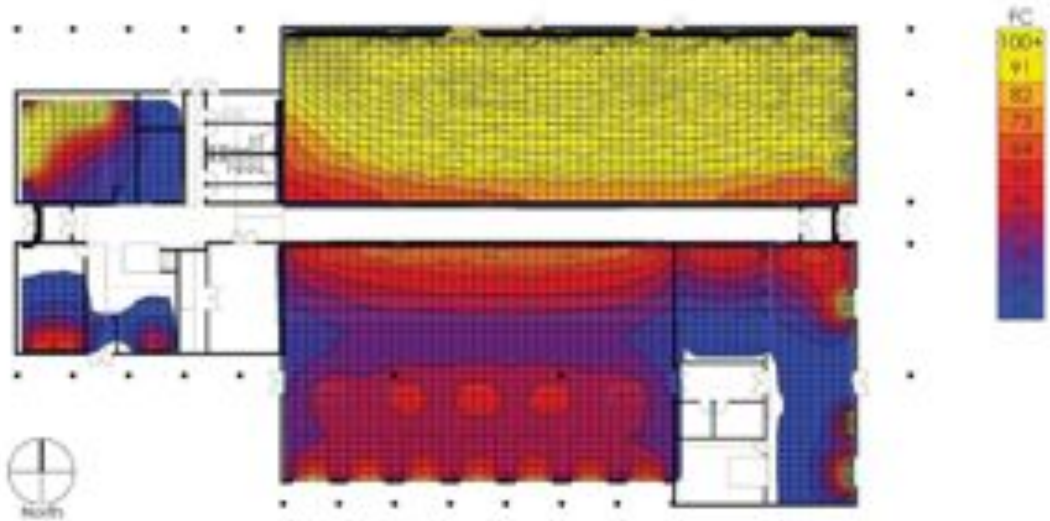
BASELINE

SEPTEMBER 21 - 12PM - OVERCAST SKY

GEOMETRY:
Model built from scratch in Ecotect using provided sketchup model and CAD building dimensions.

APERTURES:
N. Windows & 2 Clerestorys:
VLT-**70%** PPG Solarban 60 Clear
All other Glazing:
VLT- **55%** PPG Solarban 60 Clear

MATERIALITY:
Floor:
IRC- **40%** Slab Concrete
Walls:
IRC- **80%** Concrete



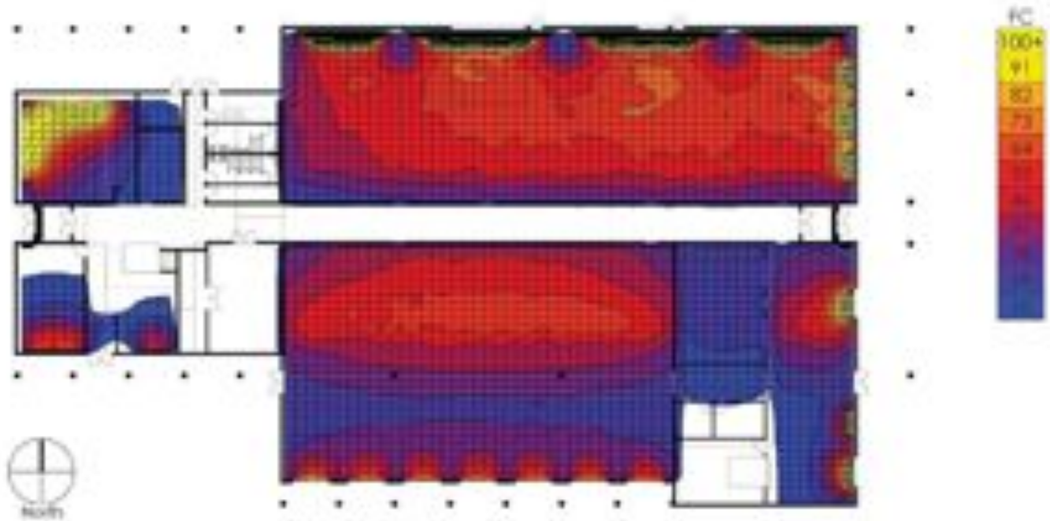
MODIFICATION 1

SEPTEMBER 21 - 12PM - OVERCAST SKY

GEOMETRY:
Moved the Autobody clerestory North 20' to wash the back wall with DL and added 5 (4x8) skylights 25' from S. wall.

APERTURES:
N. Windows & 2 Clerestorys:
VLT-**70%** PPG Solarban 60 Clr
All other Glazing:
VLT- **55%** PPG Solarban 60 Clr
Skylights:
VLT- **50%** Translucent Panel

MATERIALITY:
Floor:
IRC- **40%** Slab Concrete
Walls:
IRC- **80%** Concrete



MODIFICATION 2

SEPTEMBER 21 - 12PM - OVERCAST SKY

GEOMETRY:

Using the original autobody clerestory plan and reduced the glazing on the North facade: from approx. 3000sf glazing to 975sf.

APERTURES:

N. Windows & 2 Clerestorys:

VLT-**70%** PPG Solarban 60 Clr

All other Glazing:

VLT- **55%** PPG Solarban 60 Clr

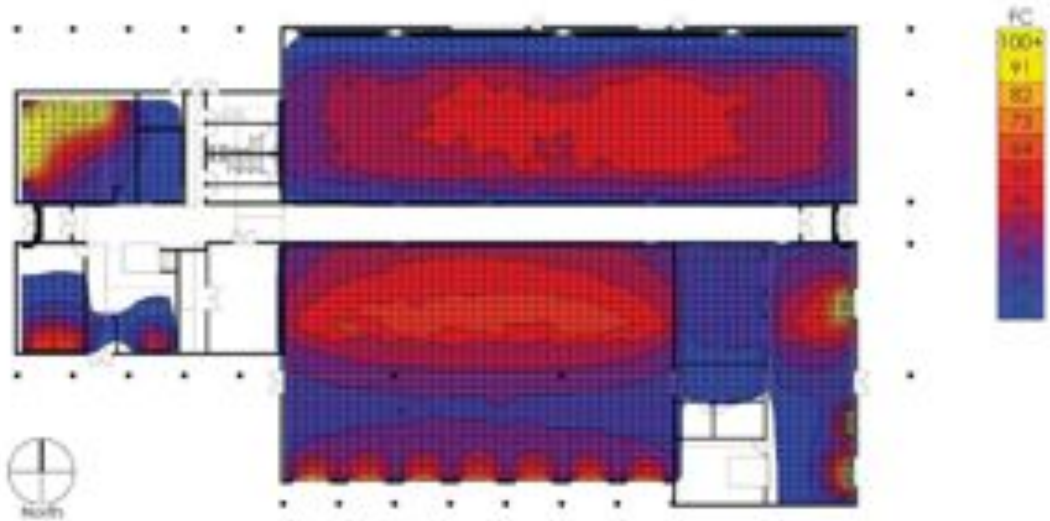
MATERIALITY:

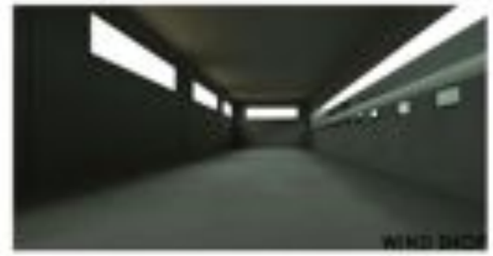
Floor:

IRC- **40%** Slab Concrete

Walls:

IRC- **80%** Concrete





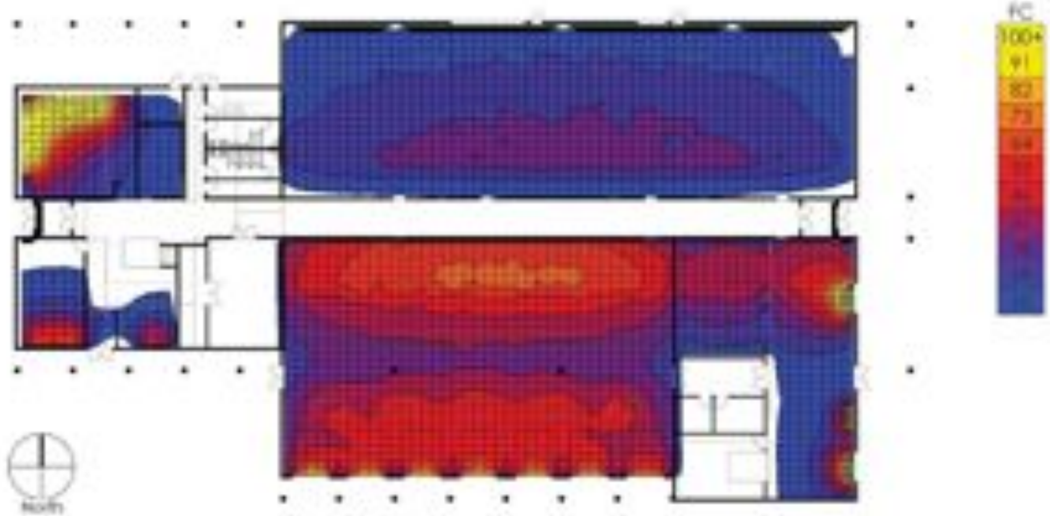
MODIFICATION 3

SEPTEMBER 21 - 12PM - OVERCAST SKY

GEOMETRY:
Used the original autobody clerestory plan and removed the view windows in the N shop to anaysis the daylight windows.

APERTURES:
N. Windows & 2 Clerestorys:
VLT-**70%** PPG Solarban 60 Clr
All other Glazing:
VLT- **55%** PPG Solarban 60 Clr

MATERIALITY:
Floor:
IRC- **40%** Slab Concrete
Walls:
IRC- **80%** Concrete



MODIFICATION 4

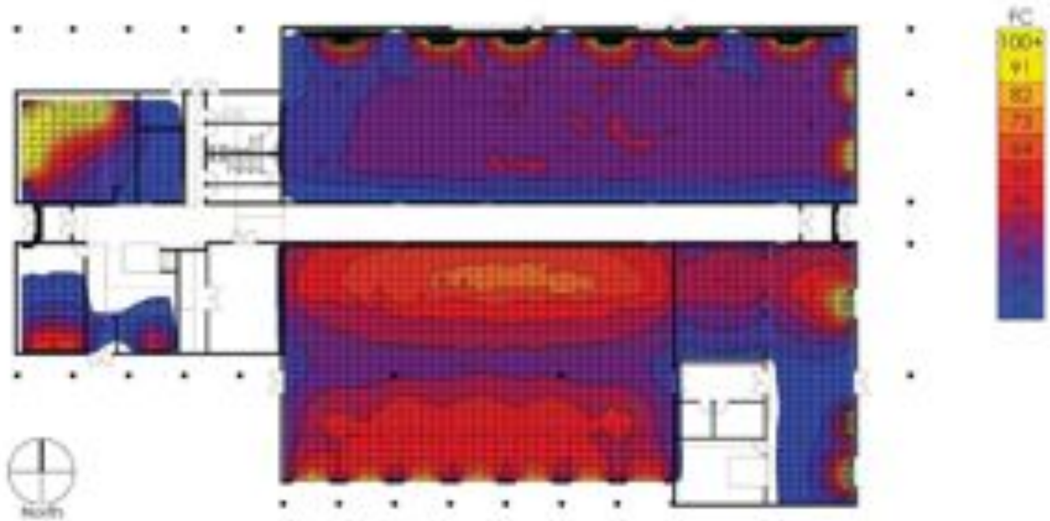
Note - This mod uses the modified clearestory plan in the autobody shop. This has little to no effect in the Windshop.

SEPTEMBER 21 - 12PM - OVERCAST SKY

GEOMETRY:
Removed the windshop N. Facade windows to test the additions of 6 (4x8) skylights.

APERTURES:
N. Windows & 2 Clerestorys:
VLT-**70%** PPG Solarban 60 Clr
All other Glazing:
VLT- **55%** PPG Solarban 60 Clr
Skylights:
VLT- **50%** Translucent Panel

MATERIALITY:
Floor:
IRC- **40%** Slab Concrete
Walls:
IRC- **80%** Concrete



MODIFICATION 5

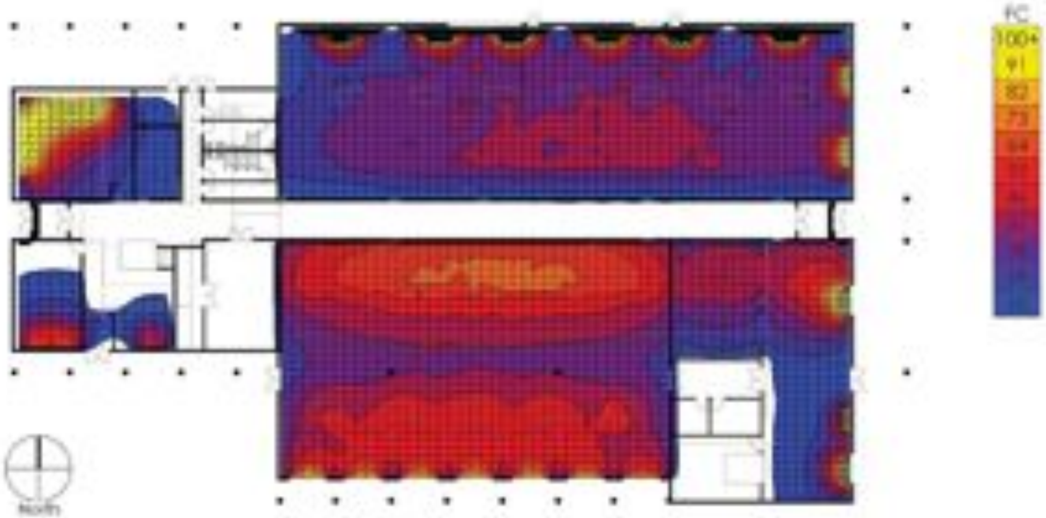
Note - This mod uses the modified clearestory plan in the autobody shop. This has little to no effect in the Windshop.

SEPTEMBER 21 - 12PM - OVERCAST SKY

GEOMETRY:
Added the windshop N. Facade view windows to test with the 6 (4x8) skylights.

APERTURES:
N. Windows & 2 Clerestorys:
VLT-**70%** PPG Solarban 60 Clr
All other Glazing:
VLT- **55%** PPG Solarban 60 Clr
Skylights:
VLT- **50%** Translucent Panel

MATERIALITY:
Floor:
IRC- **40%** Slab Concrete
Walls:
IRC- **80%** Concrete



MODIFICATION 6

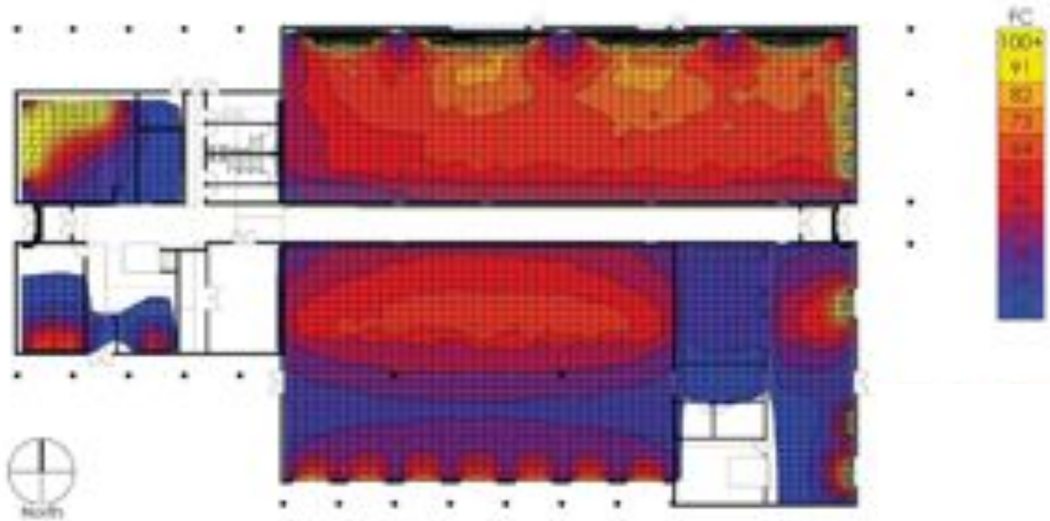
Note - This mod uses the modified clearestory plan in the autobody shop. This has little to no effect in the Windshop.

SEPTEMBER 21 - 12PM - OVERCAST SKY

GEOMETRY:
Moved the 6 (4x8) skylights near the middle of the ceiling/roof.

APERTURES:
N. Windows & 2 Clerestorys:
VLT-**70%** PPG Solarban 60 Clr
All other Glazing:
VLT- **55%** PPG Solarban 60 Clr
Skylights:
VLT- **50%** Translucent Panel

MATERIALITY:
Floor:
IRC- **40%** Slab Concrete
Walls:
IRC- **80%** Concrete



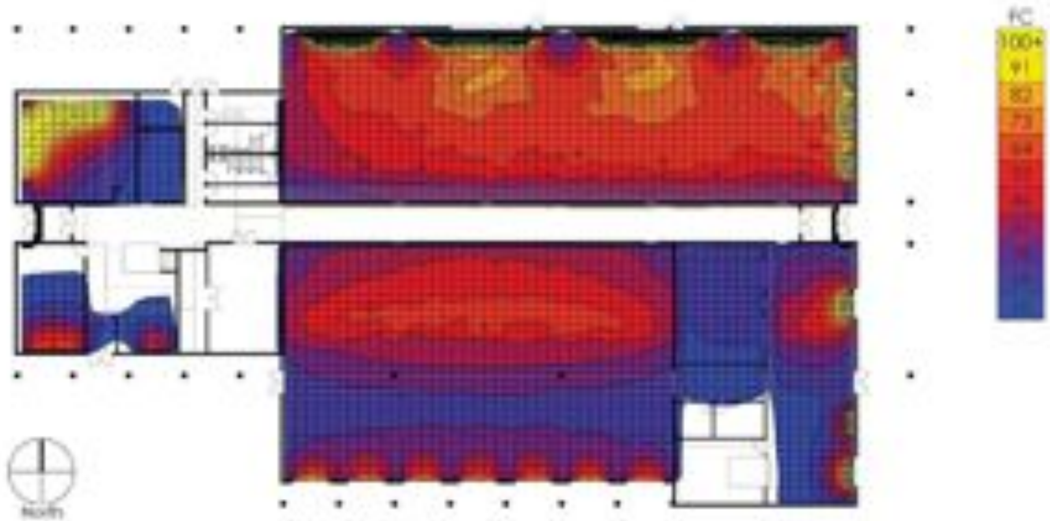
MODIFICATION 7

SEPTEMBER 21 - 12PM - OVERCAST SKY

GEOMETRY:
Using mod 2 N. facade window layout. Added light diffusion devices above the corridor to bounce light into autobody shop. See section.

APERTURES:
N. Windows & 2 Clerestorys:
VLT-**70%** PPG Solarban 60 Clr
All other Glazing:
VLT- **55%** PPG Solarban 60 Clr

MATERIALITY:
Floor:
IRC- **40%** Slab Concrete
Walls:
IRC- **80%** Concrete
Light Diffusion Device:
VLT- **24%** Translucent Panel



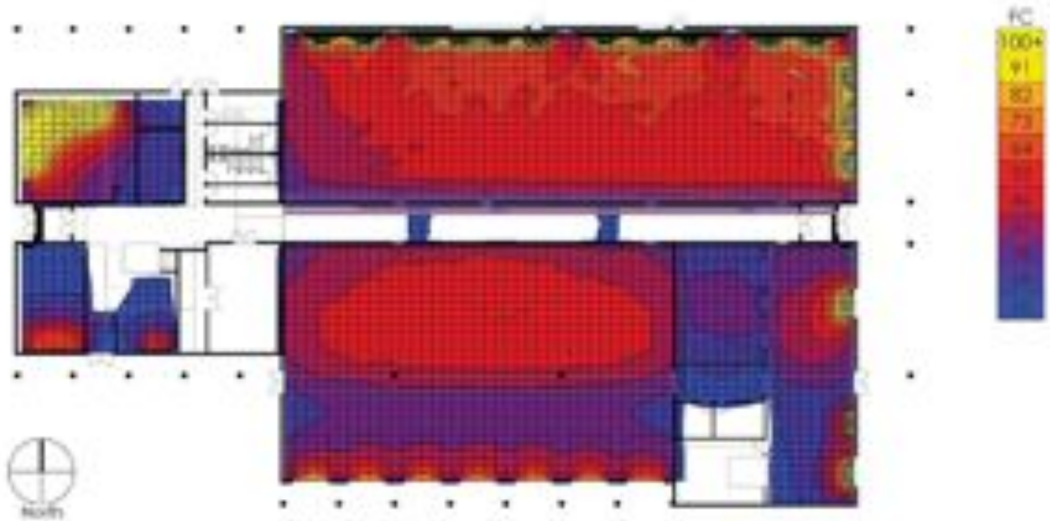
MODIFICATION 8

SEPTEMBER 21 - 12PM - OVERCAST SKY

GEOMETRY:
Changed materiality of light diffusion device.

APERTURES:
N. Windows & 2 Clerestorys:
VLT-**70%** PPG Solarban 60 Clr
All other Glazing:
VLT- **55%** PPG Solarban 60 Clr

MATERIALITY:
Floor:
IRC- **40%** Slab Concrete
Walls:
IRC- **80%** Concrete
Light Diffusion Device:
IRC- **70%** Opaque Plaster Panel



MODIFICATION 9

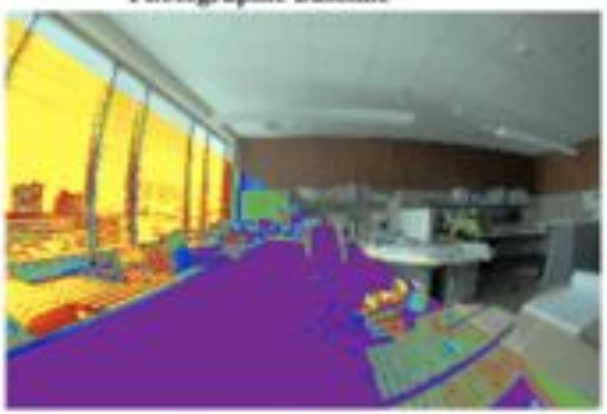
SEPTEMBER 21 - 12PM - OVERCAST SKY

GEOMETRY:
Sizing of daylight (DL) and view (VW) windows on N. and E. Facade. (North =11DL & 11 VW (3'4" x 7'8") ~ 560sf of glazing) & (East = 3 DL and 3 VW ~ 154sf of glazing)

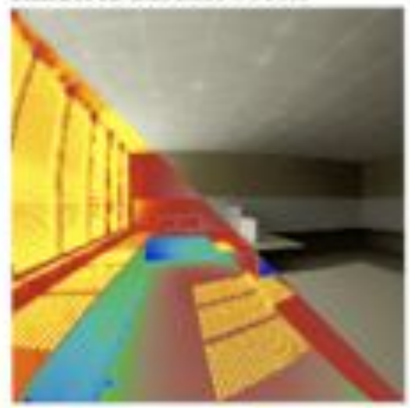
APERTURES:
N. Windows & 2 Clerestorys:
VLT-**70%** PPG Solarban 60 Clr
All other Glazing:
VLT- **55%** PPG Solarban 60 Clr

MATERIALITY:
Floor: IRC- **40%** Slab Concrete
Bottom Walls:
IRC- **70%** Concrete
Upper Walls & Ceiling:
IRC- **80%** Concrete
Light Diffusion Device:
IRC- **70%** Opaque Plaster Panel

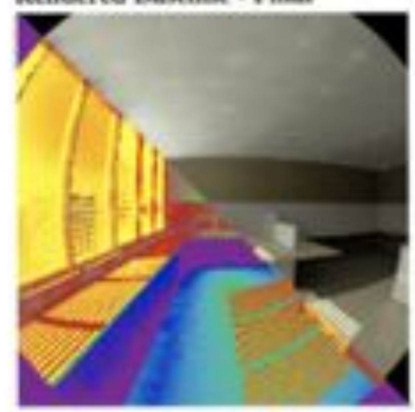
Photographic Baseline



Rendered Baseline Proces



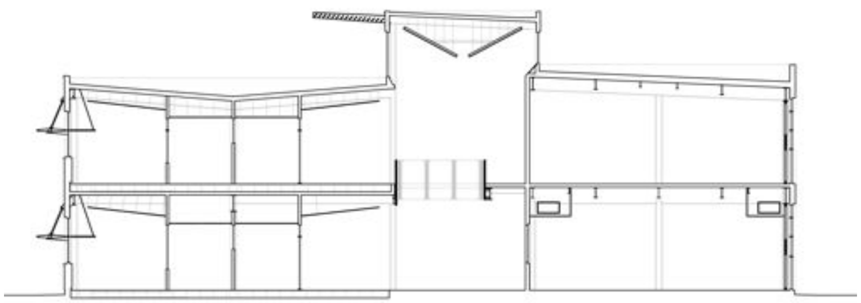
Rendered Baseline - Final



CALIBRATING EXPECTATIONS

CAES – Idaho Falls, ID

GSBS Architects, Salt Lake



VOCATIONAL EDUCATION BUILDING

V. 1 DIGITAL MODEL ANALYSIS
6.05.09
V.2 DIGITAL MODEL ANALYSIS
6.19.09
V.3 DIGTIAL MODEL ANALYSIS
7.15.09
V.1 PHYSICAL MODEL ANALYSIS
9.08.09
V.4 DIGITAL MODEL ANALYSIS
9.09.09
V.2 PHYSICAL MODEL ANALYSIS
9.22.09

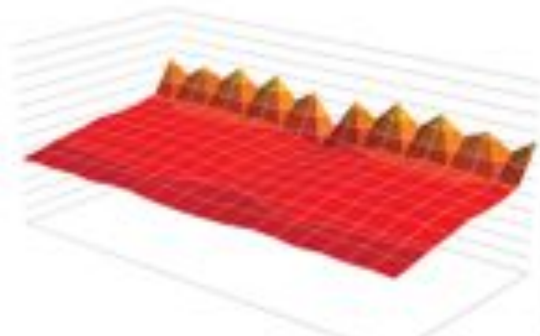
INTEGRATED DESIGN LAB

DAYLIGHT ANALYSIS: WINDSHOP

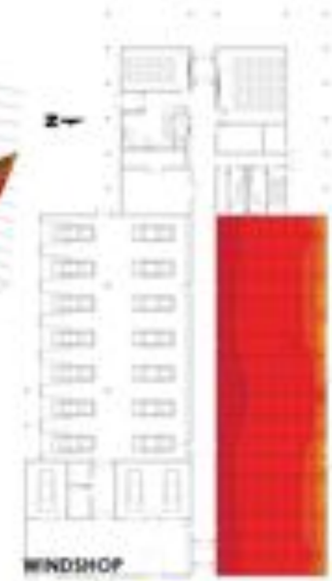
The Windshop space would be used to teach installation and repair of wind turbines. From a daylighting stand point, we are investigating design options that would provide adequate illumination for the critical visual tasks occuring in the space. Another issue that must be taken into account is the glare that a southfacing clerestory could create.

Wind shop: added skylights, modified north facade glazing.
Analysis of light diffuser above corridor.

ADEQUATE
DAYLIGHT (%)



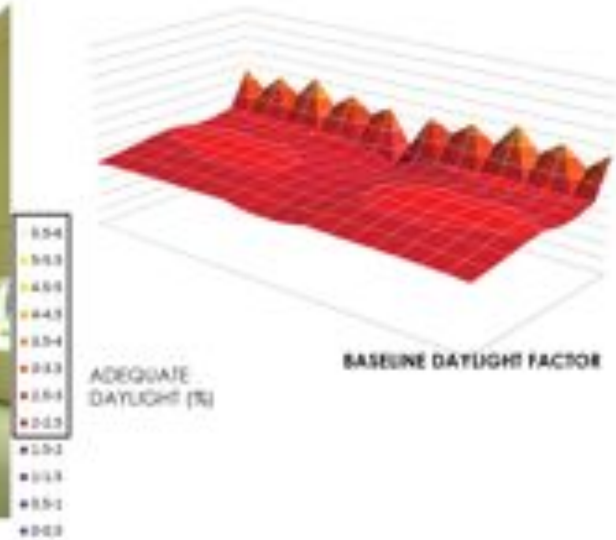
BASELINE DAYLIGHT FACTOR

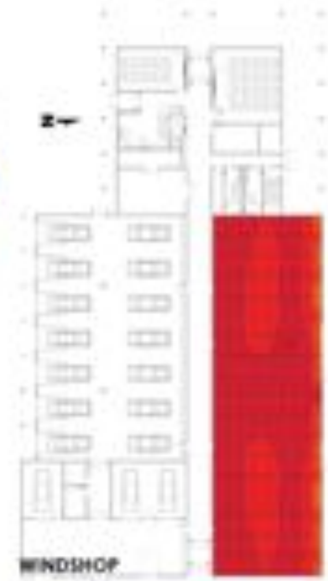


BASELINE

WINDSHOP BASELINE

Knowing that full glazing on the north wall was too much, measurements on the best glazing ratio were tested with a physical model in the skybox. The baseline case for the glazing has 10 window bays each 9' wide. Openings start at 4' high for lower view windows and 3' high for top windows. There is no re-light baffle in the baseline case. The above floor plan graphically shows the amount of daylight hitting the work plane at 32 inches above the floor.



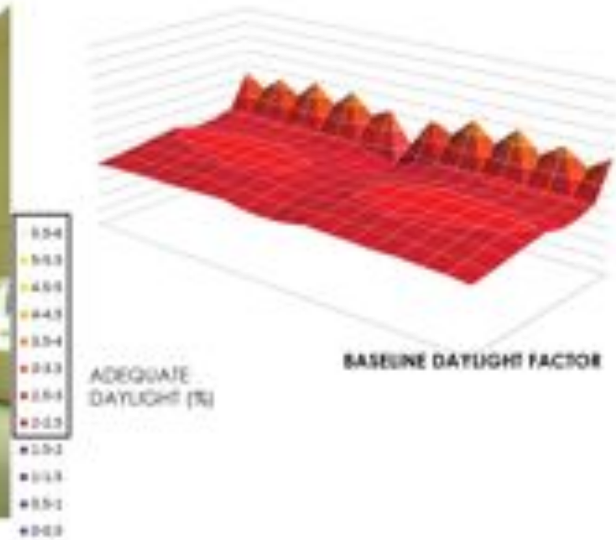


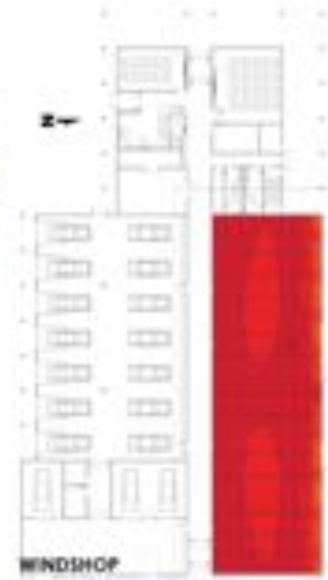
MODIFICATION 1

WINDSHOP MODIFICATION 1

Modification 1 tests the effects of a 6' high flat baffle hanging from the bottom cord of the trusses. It is positioned approximately 10' back from clerestory glazing.

Daylight factor readings stay above 2 but light is a little less even against the southern side of the room.



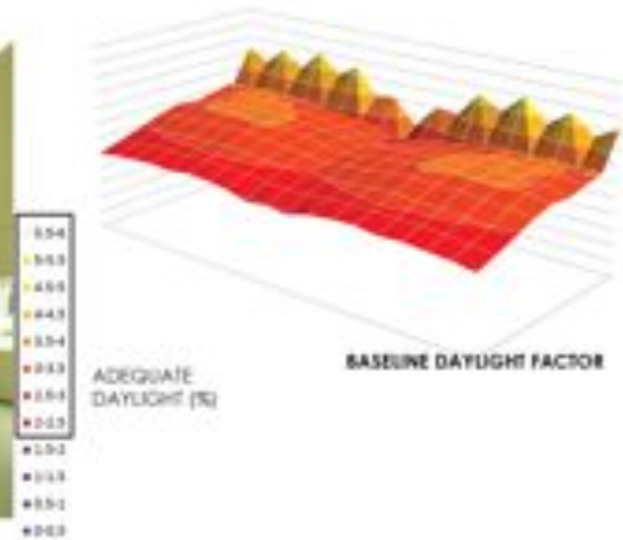


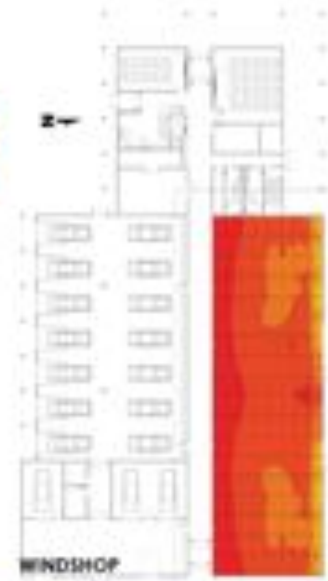
MODIFICATION 2

WINDSHOP MODIFICATION 2

Modification 2 tests the effects of a 6' high curved baffle hanging from the bottom cord of the trusses. It is positioned approximately 10' back from clerestory glazing.

Very little change occurs between the straight baffle to the curved.



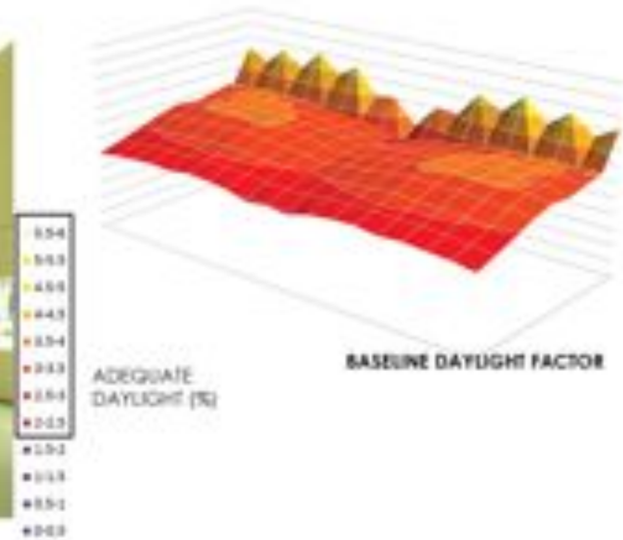


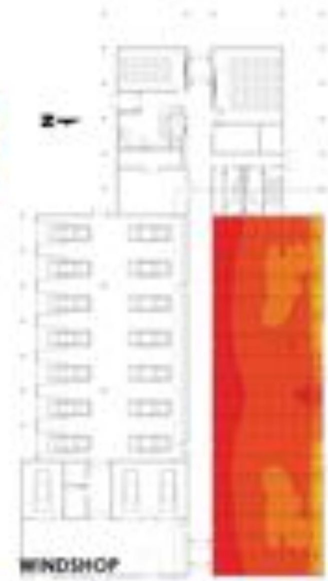
MODIFICATION 3

WINDSHOP MODIFICATION 3

Modification 3 changes the north wall glazing. The lower view window stays at 4' tall and the upper glazing changes from 3' tall to 5' tall. The 6' high curved baffle is used. It is positioned approximately 10' back from clerestory glazing.

Very little changes at the north wall but large changes in the center of the space. The central readings jump from 2.0-2.5 up to 2.5-3.5.



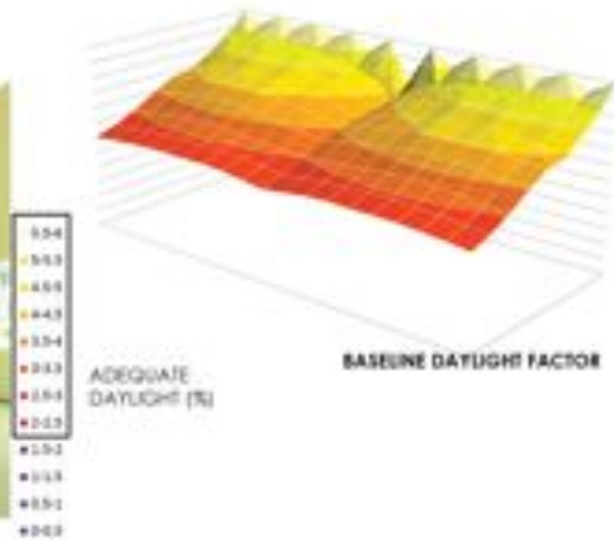


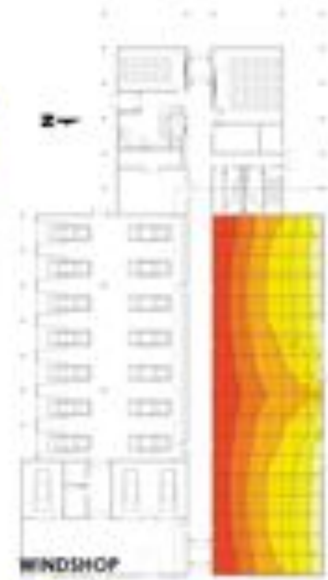
MODIFICATION 4

WINDSHOP MODIFICATION 4

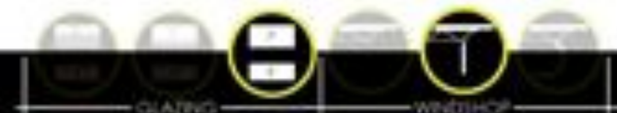
Modification 4 keeps the lower view window at 4' tall and the upper glazing at 5' tall. The 6' high straight baffle is used. It is positioned approximately 10' back from clerestory glazing.

Very little changes between modification 3 and 4.





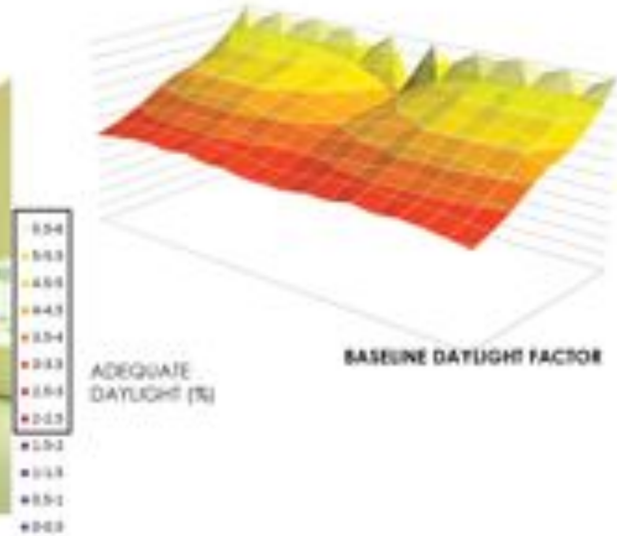
MODIFICATION 5

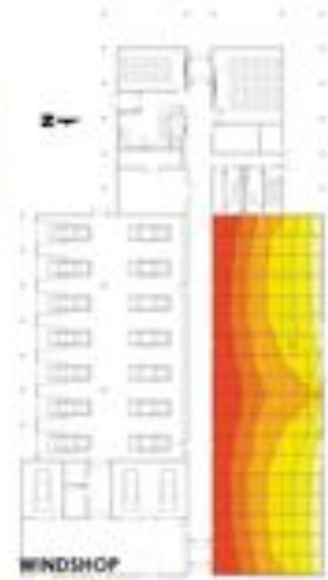


WINDSHOP MODIFICATION 5

Modification 5 changes the north wall glazing. The lower view window changes from 4' tall to 5' tall, and the upper glazing changes from 5' tall to 7' tall. The 6' high straight baffle is used. It is positioned approximately 10' back from clerestory glazing.

Lighting levels rise dramatically. Against the north glazing wall they jump above 6 and fall off to 3 at the back of the room.



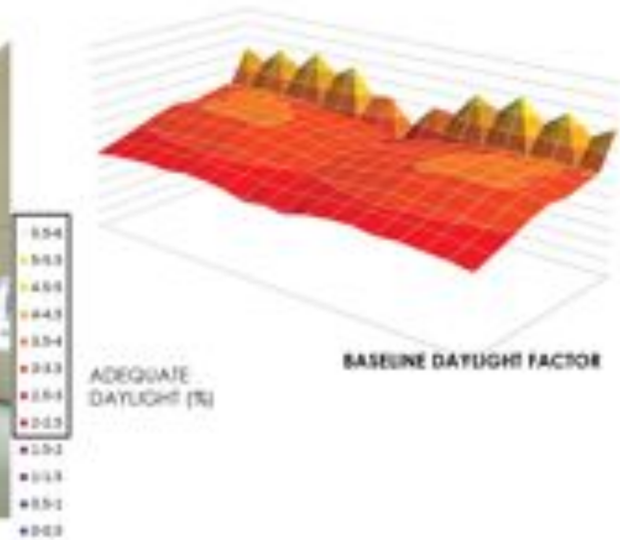


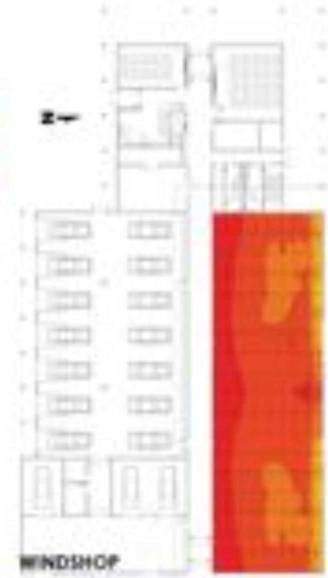
MODIFICATION 6

WINDSHOP MODIFICATION 6

Modification 6 keeps the lower view window at 5' tall, and the upper glazing changes at 7' tall. The 6' high curved baffle is used. It is positioned approximately 10' back from clerestory glazing.

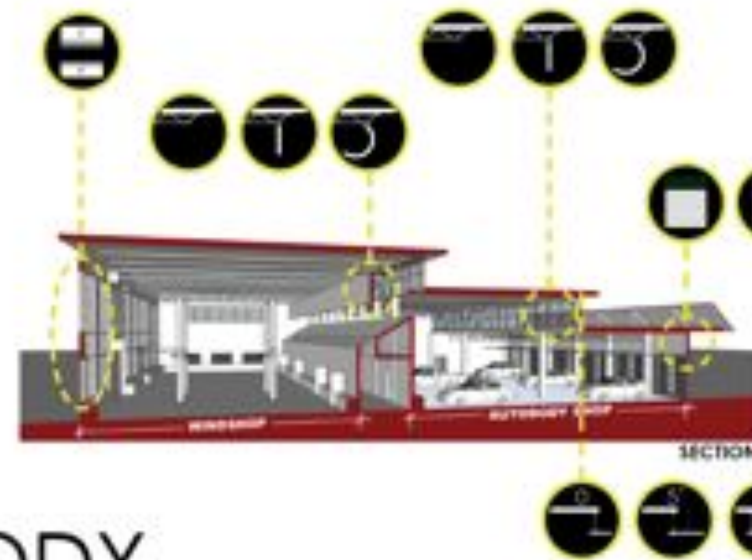
Little change between modification 5 and 6. Some changes in lighting against the north wall.





WINDSHOP SELECTION MOD 4

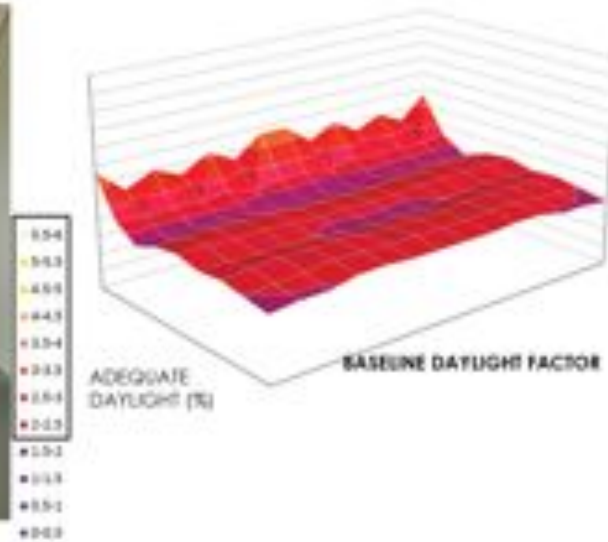
Modification 4 is the preferred modification. Regarding visual comfort in the photographs, modification 4 was comfortably illuminated without any areas of concern for glare. The straight baffle blocks direct southern sun while deflecting light into the relight at the northern side of the autobody shop. The horizontal illumination graphs illustrate a similar story to the photograph. Overall, the room is within the adequate daylight factor percentage and relatively evenly daylighted. One addition that could be made is to use a translucent material on the baffle to reflect light as well as illuminate that surface adjacent to the clerestory.

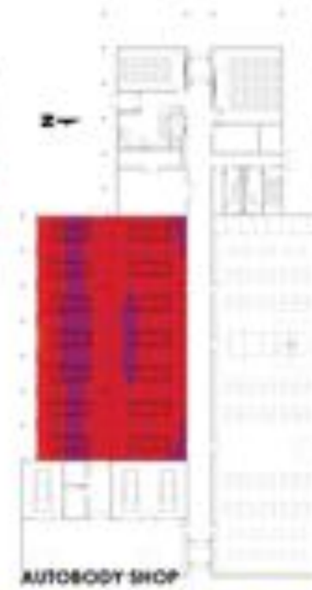


ANALYSIS DATA: AUTOBODY

For the autobody shop we investigated: a) how modifications in the windshop affect the daylight coming through the relight into the autobody, and b) how iterations within the autobody shop can improve illuminance levels and daylight uniformity.

Autobody shop: Analysis of clerestory baffle type, clerestory position, daylighting window above garage door
Wind shop: Analysis of clerestory baffle type

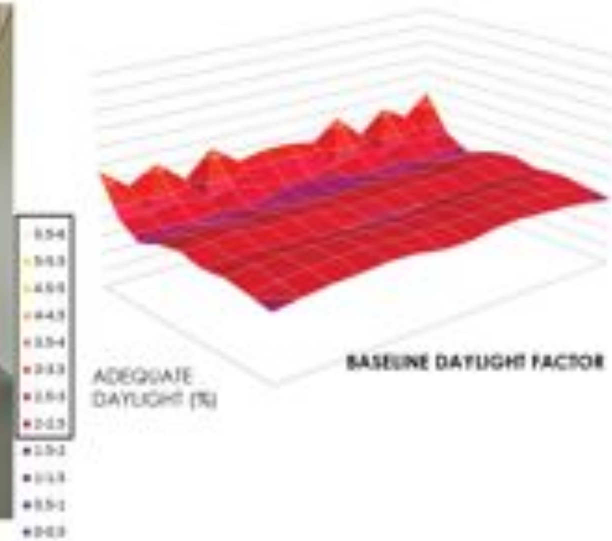


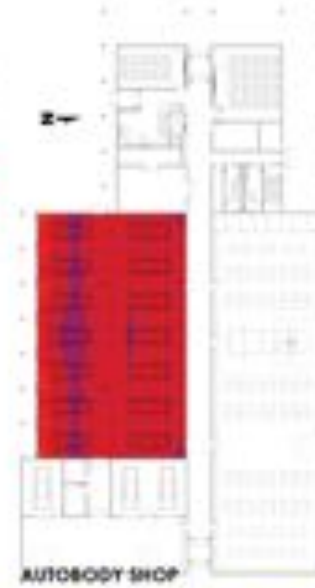


BASELINE

AUTOBODY SHOP BASELINE

Because the modifications in the windshop have an effect on the daylight in the autobody shop. we observed how a baffle in the windshop would change the quality of daylight in the autobody. the dimensions of the glazing on the north facade of the windshop will be fixed. The baseline case for the glazing has 10 window bays each 9' wide. Openings start at 4' high for lower view windows and 3' high for top windows. There is no re-light baffle in the baseline case. The above floor plan graphically shows the amount of daylight hitting the work plane at 32 inches above the floor.

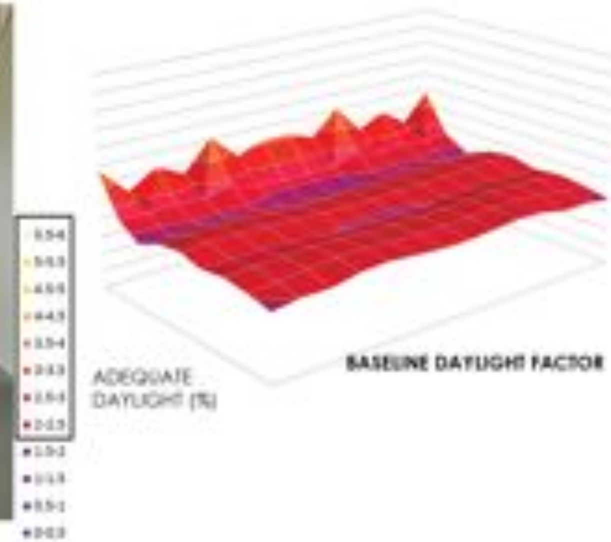


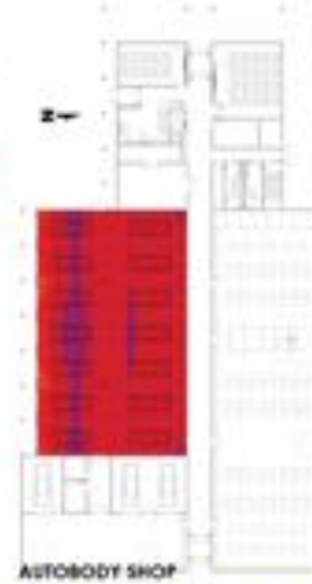


MOD 1

AUTOBODY SHOP MODIFICATION 1

Modification 1 will used the selected window dimensions for the north facade of the windshop as well as the straight baffle to deflect light into the autobody. In the autobody, mod1 will have no baffle on the clerestory, and no glazing above the garage doors.

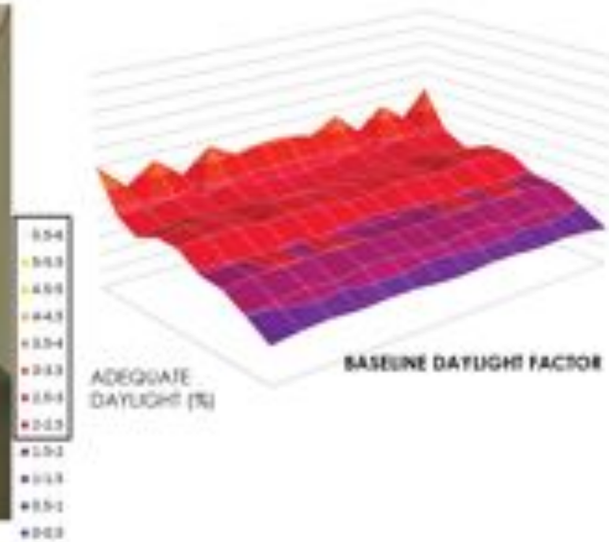


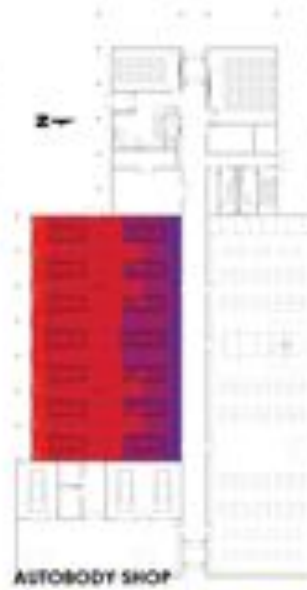


MOD 2

AUTOBODY SHOP MODIFICATION 2

Modification 2 will used the selected window dimensions for the north facade of the windshop with a curved baffle to deflect light into the autobody. In the autobody, mod 2 will have no baffle on the clerestory, and no glazing above the garage doors.

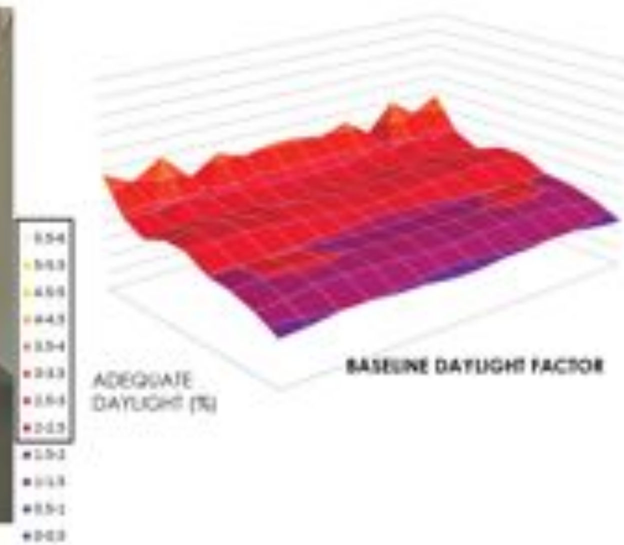


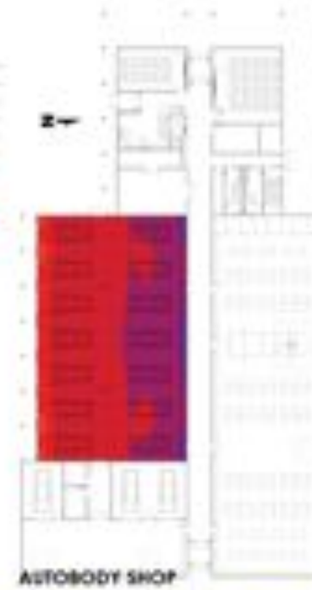


MOD 3

AUTOBODY SHOP MODIFICATION 3

Modification 3 will used the selected window dimensions for the north facade of the windshop with a straight baffle to deflect light into the autobody. In the autobody, mod 3 will have a curved baffle on the clerestory, and no glazing above the garage doors.

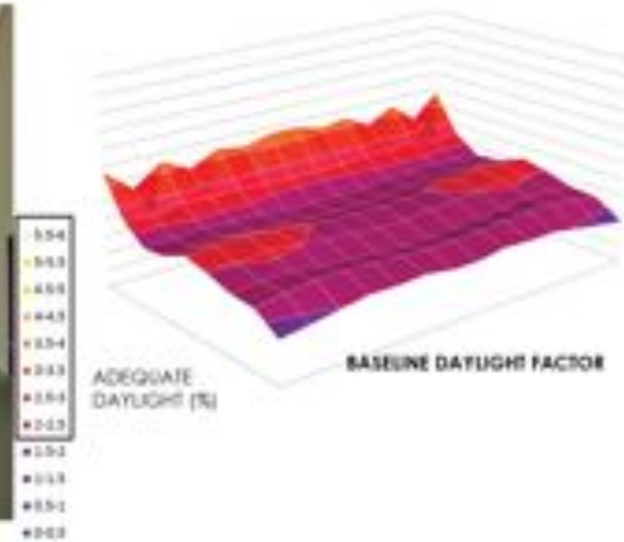


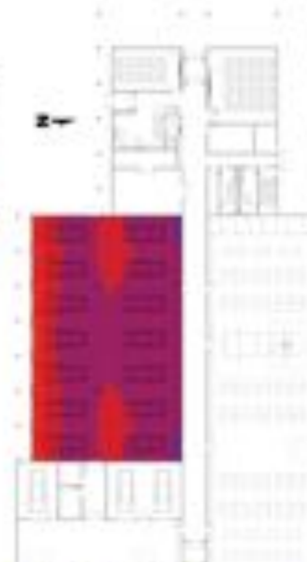


MOD 4

AUTOBODY SHOP MODIFICATION 4

Modification 4 will used the selected window dimensions for the north facade of the windshop with a straight baffle to deflect light into the autobody. In the autobody, mod 4 will have a straight baffle on the clerestory, and no glazing above the garage doors.

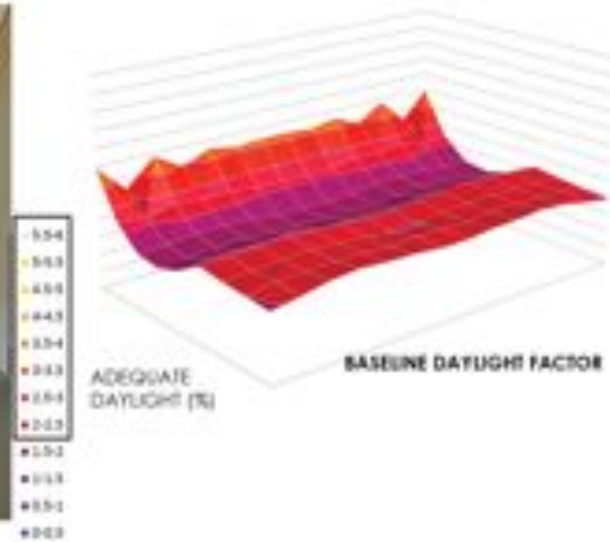


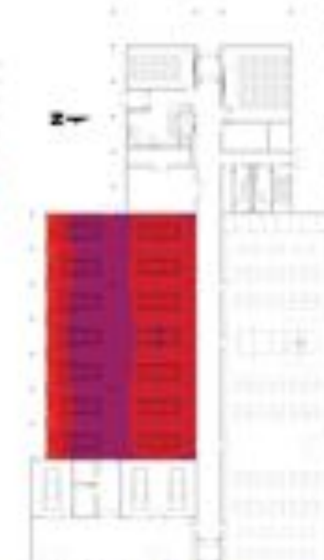


MOD 5

AUTOBODY SHOP MODIFICATION 5

Modification 5 will used the selected window dimensions for the north facade of the windshop with a straight baffle to deflect light into the autobody. In the autobody, mod 5 will have a curved baffle on the clerestory, a shift of the clerestory five feet north, and no glazing above the garage doors.

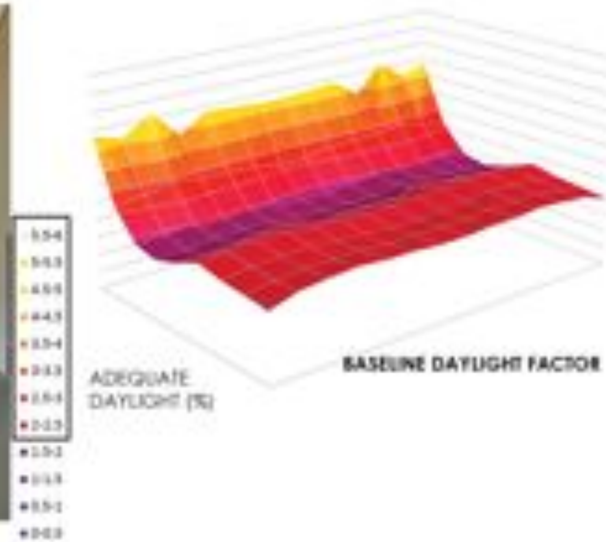


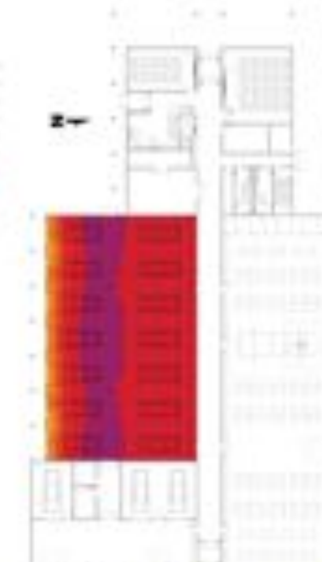


MOD 6

AUTOBODY SHOP MODIFICATION 6

Modification 6 will used the selected window dimensions for the north facade of the windshop with a straight baffle to deflect light into the autobody. In the autobody, mod 6 will have a curved baffle on the clerestory, a shift of the clerestory ten feet north, and no glazing above the garage doors.

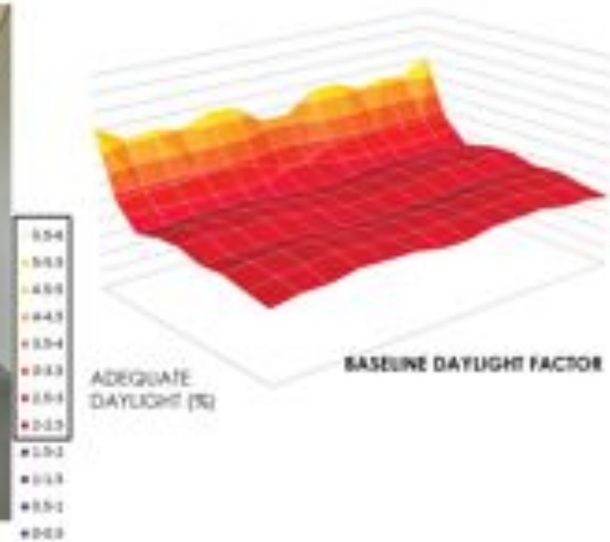


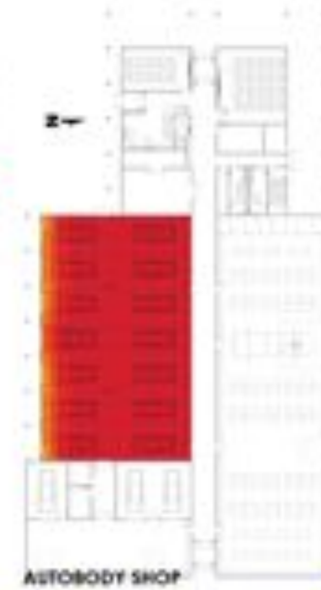


MOD 7

AUTOBODY SHOP MODIFICATION 7

Modification 7 will used the selected window dimensions for the north facade of the windshop with a straight baffle to deflect light into the autobody. In the autobody, mod 7 will have a curved baffle on the clerestory, a shift of the clerestory ten feet north, and clear glazing above the garage doors.

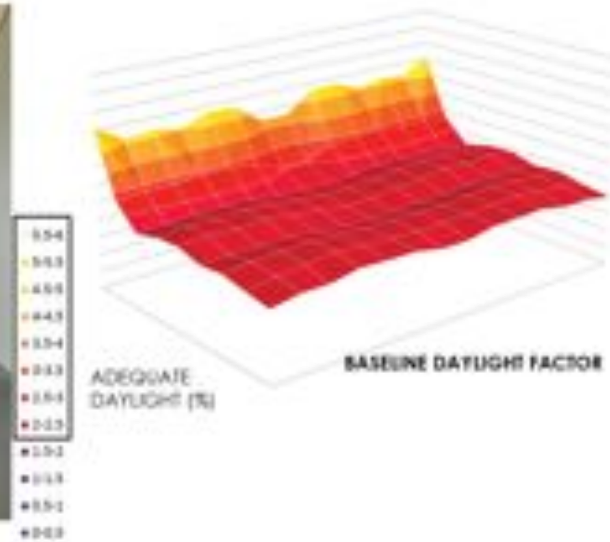


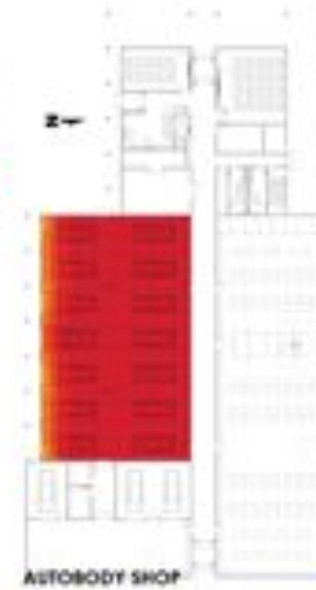


MOD 8

AUTOBODY SHOP MODIFICATION 8

Modification 8 will used the selected window dimensions for the north facade of the windshop with a straight baffle to deflect light into the autobody. In the autobody, mod 8 will have no baffle on the clerestory, original clerestory location, and clear glazing above the garage doors.





MOD 8

AUTOBODY SELECTION

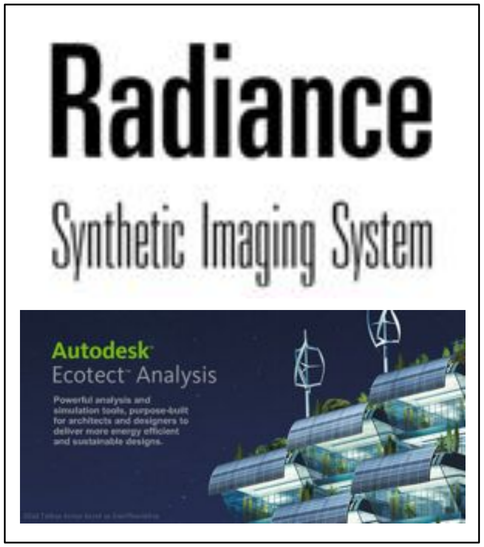
AUTOBODY SHOP MODIFICATION 8

Although the daylight uniformity is not as even as other options, modification 8 is the preferred option because of the illumination levels within the desired range. Visually, the space is comfortable and well lit. An area of concern would be potential glare caused by the south facing clerestory. Careful design of overhangs or mulitple exterior louvres would satisfy the issue.



COMBINED

Shown above are the hdr images of the chosen modification of the three studied spaces

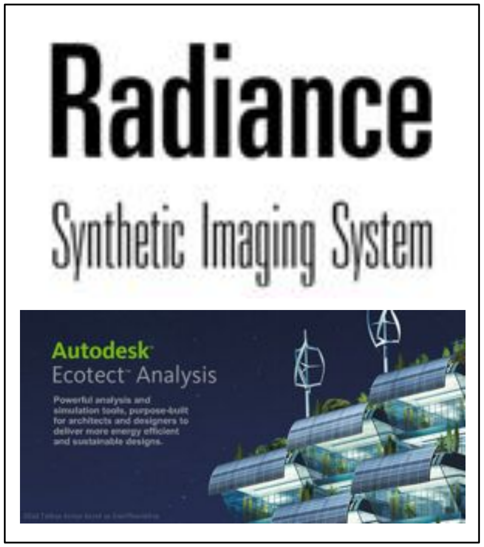


Comparisons from Architects' Perspective

- general appearance of images
- type of data available
- usefulness of data to inform design decisions
- closing the loop
- time investment

MODELING COMPARISIONS*

* Not a validation exercise



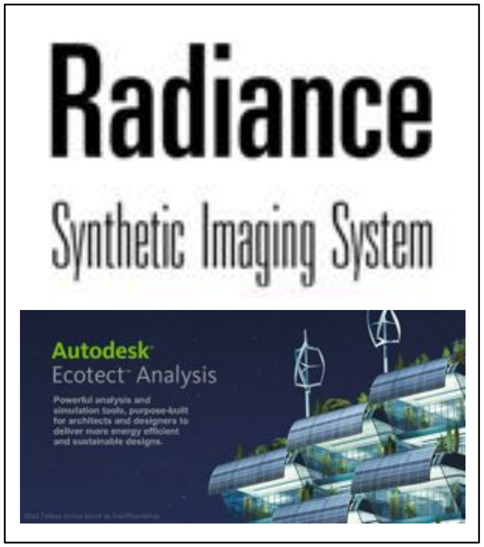
?

MODELING COMPARISIONS

- Detailed – Single Case
- Detailed - Iterative
- Simple – Single Case
- Simple – Iterative

(Vocational Education Building – CTA Group)

(Airport Terminal – HDR Inc.)



?

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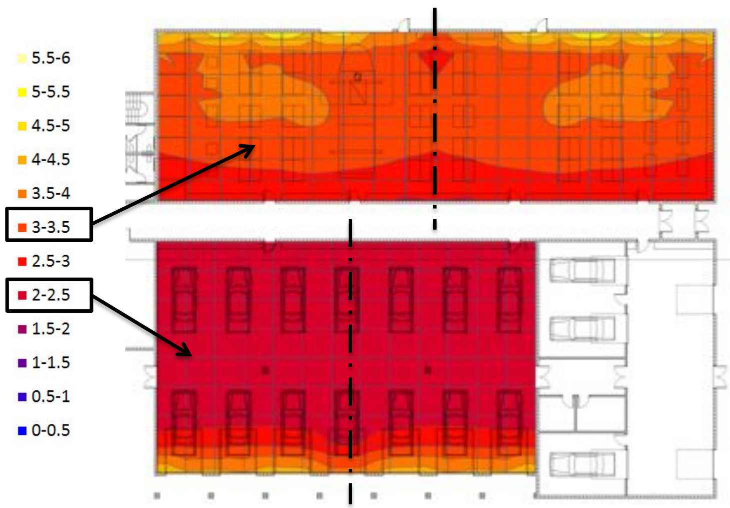
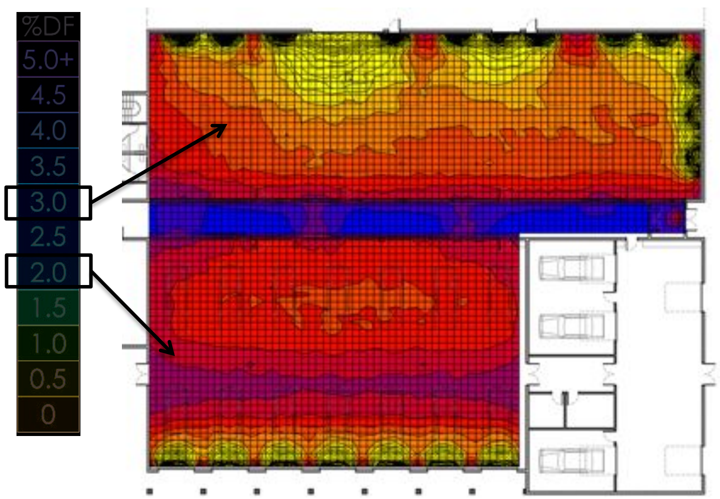
(Airport Terminal – HDR Inc.)



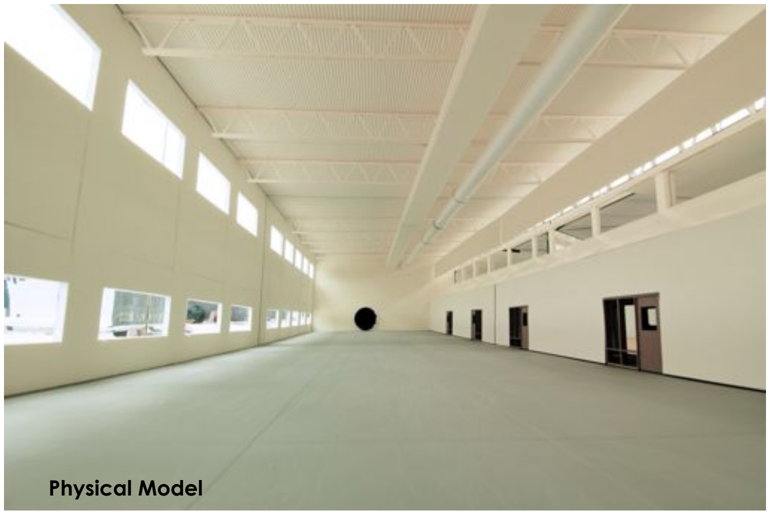
Physical Model



Digital Model

DAYLIGHT FACTOR

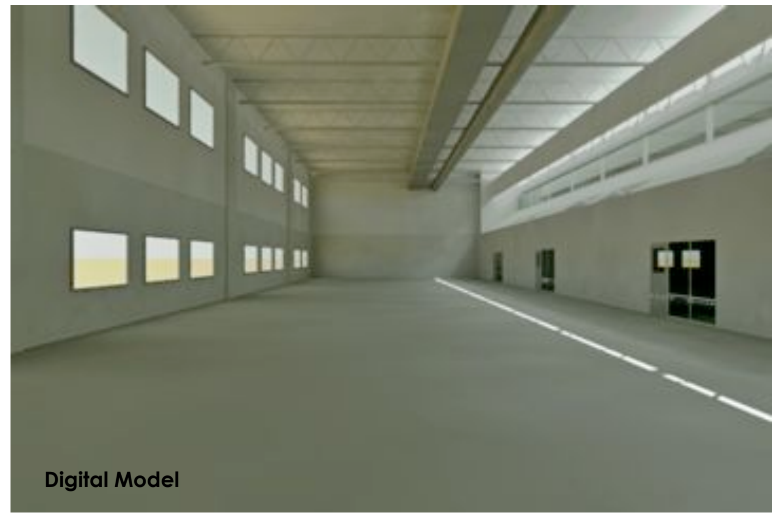
Several key factors are to be considered when comparing these two models. Only half of the physical model was actually constructed with the rest being represented by a mirror placed at midpoint, this mirroring is helpful in keeping the model to a manageable size, but reduced accuracy somewhat. The physical model also has no glass built in and must account for the specific VLT of the glass with a universal reduction factor in Excel after data collection.


Physical Model


Digital Model

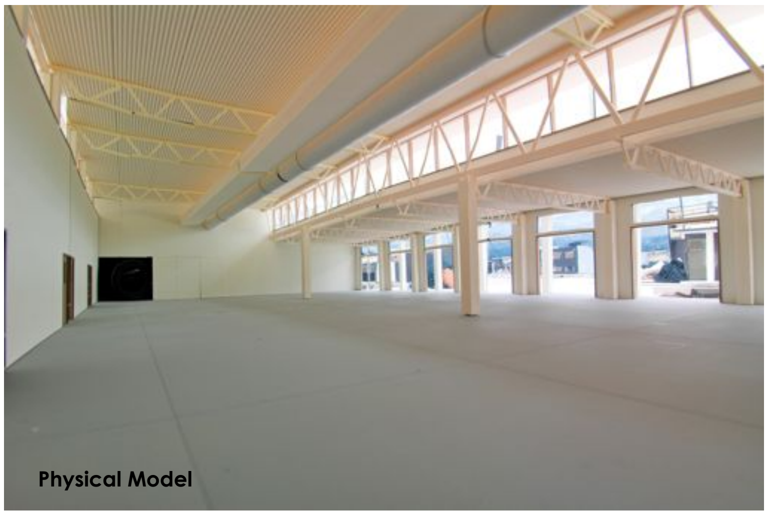
WINDSHOP September 21st Overcast


Physical Model


Digital Model

WINDSHOP September 21st Sunny 12:00pm

[redacted]



AUTOSHOP September 21st Overcast


Physical Model


Digital Model

AUTOSHOP September 21st Sunny 12:00pm

[redacted]

Simple Tone Mapping Exercise

HDR Shop

Artizen

Photoshop

RAD Display

HDR Shop (Reinhard Tone Mapping)

Photomatix

Radiance Image Viewer

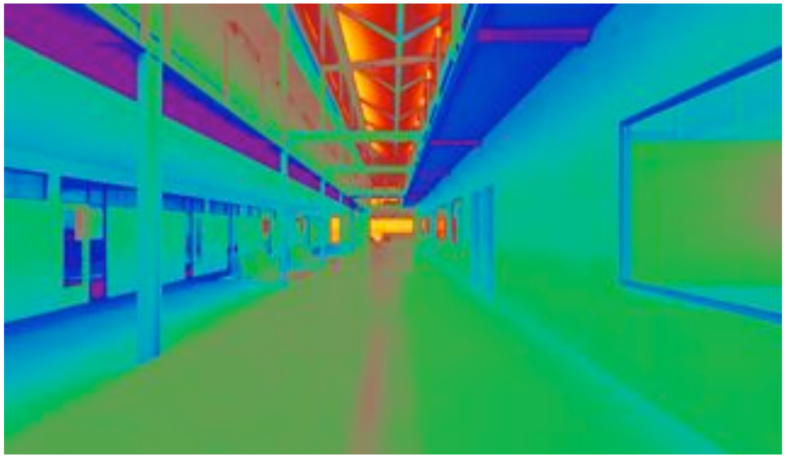
Easy HDR

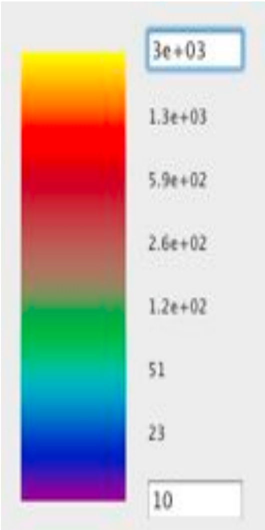
Photosphere (MAC)

Preview (MAC)

"manual" HDR

Most designers do not understand luminance…





…and depending…drastically different conclusions.

Preview (MAC)

“manual” HDR

PHYSICAL MODEL

CONSTRUCTION – Building a complex physical model may take several days to a week to complete. Modeling construction may need to account for iterative testing and the ability to modify the model for different analysis. This model had adjustable clerestory positions, window sizing and baffle location and type.
75.5 Hr.

DATA COLLECTION / ANALYSIS – Time in this process is driven by the amount and difficulty of modification being tested. In this project 14 physical iterations were tested during analysis.
48 Hr.

DOCUMENATATION/REPORTING – Displaying data in a meaningful and simple manner is essential.
19.75 Hr.

143.25 Hr. Total for 14 iterations ~ 10.23 hours each

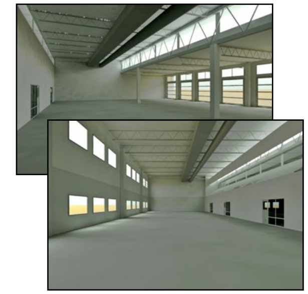
DIGITAL MODEL

CONSTRUCTION – A complex digital model may be imported from other software platforms into Ecotect or directly to Radiance, however more this often requires significant remodeling. Extreme detail is possible but increased vertices results in increased processing time.
86.5 Hr.

DATA COLLECTION / ANALYSIS – This analysis included Daysim and Radiance runs but excludes computer processing time entirely. 18 digital iterations were tested during analysis.
56 Hr.

DOCUMENATATION/REPORTING – Displaying data in a meaningful and simple manner is essential.
58 Hr.

200.5 Hr. Total for 18 iterations ~ 11.11 hours each
(Plus computer processing time)



MODELING Detailed Iterative

Depending on the project and level of design resolution a highly detailed model can be created and simulated with both digital and physical tools.

PHYSICAL MODEL

CONSTRUCTION – **50 Hr.**

DATA COLLECTION / ANALYSIS – **14 Hr.**

DOCUMENATATION/REPORTING – **2.5 Hr.**

66.5 Hr. Total

DIGITAL MODEL

CONSTRUCTION – **26 Hr.**

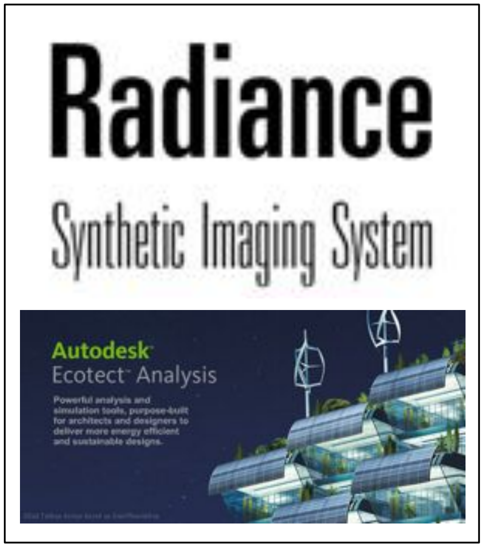
DATA COLLECTION / ANALYSIS – **31.5 Hr.**
- 26.5 Hr. Radiance
- 5 Hr. DAYSIM

DOCUMENATATION/REPORTING – **4.5 Hr.**

62 Hr. Total

MODELING Detailed Single Case

Depending on the project and level of design resolution a highly detailed model can be created and simulated with both digital and physical tools.



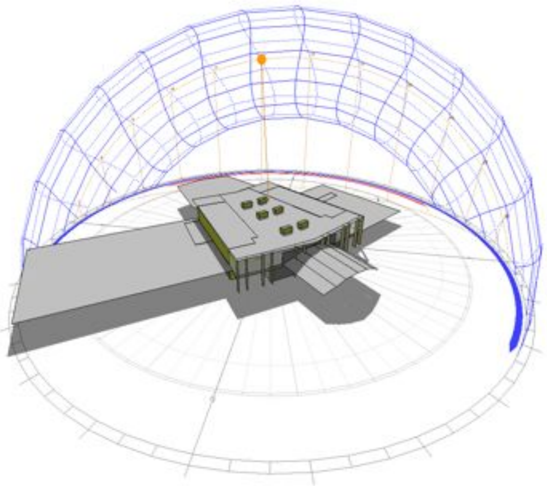
?

MODELING COMPARISIONS

- Detailed – Single Case
- Detailed - Iterative
- Simple – Single Case
- Simple – Iterative

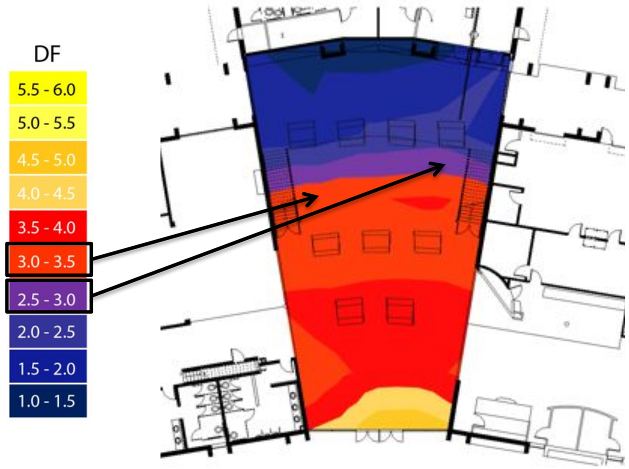
(Vocational Education Building – CTA Group)

(Airport Terminal – HDR Inc.)

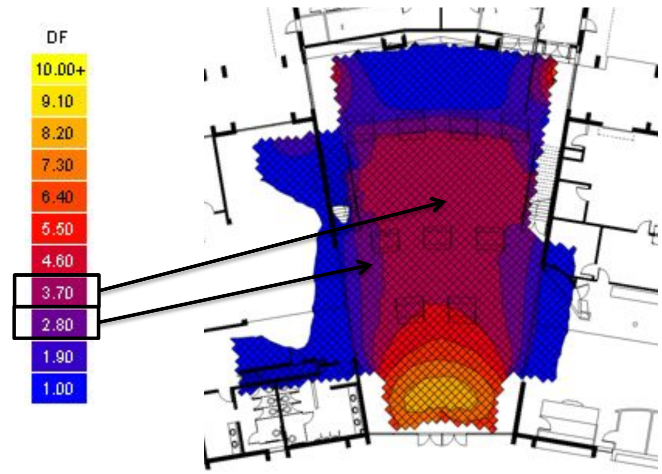


AIRPORT TERMINAL Simple Iterative

HDR Inc. Boise Office



Physical Model



Digital Model

TERMINAL

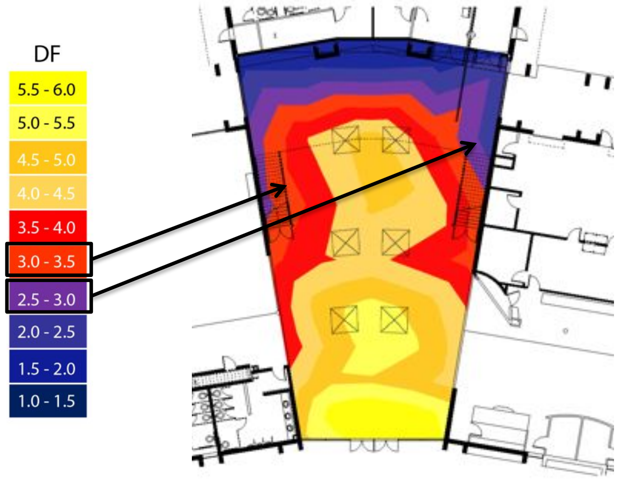
September 21st Overcast – 12PM
9 skylights


Physical Model

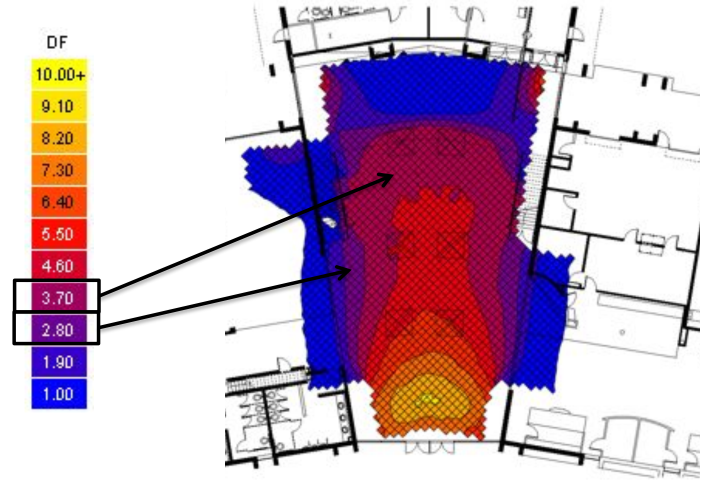

Digital Model

TERMINAL

September 21st Overcast – 12PM
9 skylights



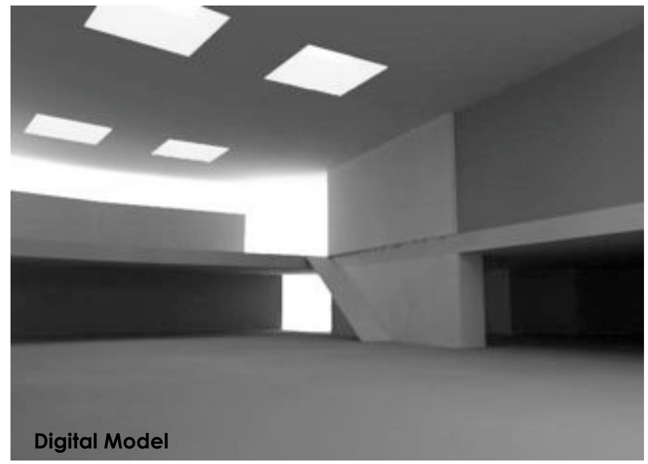
Physical Model



Digital Model

TERMINAL

September 21st Overcast – 12PM
6 skylights



TERMINAL

September 21st Overcast – 12PM
6 skylights

PHYSICAL MODEL

CONSTRUCTION – Simple physical models can be constructed in a single day can be modified on the fly during data collection and analysis phases. These models need only represent a scaled space and the requisite surfaces at a reflectance similar to those planned for the building
38 Hr.

DATA COLLECTION / ANALYSIS – Time in this process is driven by the amount and difficulty of modification being tested. In this project 4 physical iterations were tested during analysis.
17.5 Hr.

DOCUMENATATION/REPORTING – Displaying data in a meaningful and simple manner is essential.
18.5 Hr.

74 Hr. Total for 4 iterations ~ 18.5 hours each

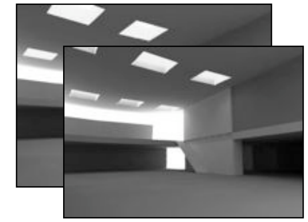
DIGITAL MODEL

CONSTRUCTION – Creation of simple digital models from geometry inputs from other software can some times mean re-modeling, However if speed is more concerning than quality and accuracy, ie. at the initial design phase, it is possible to work directly from an imported model or even to work directly out of a modeling program such as SketchUp.
12.5 Hr.

DATA COLLECTION / ANALYSIS – This value excludes computer processing time entirely. 4 digital iterations were tested during analysis.
35.5 Hr.

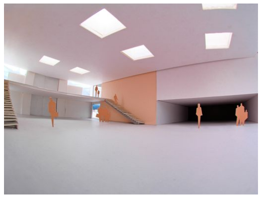
DOCUMENATATION/REPORTING – Displaying data in a meaningful and simple manner is essential.
23.5 Hr.

71.5 Hr. Total for 4 iterations ~ 17.85 hours each



MODELING Simple Iterative

Depending on the project and level of design resolution a highly detailed model can be created and simulated with both the digital and physical tools



PHYSICAL MODEL

CONSTRUCTION – **26 Hr.**

DATA COLLECTION / ANALYSIS –**14 Hr.**

DOCUMENATATION/REPORTING – **5.5 Hr.**

45.5 Hr. Total

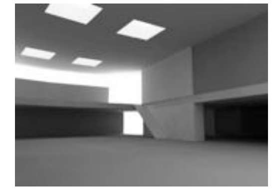
DIGITAL MODEL

CONSTRUCTION – **9 Hr.**

DATA COLLECTION / ANALYSIS – **10 Hr.**

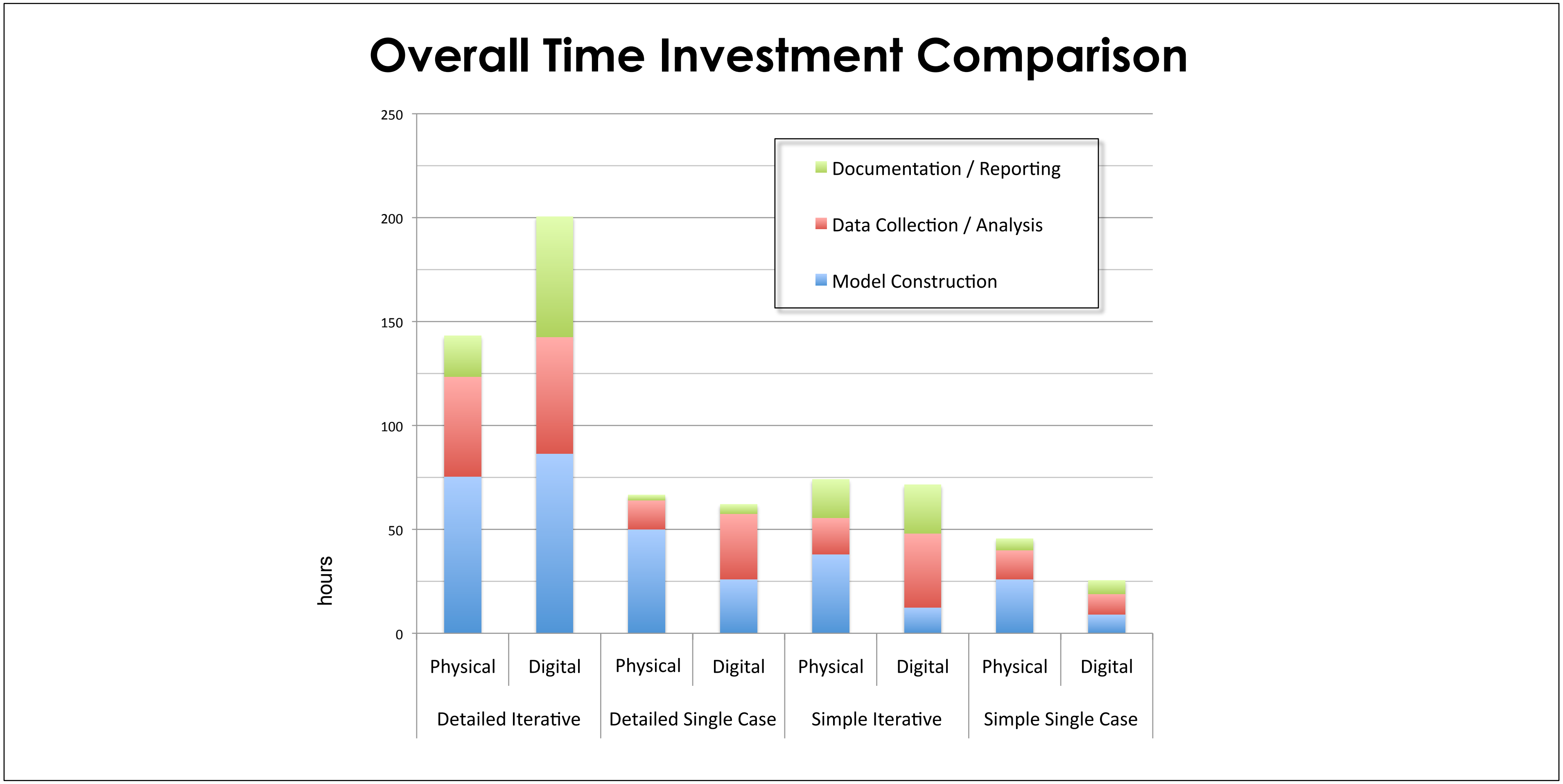
DOCUMENATATION/REPORTING – **6.5 Hr.**

25.5 Hr. Total



MODELING Simple Single Case

Depending on the project and level of design resolution a highly detailed model can be created and simulated with both the digital and physical tools


Overall Time Investment Comparison
Documentation / Reporting
Data Collection / Analysis
Model Construction
hours
250
200
150
100
50
0
Physical
Digital
Physical
Digital
Physical
Digital
Physical
Digital
Detailed Iterative
Detailed Single Case
Simple Iterative
Simple Single Case

Physical		Digital
Real time	⟺	Processing time
Eye adaptation	⟺	Tone Mapping
Approximate sky	⟺	More accurate sky files
Real sky	⟺	Real sky (potential)
Slower to build	⟺	Quicker to build
Quicker to test	⟺	Slower to test
Intuitive	⟺	High expertise
Expensive equipment	⟺	Freeware
Physical materials	⟺	Complex material specs

For Designer's

- Commit to test daylight design ideas
- Iterative analysis, not compliance
- Interpret data systematically & critically
- Follow up, close the loop

Conclusions

A Comparative Discussion

Using Radiance, DAYSIM and Physical Models in Architectural Practice

8th International Radiance Workshop, Harvard GSD
2009_10_22

Presented by: Kevin Van Den Wymelenberg, University of Idaho, Integrated Design Lab - Boise

Thanks to: Northwest Energy Efficiency Alliance
IDL Staff Ery Djunaedy PhD, Gunnar Gladics, Nick Hubof and Tim Hedrick
Special thanks: Mehlika Inanici, PhD