Experiences with Radiance in Daylighting Design, Part V

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Presentation Outline

• Project Examples
  – Laboratory / Office Atrium Study
  – Raleigh-Durham Airport Study

• Overhead Projector Studies

• Skylight Validation Studies

• Parametric Modeler and Daylight Profiler
Lab/Office Atrium Study – Schott PV

- Lab / Office building with Zero Energy Goals
- Balance between PV production and daylight saturation
- Schott PV with small gaps between each small cell
- Low PV efficiency, glare / solar gain concerns for office
Lab/Office Atrium Study – PV

- High Efficiency PV with gaps between each panel
- Glare / solar gain concerns for office
Lab/Office Atrium Study – 3 Open Strips

- Nice sky view
- Direct glare and solar gain issues for offices
Lab/Office Atrium Study – 3 Translucent Strips

- No sky view
- No glare and solar gain issues for offices
- Nice diffusion, brightened walls
Lab/Office Atrium Study – 3 Baffled Skylights

- Nice sky view
- Limited glare and solar gain issues for offices
- Baffles help provide some diffusion and brighten walls
Lab/Office Atrium Study – Random Translucent Skylights

- Some sky view
- No glare and solar gain issues for offices
- Filtered light through tree canopy effect
Lab/Office Atrium Study – Stair Tower Highlight 1

- Some sky view
- Limited glare and solar gain issues for offices
- Highlighted stair tower walls
Lab/Office Atrium Study – Stair Tower Highlight 2

- Some sky view
- No glare and solar gain issues for offices
- Highlighted stair tower walls
Lab/Office Atrium Study – Combined Strips

- Some sky view
- No glare and solar gain issues for offices
Lab/Office Atrium Study – Sloped Ceiling

- Slight increase in the north zone of the lab
Raleigh-Durham Airport Terminal 1 Renovation

- Glare and thermal comfort issues on recently finished Terminal 2
- Expensive ($ and political) after the fact fix could have been avoided by inexpensive design effort
- Interesting mix of mainly public, transient spaces with critical task locations
RDU Terminal 1 Ticketing Hall – 8% Kalwall

- Ticket counters are critical view
- 15 min of glaring sunlight when a passenger has just missed a plane is intolerable
- Large variance between morning (no sun) and afternoon (sun) conditions
- Lack of clerestory contribution apparent in splotchy shadow line

Summer 5pm

Equinox 9am
RDU Terminal 1 Ticketing Hall – 30% Kalwall

- Higher Tvis improves annual contribution
- Still large variance from morning to afternoon
- Increases potential for glare under direct sun
- Shadow line diminished

![Graph showing daylight illuminance profile](image)

- Summer 5pm
- Equinox 9am
RDU Terminal 1 Ticketing Hall – 1% Automated Shades

- Variable window treatment provides good contribution annually
- Balances the morning to afternoon condition
- Maintains acceptable glare conditions in the afternoon
- Shadow line gone

![Graph showing daylighting illuminance profile](image)

Summer 5pm  
Equinox 9am
RDU Terminal 1 Security Checkpoint – Critical Views

- Security checkpoint most critical task in airport
- View of X-ray displays defined as most critical views
RDU Terminal 1 Security Checkpoint – Glare Analysis

- Evalglare used to calculate Daylight Glare Probability for each scenario
- Task defined as 0.3 radian cone centered on display monitor
- Used cautiously – not as much absolute, more relative glare improvement

• Imperceptible: <33% critical, fixed location
• Perceptible: <38% critical, flexible location
• Disturbing: <42% no critical, “sparkle” desired
• Intolerable: <53%

View 2 – 8% Kalwall: DGP 23%
View 2 – 30% Kalwall: DGP 38%
View 2 – 2% Fabric Shade: DGP 43%
RDU Terminal 1 Holding Rooms – Base Design

- Holding rooms contain small gate counter critical tasks
- Mostly leisure passenger space
- Thermal comfort major concern for crowded and delayed holding room
- Southwest facing 16’ wall of glass!
- Too much direct sun – some control is needed
- Lower “view” glass treated separately
RDU Terminal 1 Holding Rooms – 30% Kalwall

• Diffusing glass provides thermal comfort

• Reduces direct sunlight glare, introduces potential glare from glass brightness

• Eliminates clerestory view to sky, does this matter?

• Fabric shade or additional translucent glass still likely needed mid and low panes

• Highly variable from morning to afternoon
RDU Terminal 1 Holding Rooms – 2% Fabric Shade

- Fabric shade provides visual relief and thermal comfort
- Provides balance between morning and afternoon
- Maintains some view through clerestory windows
- Airport authority scared of automated / motorized systems
RDU Terminal 1 Holding Rooms – Pivoting Ext. Louvers

- Static and pivotable exterior louver option explored

- Static option, given tough angles at 45deg south-east, deemed unacceptable

- Pivoting option allows for solar control while maintain views when possible – sun from north, view to the south

- Horizontal solutions undesirable – bird roosting, cleaning concerns
RDU Terminal 1 Holding Rooms – Pivoting Ext. Louvers

• Explored maintaining gaps between louvers at fully closed position

• Is a 21” shade patch between a 4” sun patch adequate for glare/thermal comfort control

• Are 4” gaps adequate to maintain view, is too much contrast introduced

• Gaps would only exist 30min when sun is near perpendicular
RDU Terminal 1 Holding Rooms – LightLouver Combo

- Combination LightLouver solution with diffusing glass
- Ceiling configuration not optimal, exploring reconfiguration
- LightLouver IES files created via TracePro
- Script automatically sizes LightLouver “light” definitions
- New BSDF material is awesome!!!
Projector Studies

- Will a projection wall be visible in a highly glazed common room?
- Projector model built in Radiance
  - Explored directly mapping image to screen using “light” material – ambient light did not show up on surface
  - Explored mapping directly to a “spotlight” definition
  - With my limited Radiance skill, created a spotlight source, aimed through a “trans” film with image mapped, shielded to create square projection
- Globe map used to explore varying levels of contrast – black text on white least concern – dark and intricate images greatest concern

6,000 mid-range projector
Projector Studies

• Explored varied fabric shade openness in 3 different zones

• Explored different projector lumen output options – increased lumens typically increased $

• Claims of 5,000:1 contrast?
  • Projector provides a max of 22fc for our globe scene
  • Ambient lighting would have to be less than 0.004fc?

• Vertical illuminance must be below 20fc to even maintain 2:1 contrast
Projector Studies – Top 3% Shades, 6,000 Lumen projector
Projector Studies – Zone 1 Shades
Projector Studies – Zone 1 & 2 Shades
Projector Studies – Zone 1 – 3 Shades
Projector Studies – 1% Shade
Projector Studies – 1% Shade, 12,000 lumen projector
Optical Skylight Validation – Team and Facility

• Effort to capture HDR skies and interior photometrics for optical skylights

• Thanks to Luis Fernandez and Anothai Thanachareonkit for developing measurement equipment and methodology

• Thanks to Bruce Mosher for providing facility
Optical Skylight Validation – Equipment / Installation

• Initially aimed at validating TracePro and Photopia methods for generating daylighting system photometrics

• Interest in validating photon-mapping and maybe genBSDF for larger optical systems?

• Testing done during July in Greenwood, South Carolina

• 90deg, 90% humidity = challenge: how to keep your butt from burning and your notes dry

• Chose summer to capture low and high sun angles
Optical Skylight Validation – Skylight Systems

- Tested range of optical complexity
  - Simple: single layer of optics, diffuse light box
  - Medium: two layers of optics, simple mirror light box
  - Complex: two layers of optics, complex interreflection in between
- Imperfections in physical systems inevitable – how close can a computer simulation come
- Suggest adding computer simulation path for testing daylighting products in IESNA LM-81-10
Optical Skylight Validation – HDR Sky Images

- Captured 31 skies, roughly 10 for each skylight system
- Used a 10° disc to shield sun
- Only got 1 partly cloudy sky with the solar disc obscured
- Need to figure out a way to fill in the disc

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Optical Skylight Validation – HDR Sky Cropping

- First cropped sky capture to a perfect hemisphere

- Cropped image lost absolute luminance information
  - Zenith luminance appears to drop in cropped image
  - Thanks to Greg / Radiance online for method of maintain header information

- Concern with actual angular hemispherical mapping of Nikon FCE9 Fisheye Converter Lens system, any experience?
Optical Skylight Validation – Masking
Optical Skylight Validation – Combined Sky

- Calibrate masked sky image to diffuse sky illuminance measurement
- Calibrate patch filler by matching luminance in circumsolar region
- Calibrate solar intensity to direct illuminance
- Create TracePro / Photopia source files via lookup to final sky HDR image
Parametric Modeling and Daylight Profiling – stay tuned

- Parametric modeler that creates Radiance and Energy Plus models via IFC files

- Challenge: how to efficiently automate daylight simulation for an entire building
  - Method to autogenerate illuminance grids for any shape of daylit space
  - Method to identify similar spaces to reduce overall calculation time
SPOT v4.2 Released

• Upgraded to work with newer Windows OS (Windows XP, Vista, 7; 32bit, 64bit)

• Upgraded to work with new versions of Office 2007 and 2010. Best under Excel 2010

• Variety of bugs fixed (some introduced?)
  • Compiled python scripts (eases installation)
  • Eliminated path related issues

• Added new annual daylight metrics
  • Daylight Saturation (aka Continuous Daylight Autonomy)
  • UDI

• Available for download: www.archenergy.com/SPOT

• New SPOT user list on google groups
Questions?

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