Experiences with Radiance in Daylighting Design, Part IV

8th Annual Radiance Conference
Harvard Graduate School of Design
October 22nd, 2009

Zack Rogers
Integrated Design Associates, Inc.

Presentation Outline

- Project sampling
- Projects Revisited
- Early design optimization engine (PIDO)
- Radiance comparison

Project Sampling

- Orchard School District - Library Expansion, San Jose, CA
- Sequoia Gymnasium, Redwood City, CA
- Arapahoe Elementary School, Arapahoe, WY
- Casey Middle School, Boulder, CO
- Las Cruces Recreation Center, Las Cruces, NM
- Downtown Education Center, Oakland, CA
- CalTech Linde Robinson Lab, Pasadena, CA

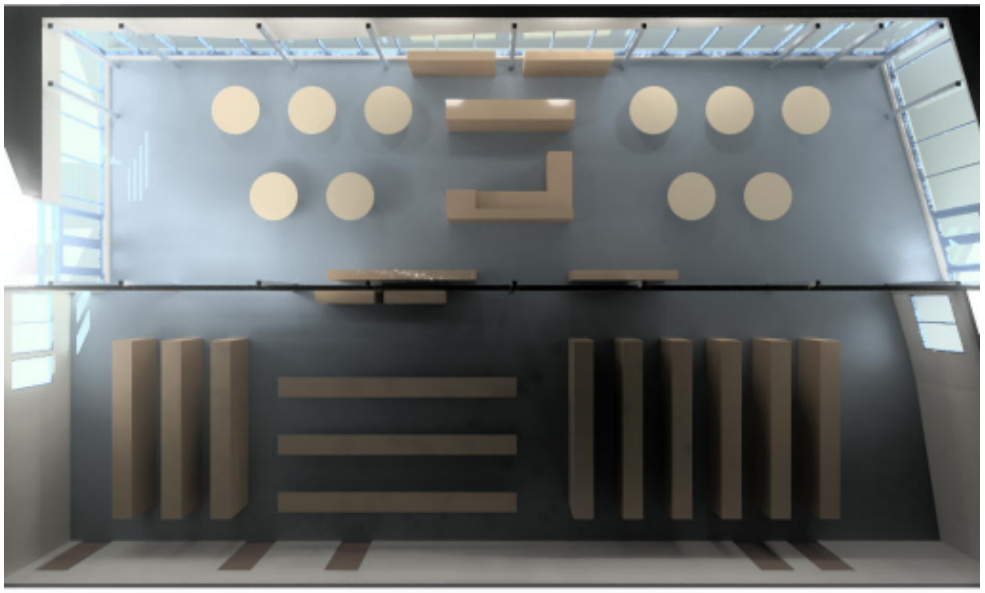
Orchard School Library Expansion

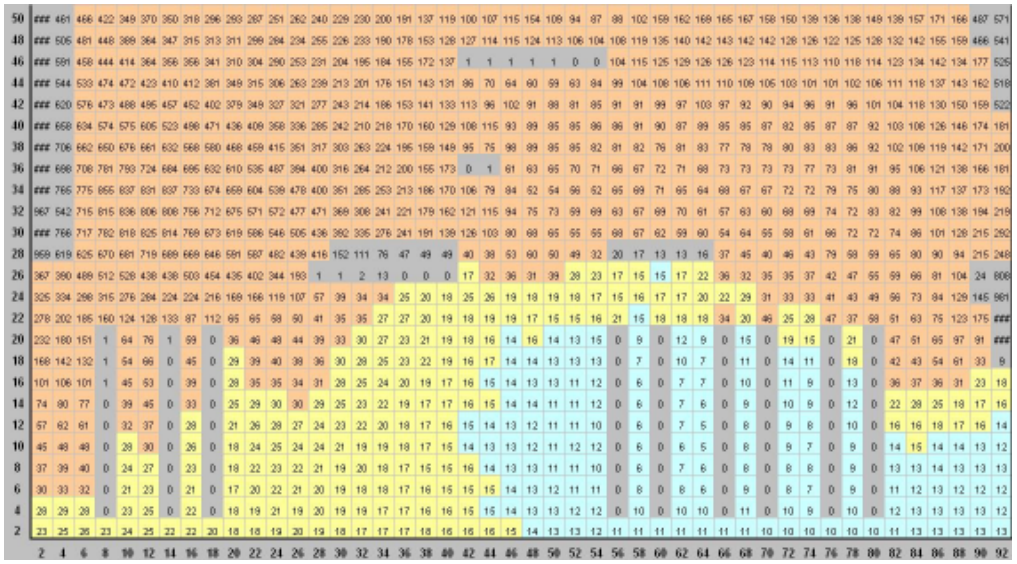
- New open daylit expansion to an existing non-daylit library
- Balance of daylight between old and new and from bright entry
- Washing surfaces to reduce contrasts

Orchard School Library Expansion

Daylight Illuminance

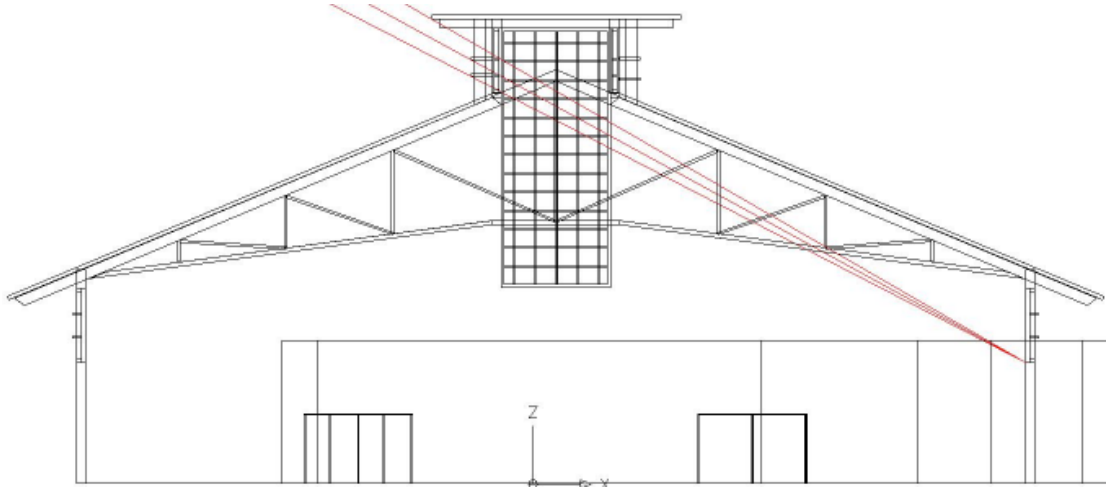
- SPOT_day_calcs.py, “field files”, genfieldpts.py, and new excel tool to process and display illuminance data
- Solatubes to brighten darker bookshelf areas





Sequoia High School Gymnasium

- Large central pop-up monitor provides majority of daylight in glare free, veiling free manner.
- Monitor geometry provides direct solar control
- PV's maximized on roof area



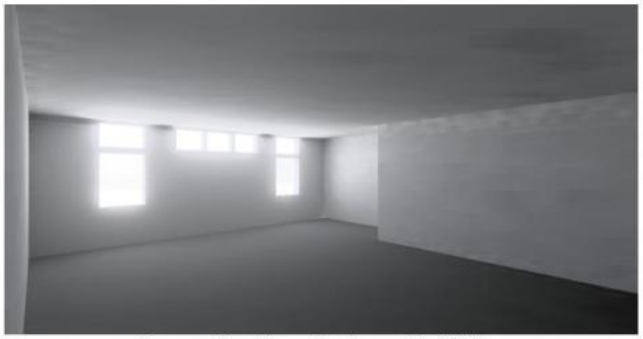
Sequoia High School Gymnasium

- Contrast and glare concerns for large north and south clerestory windows
- Large “lightshelf” integrated into basketball hoop structure

Arapahoe Elementary School

East Classrooms

Current Design Performance

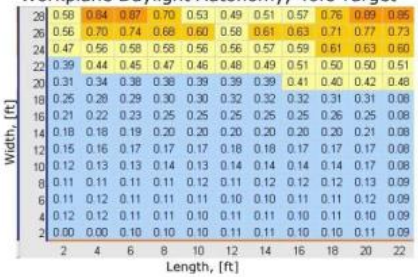


Perspective View, Equinox, 12:00PM

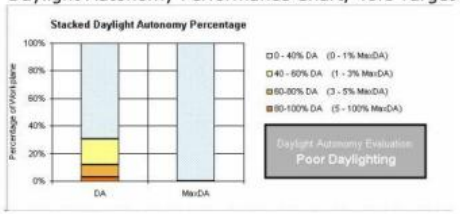
Annual Daylight Illuminance, [fc]

Design Condition		Zone 1 Avg	Zone 1 Max	Zone 1 Min	Zone 2 Avg	Zone 2 Max	Zone 2 Min
Clear Sky							
Winter	8:00 AM	6	11	3	2	4	1
	12:00 PM	16	31	10	5	11	2
	4:00 PM	8	16	4	3	6	1
Equinox	8:00 AM	20	37	13	6	13	3
	12:00 PM	28	47	17	8	18	4
	4:00 PM	19	33	12	6	13	3
Summer	8:00 AM	52	97	29	13	31	5
	12:00 PM	43	69	27	12	27	5
	4:00 PM	31	54	20	9	20	4
Overcast Sky							
Winter	8:00 AM	1	3	1	0	1	0
	12:00 PM	12	27	5	3	7	1
	4:00 PM	3	7	1	1	2	0
Equinox	8:00 AM	9	20	4	2	5	1
	12:00 PM	21	48	9	5	12	2
	4:00 PM	12	28	6	3	7	1
Summer	8:00 AM	16	38	7	4	10	2
	12:00 PM	27	62	12	6	16	3
	4:00 PM	18	43	8	4	11	2
Annual Average		24			7		
Annual Maximum			115			30	

Workplane Daylight Autonomy, 40fc Target



Daylight Autonomy Performance Chart, 40fc Target



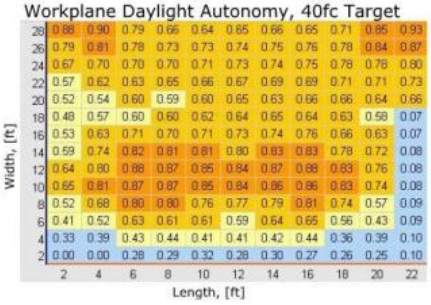
Design Alternative Performance

Perspective View, Equinox, 12:00PM

Annual Daylight Illuminance, [fc]

Design Condition		Zone 1 Avg	Zone 1 Max	Zone 1 Min	Zone 2 Avg	Zone 2 Max	Zone 2 Min
Clear Sky							
Winter	8:00 AM	7	13	4	4	5	1
	12:00 PM	21	36	15	27	52	8
	4:00 PM	9	18	5	6	9	3
Equinox	8:00 AM	26	41	19	20	36	6
	12:00 PM	38	57	27	50	102	13
	4:00 PM	24	37	19	28	55	9
Summer	8:00 AM	66	108	39	45	84	15
	12:00 PM	57	85	37	68	144	16
	4:00 PM	42	64	29	46	95	15
Overcast Sky							
Winter	8:00 AM	2	3	1	1	1	0
	12:00 PM	15	29	9	7	11	3
	4:00 PM	4	8	2	2	3	1
Equinox	8:00 AM	11	22	6	5	8	2
	12:00 PM	26	52	15	12	19	5
	4:00 PM	15	30	9	7	11	3
Summer	8:00 AM	21	41	12	9	15	4
	12:00 PM	34	67	20	15	24	6
	4:00 PM	23	46	14	11	17	4
Annual Average		30			29		
Annual Maximum			125			122	

Workplane Daylight Autonomy, 40fc Target



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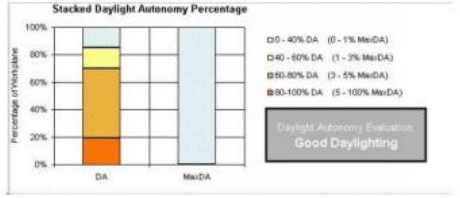
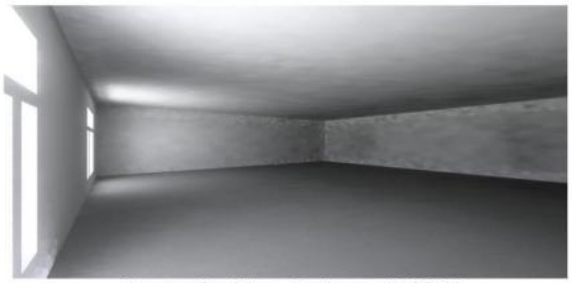


Arapahoe Elementary School
Media Center

Current Design Performance



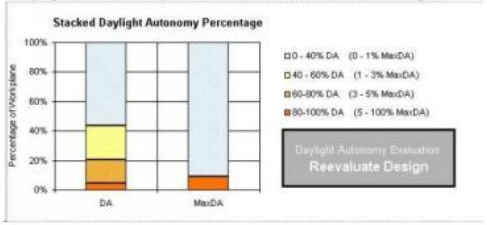
Perspective View, Equinox, 12:00PM

Annual Daylight Illuminance, [fc]

		Zone 1			Zone 2		
Design Condition		Avg	Max	Min	Avg	Max	Min
Clear Sky							
Winter	8:00 AM	3	8	1	1	2	0
	12:00 PM	10	28	4	2	4	1
	4:00 PM	15	72	4	4	59	2
Equinox	8:00 AM	6	16	2	2	3	1
	12:00 PM	16	45	6	4	8	2
	4:00 PM	185	1626	17	9	19	5
Summer	8:00 AM	8	22	3	2	4	1
	12:00 PM	25	65	9	5	11	3
	4:00 PM	301	2886	21	11	24	6
Overcast Sky							
Winter	8:00 AM	1	4	0	0	0	0
	12:00 PM	8	31	2	1	2	1
	4:00 PM	2	8	1	0	1	0
Equinox	8:00 AM	6	23	2	1	2	1
	12:00 PM	14	55	4	2	4	1
	4:00 PM	8	32	2	1	2	1
Summer	8:00 AM	11	43	3	2	3	1
	12:00 PM	18	71	5	3	5	2
	4:00 PM	12	49	3	2	4	1
Annual Average		55			6		
Annual Maximum			2776			247	

Workplane Daylight Autonomy, 30fc Target

Daylight Autonomy Performance Chart, 30fc Target



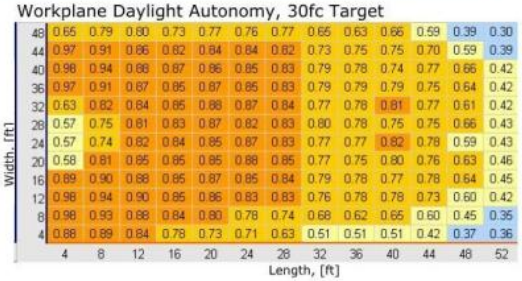
Design Alternative Performance

Perspective View, Equinox, 12:00PM

Annual Daylight Illuminance, [fc]

		Zone 1			Zone 2		
Design Condition		Avg	Max	Min	Avg	Max	Min
Clear Sky							
Winter	8:00 AM	4	14	1	1	2	1
	12:00 PM	19	44	8	11	19	4
	4:00 PM	15	106	3	3	4	1
Equinox	8:00 AM	11	29	3	7	13	3
	12:00 PM	20	45	5	19	35	3
	4:00 PM	147	1669	15	15	26	5
Summer	8:00 AM	14	34	3	13	28	2
	12:00 PM	28	63	9	26	52	4
	4:00 PM	173	2903	18	23	39	6
Overcast Sky							
Winter	8:00 AM	1	4	0	0	1	0
	12:00 PM	9	33	3	3	5	1
	4:00 PM	2	9	1	1	1	0
Equinox	8:00 AM	7	25	2	2	4	1
	12:00 PM	16	58	6	5	8	2
	4:00 PM	10	34	3	3	5	1
Summer	8:00 AM	13	46	4	4	7	2
	12:00 PM	21	75	7	6	11	3
	4:00 PM	15	52	5	4	7	2
Annual Average		140			27		
Annual Maximum			10051			162	

Workplane Daylight Autonomy, 30fc Target



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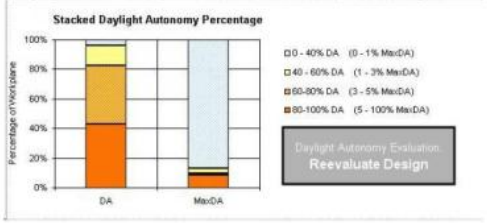


Casey Middle School

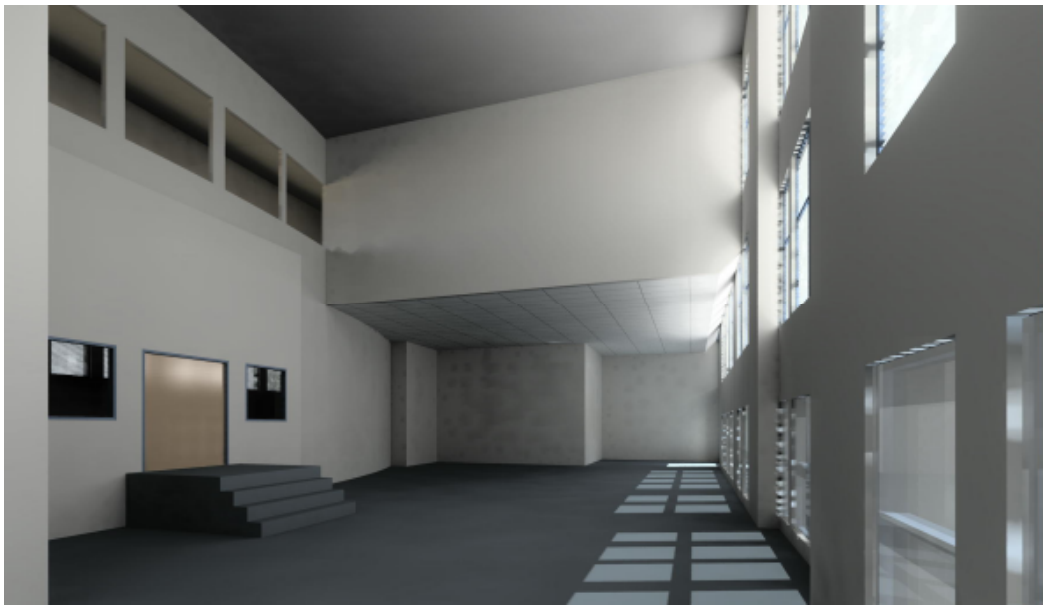
Commons / Cafeteria

- Work done at Architectural Energy Corporation
- Balance daylight from dominant east window wall
- Lightshelf used to help distribute east daylight
- Solatubes sized and spaced to provide balanced daylight throughout
- Egg shape intentional symbol, centered within school with a green roof! One of the first for Colorado

Casey Middle School

Glare Issues

- Two historic facades kept, rest of existing school demolished
- Majority of west facing façade opens up into a large media center space
- No exterior shading or too darkly tinted glass allowed
- Automated diffuse louvers at a fixed angle used to provide glare control and daylight redirection
- Core learning spaces 91% daylit!



Las Cruces Recreation Center

Pool Balance and Veiling Reflections

- Work done at Architectural Energy Corporation
- Water definition from an existing pool project – coursely calibrated using an IQ cam
- Horizontal illuminance vs. vertical
- Image subtraction helps illustrate impact of design options

Las Cruces Recreation Center

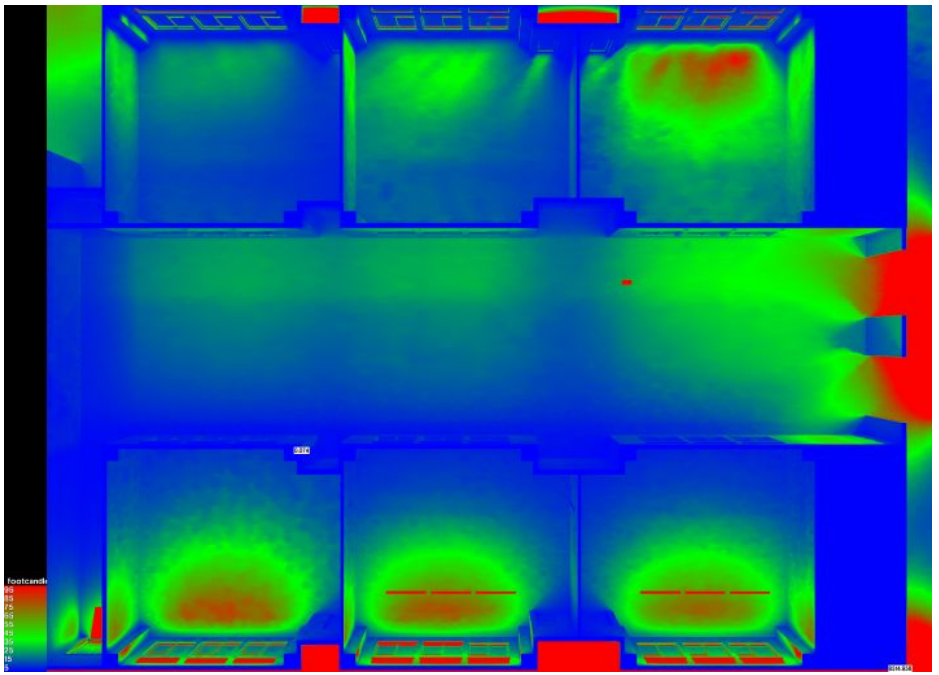
Central core and workout areas

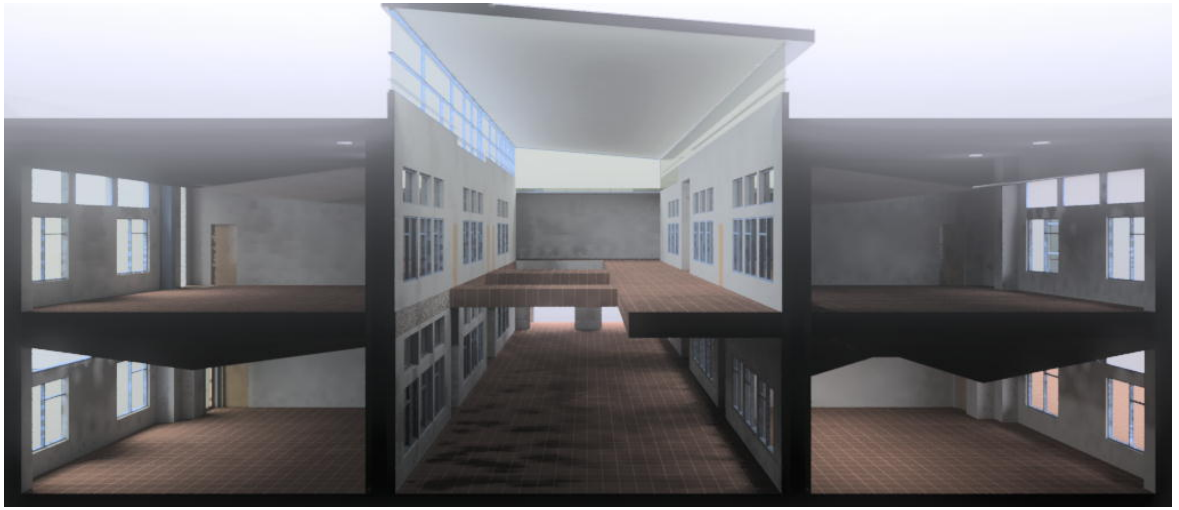
- Ceiling slopes studies to improve contrasts
- Bris soleil provided and optimized to minimize hot Las Cruces sun

Downtown Education Center

Classroom Wing

- Corridors and common space left unconditioned but sheltered
- No glass requirements provides high level of daylight to be “borrowed” by adjacent classrooms
- Overhead cut-away view rendered with –i, false color displays illuminance distribution

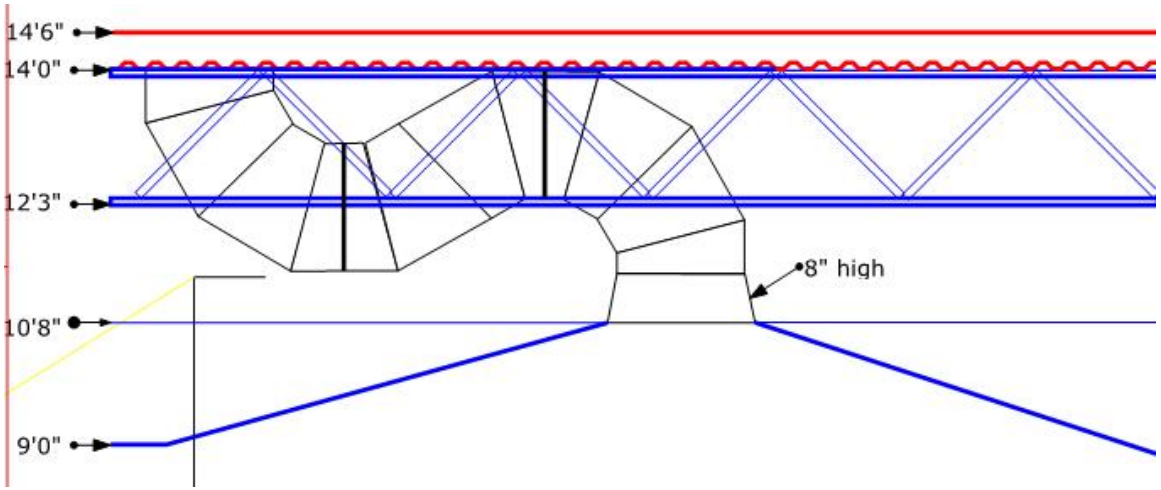


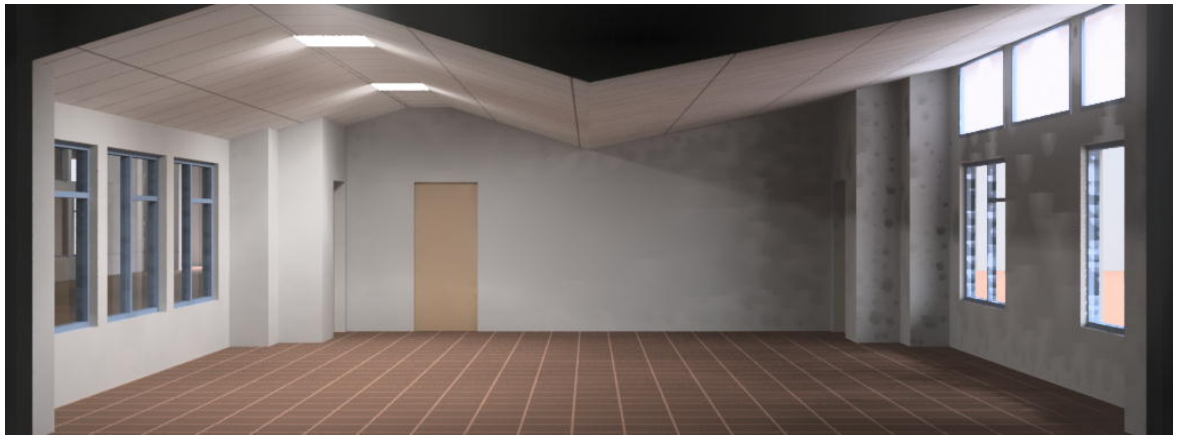


Downtown Education Center

Classroom studies

- Solatubes considered for dimmest 1st floor south classrooms
- When coordinated with trusses, solatube lens can be centered with a 3’6” plenum depth
- 6’ lightwells in commons walkway provide borrowed daylight in lieu of solatubes
- 30% translucent glazing for south daylight windows, louvered overhang shades lower windows

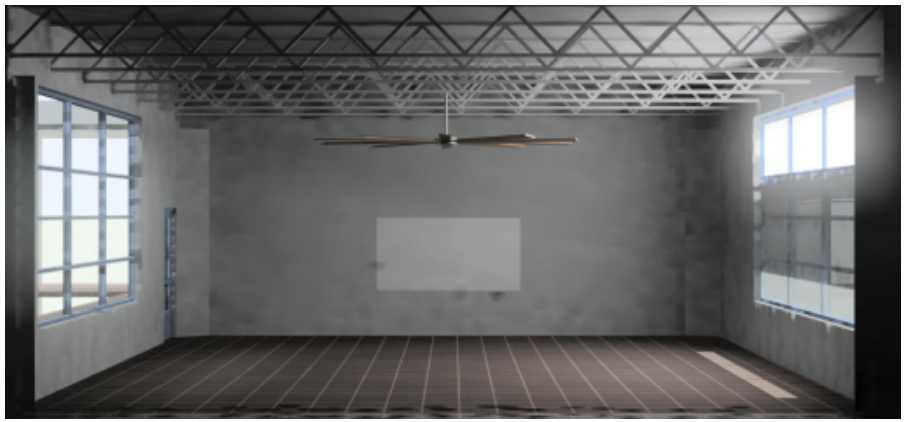


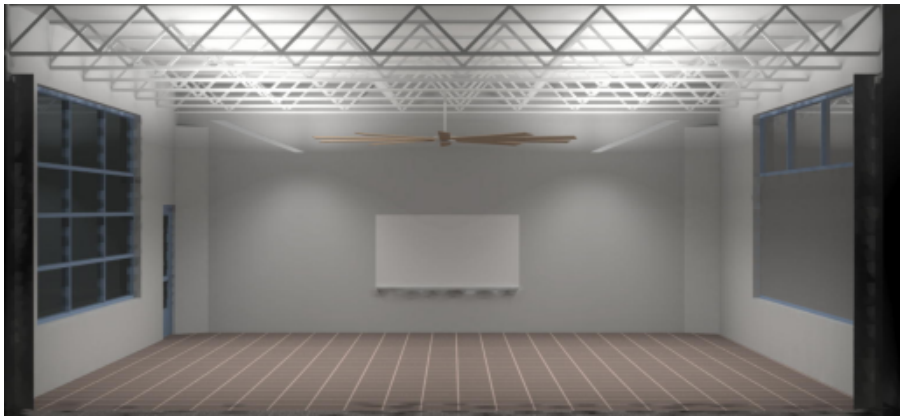


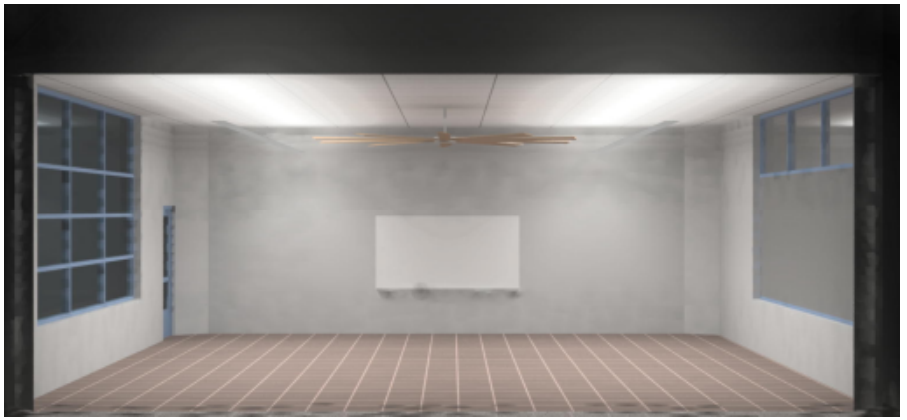
Downtown Education Center

Classroom ceiling finish comparison

- 10 – 20% light loss under daylight conditions
- 30% light loss under electric lighting (60%U/40%D)
- Big Ass fans only cooling, provide necessary air flow while keeping acceptable velocities with the least energy use



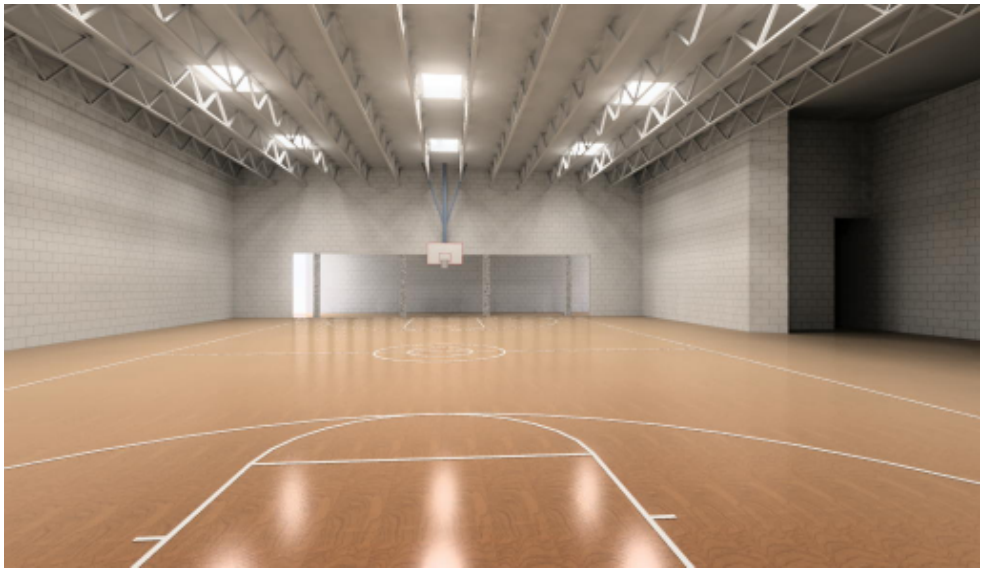




Downtown Education Center

Gymnasium studies

- Skylight array compared to a butterfly roof with clerestories
- North clerestory provides sufficient daylight, washes ceiling better and provides a nice southern slope for PV
- Slope became a common architectural theme throughout – aids in our Zero Energy Building goals



CalTech Linde Robinson Lab

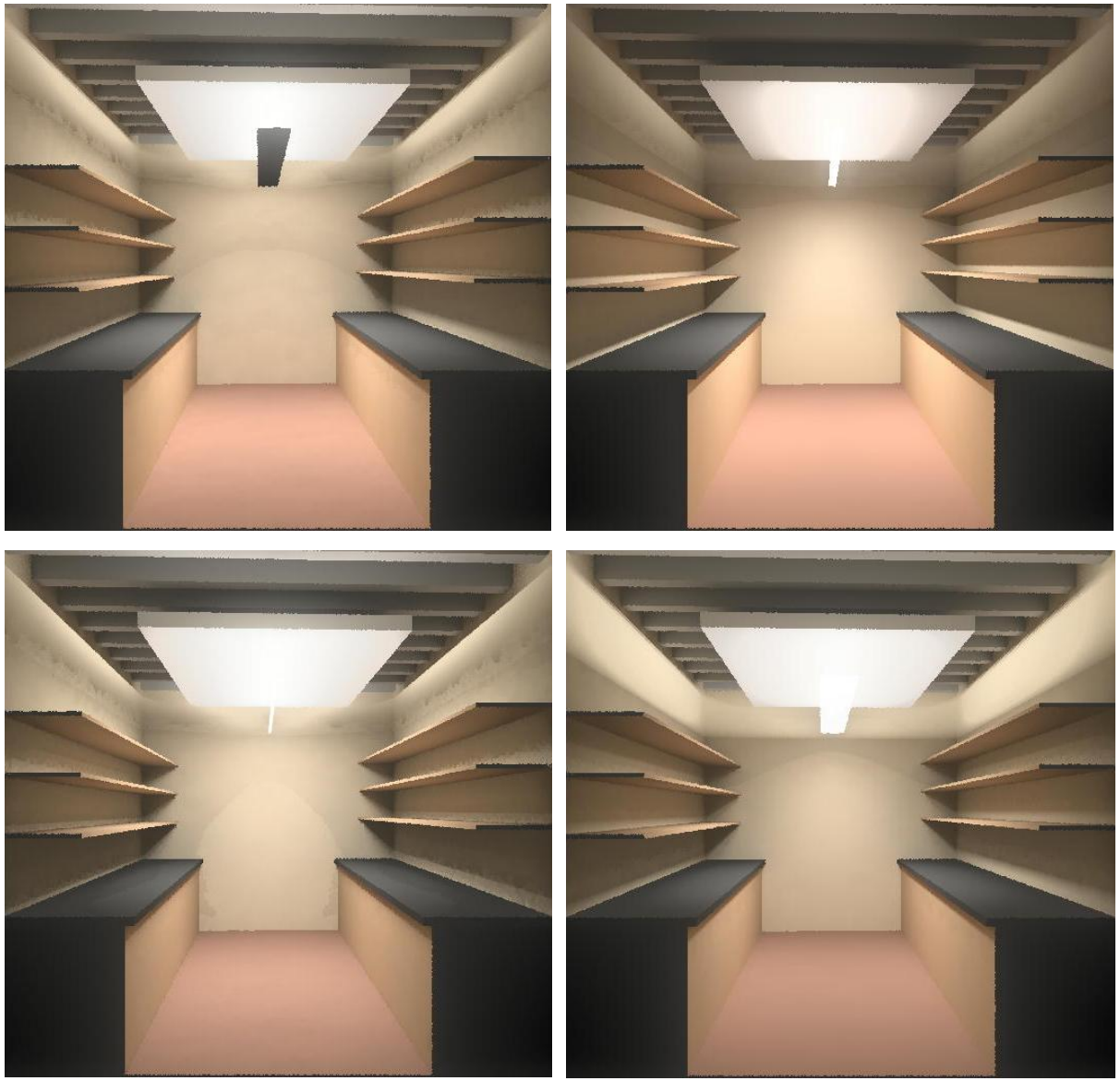
Electric lighting for library

- Cove lighting to uplight historic ceiling
- Historic inefficient fixtures retrofitted with CFLs and then MH – no IES data, modeled roughly with 3 spherical lamp sources
- LED linear wall graze fixture used to light solar tower
- Old Solar telescope converted to a daylight collector
- Daylight beams redirected into optical lab on basement floor and subbasement

CalTech Linde Robinson Lab

Task/Ambient Lighting study

- Ambient / task approach to minimize LPDs but provide necessary illuminance
- Conflict between IES and ASHRAE?
- Numerous direct/indirect fixtures studied for optimal efficiency
- Under cabinet LED fixtures boosts illuminance on benches to 70–90fc
- Lutron ecosystem controls for future churn, sophisticated zoning, and dimming



Projects revisited – lessons learned

- Kinard Junior High School, Fort Collins, CO
- Douglas County Elementary School Prototype, Castle Rock, CO
- Fossil Ridge High School, Fort Collins, CO
- Indianapolis Airport, Indianapolis, IN

Kinard Middle School

North Classrooms

- Pyramidal ceiling structure helps spread daylight and reduce contrast
- Secondary lens provided at top of tubular skylight to further soften contrast
- Projector equipment still got washed out with too much daylight, new equipment this year much better
- User take blackout into their own hands! Cheap blackout system - velcro, hooks, and foam core

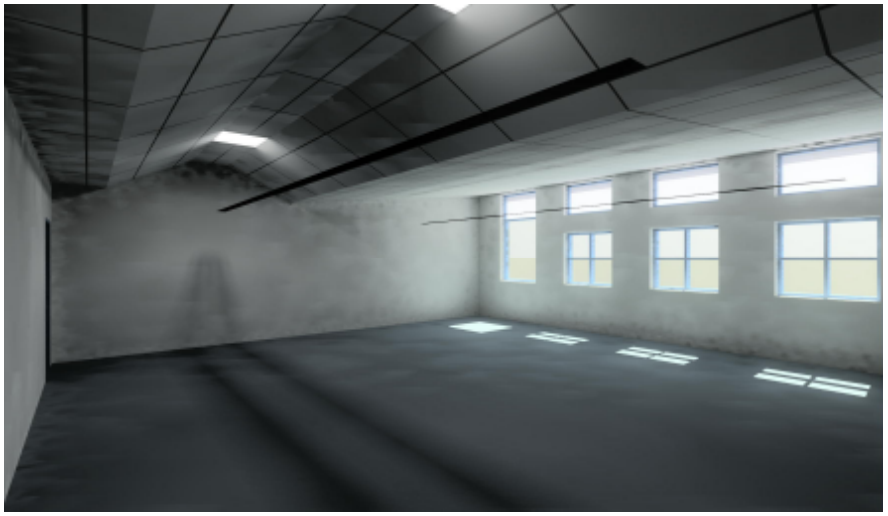
Kinard Middle School

Corridors

- Corridors and locker areas daylit with Solatubes and large south clerestories
- Additional benefit of daylit building – easier construction, no temporary electric lighting or generator needed!

Douglas County Prototype Elementary

Classroom daylighting



- Translucent polygal overhang provides diffused sunlight to daylight windows
- Sized to block majority of winter sun
- School walls are not 60% reflective
- Educate the occupants! Teachers not aware of lighting or daylight control functions

Douglas County Prototype Elementary
Media Center

- Undulating ceiling reduces contrast around solatube lens
- School floor plan required centrally located media center
- Slightly low but sufficient daylight under overcast sky – reconfirmed that contrast and adaptation is as important as overall illuminance

Fossil Ridge Glare Studies

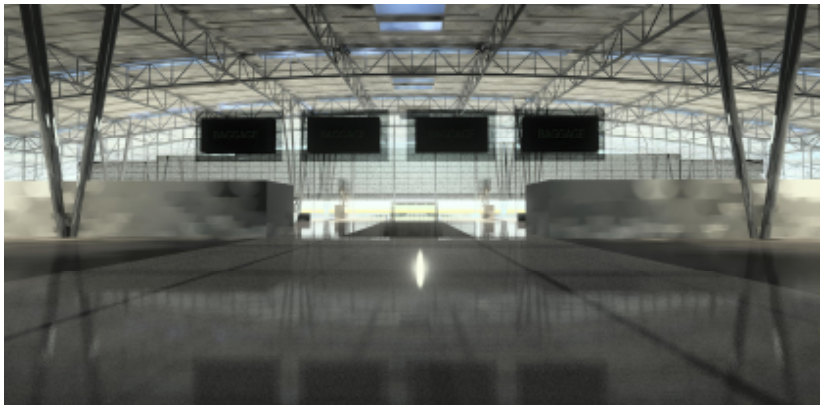
South Classrooms

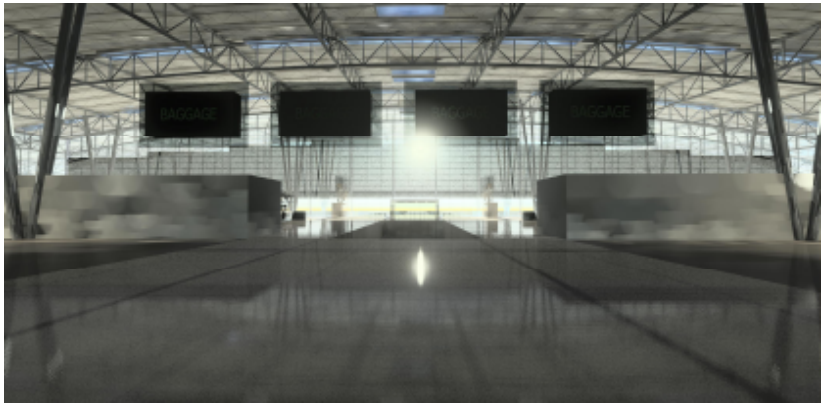
- Daylighting: The devil's in the details
- Winter time glare and projection visability complaints
- Stretched translucent fabric with metal frame chosen retrofit option
- Proper overhang sizing and detailing critical! North clerestory glare off of corrugated metal! Painted a light grey diffuse material to mitigate

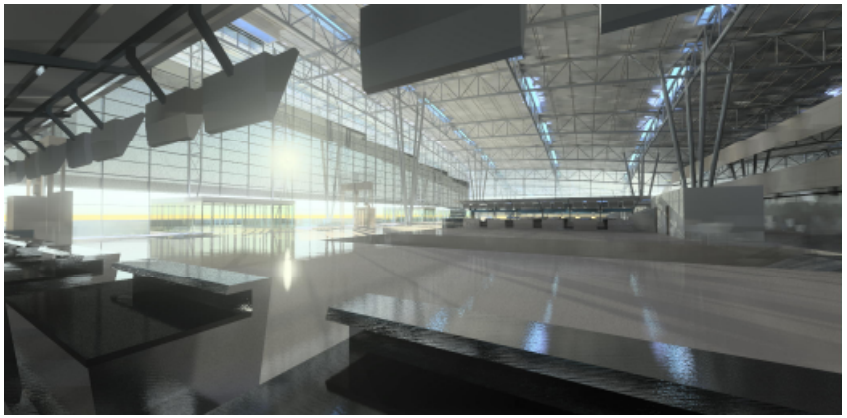
Indianapolis Airport Midfield Terminal

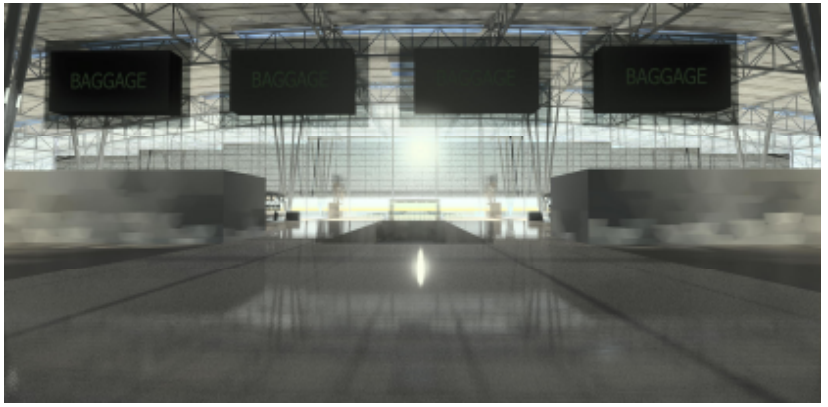
Glare Issues

- Variety of control measures studies for peak occupancy glare concerns
- Glare control measures VE'd in lieu of fritted glass, architects best friend?
- Passengers complaining about signage visibility to baggage
- Ticket counters workers complain about glare
- Expensive roller fabric shades to be added – likely with manual seasonal control due to budget
- Great intent botched due to poor follow through and VE process!



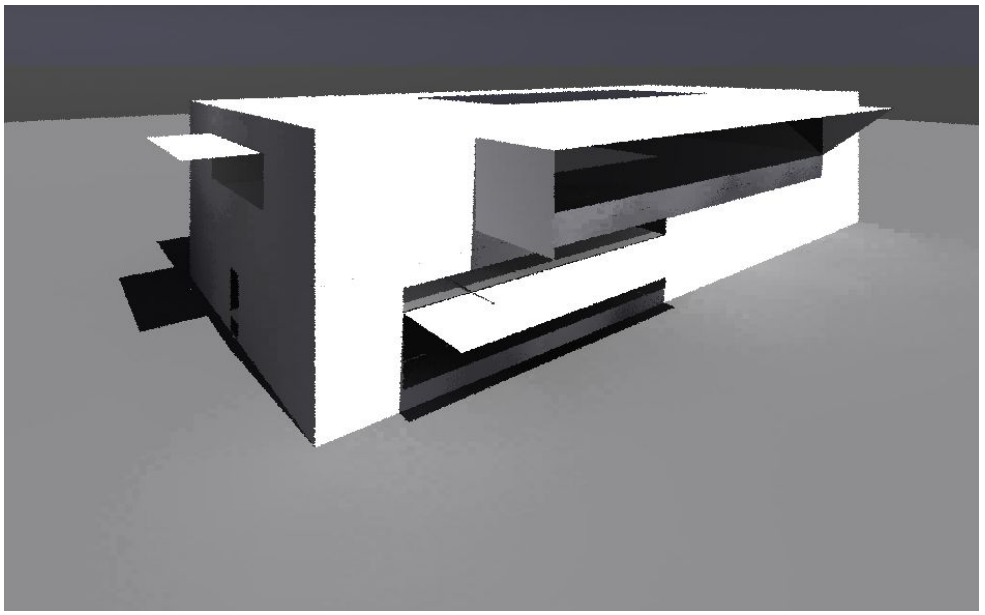


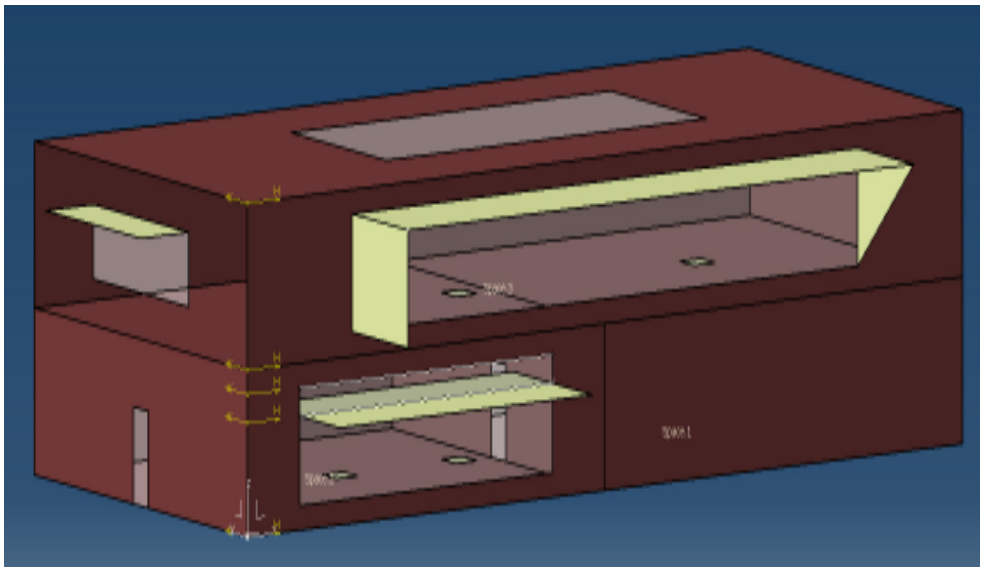




Process Integration and Design Optimization Tool (PIDO)

- Built off optimization engine used for structural design in the aerospace industry
- Digital Project CAD modeler exports to IFC file format (Industry Foundation Classes)
- Scripts create Energy Plus files, Radiance files, and structural information from IFC files
- DAYSIM daylight coefficient method used to perform a climate based annual simulation
- Daylight metrics for optimization can be chosen by user
- System runs numerous (100 – 1000) simulations depending on variables selected
- Optimization algorithms limit that amount of parameters ran as peaks are found

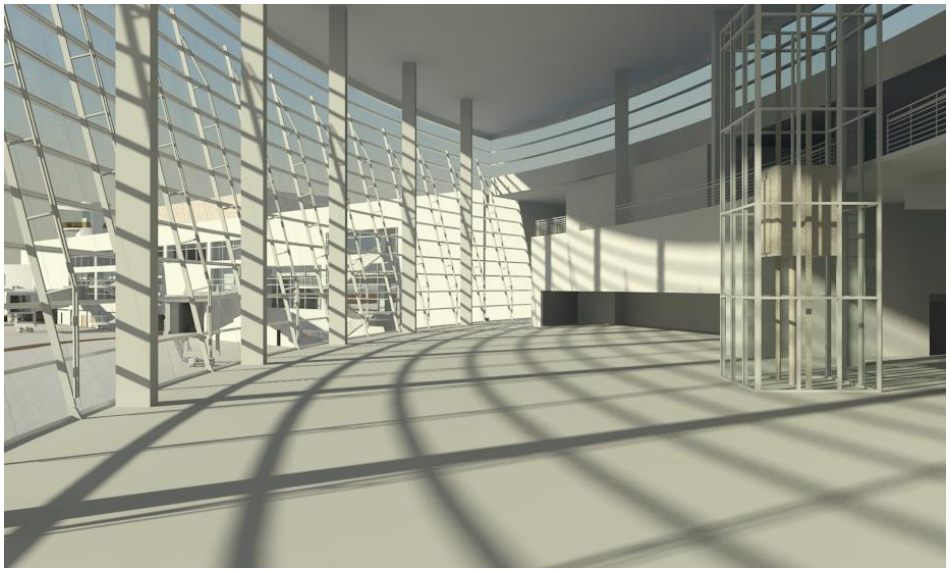


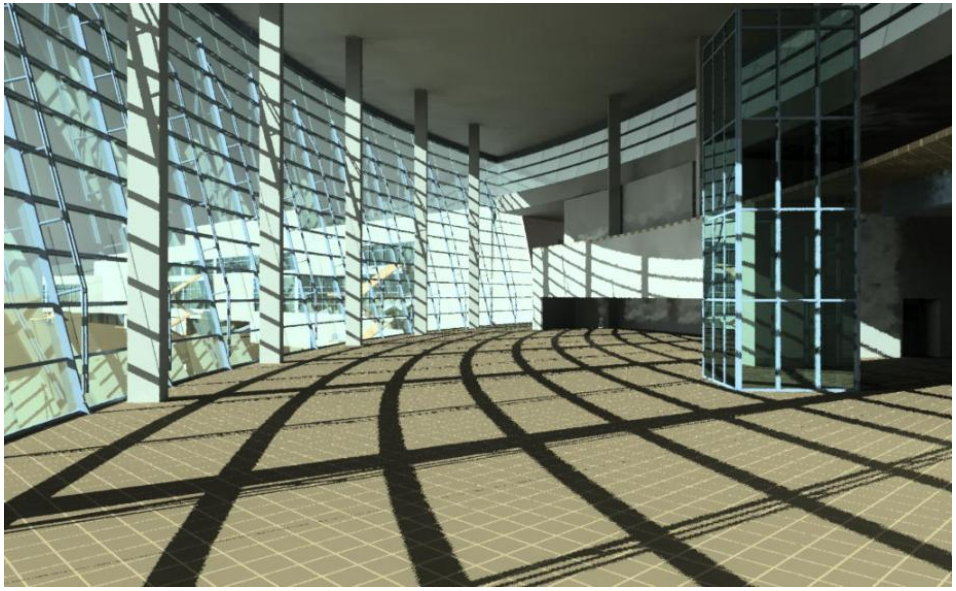


San Diego Airport

Radiance vs. mental ray

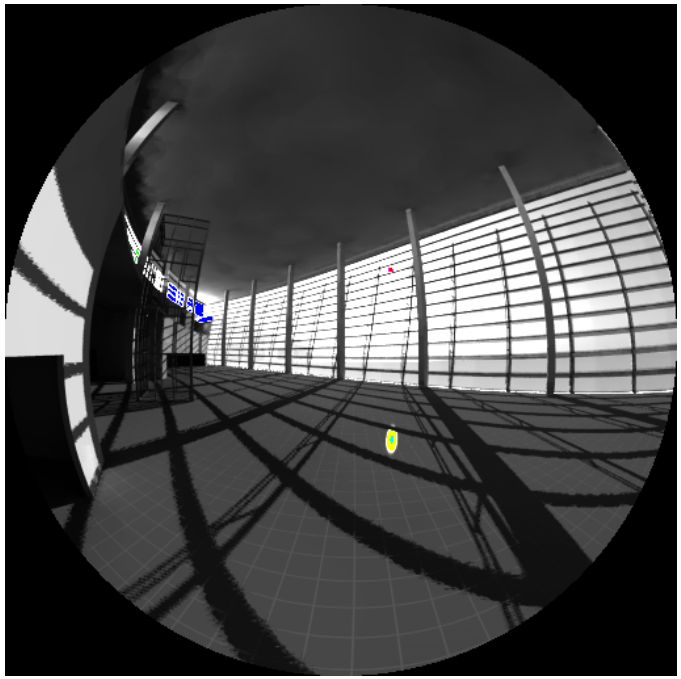
- Do we need to be worried?
- Further optimization of Radiance?
- Scriptability, flexibility and robustness of Radiance a huge plus!
- Any further validation or comparison studies?

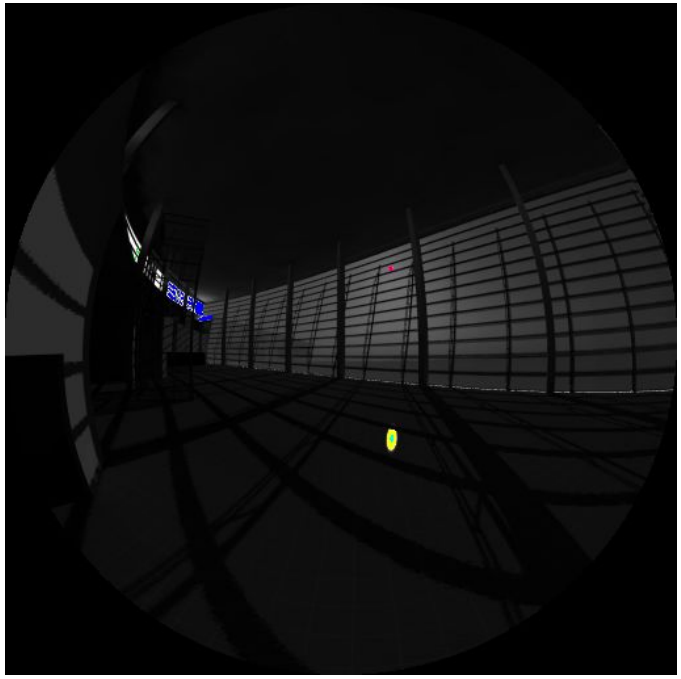




San Diego Airport
Glare

- DGP calculated for Summer 5PM condition
- DGP 100% with no shade or glare control
- Reduced to 51% with 3% openness shade
- Louvered options recommended to control high angle solar gain while preserving views





Experiences with Radiance in Daylighting Design, Part IV

Questions?

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