

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 daylight 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

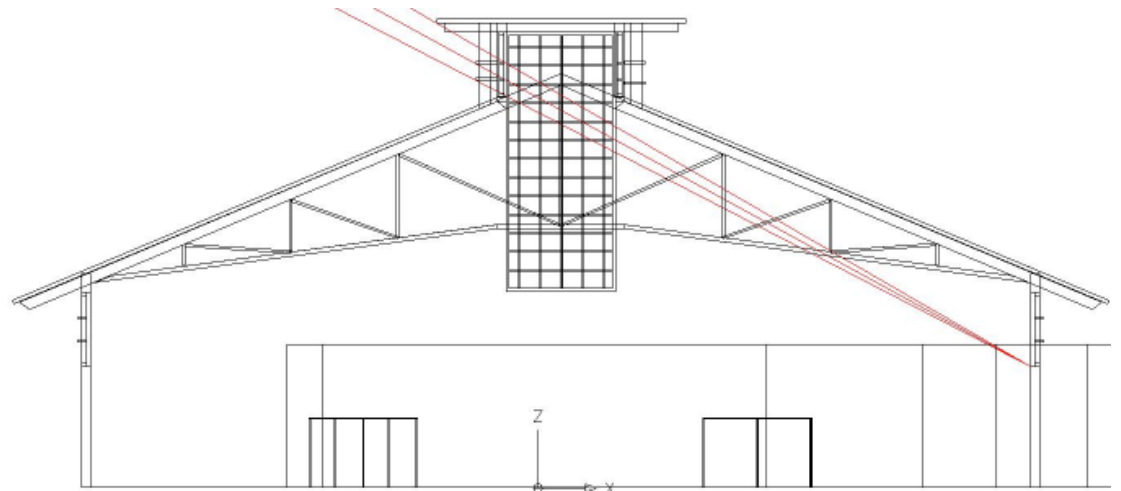
- SPOT_day_calcs.py, “field files”, genfieldpts.py, and new excel tool to process and display illuminance data
- Solatubes to brighten darker bookshelf areas



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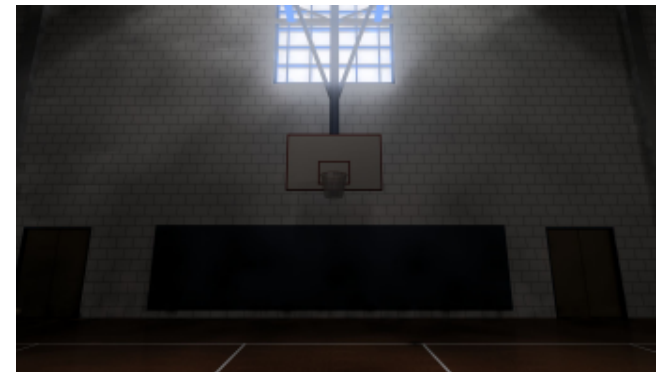
Sequoia High School Gymnasium

- 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



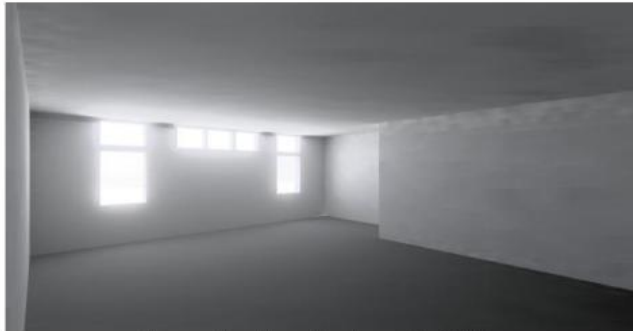
Sequoia High School Gymnasium

- 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

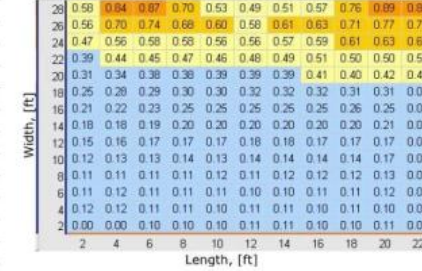


Perspective View, Equinox, 12:00PM

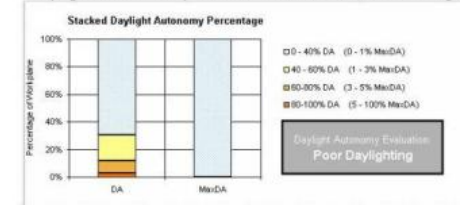
Annual Daylight Illuminance, [fc]

Design Condition		Zone 1			Zone 2		
		Avg	Max	Min	Avg	Max	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

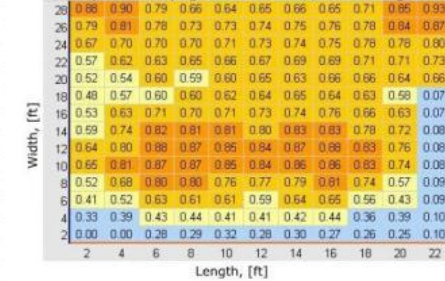


Perspective View, Equinox, 12:00PM

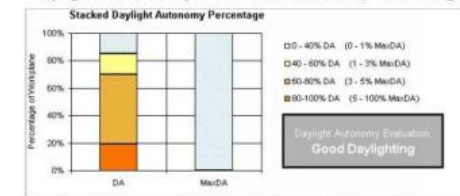
Annual Daylight Illuminance, [fc]

Design Condition		Zone 1			Zone 2		
		Avg	Max	Min	Avg	Max	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

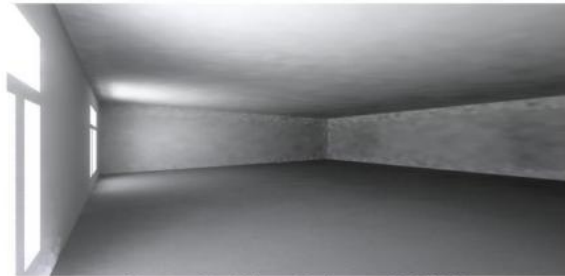


Daylight Autonomy Performance Chart, 40fc Target



Arapahoe Elementary School Media Center

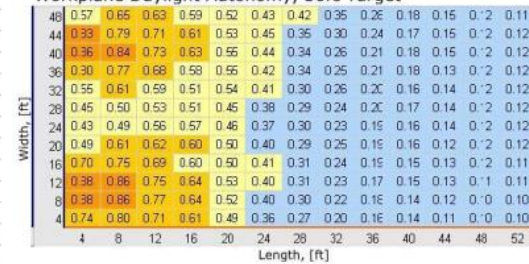
Current Design Performance



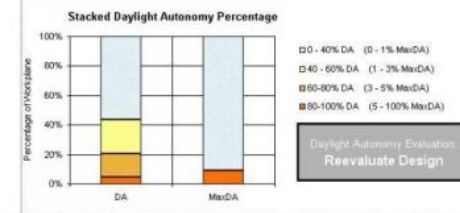
Perspective View, Equinox, 12:00PM

Design Condition		Zone 1			Zone 2		
		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



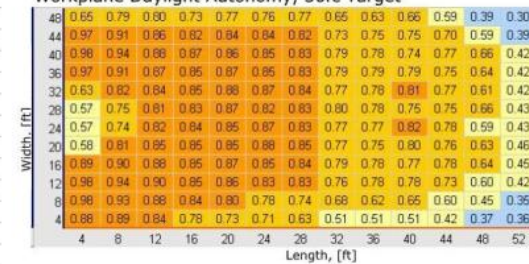
Design Alternative Performance



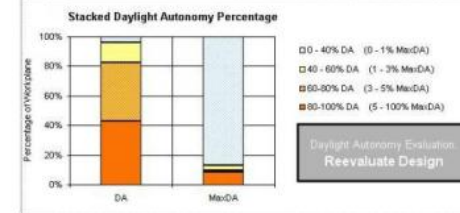
Perspective View, Equinox, 12:00PM

Design Condition		Zone 1			Zone 2		
		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



Daylight Autonomy Performance Chart, 30fc Target



Casey Middle School

Commons / Cafeteria

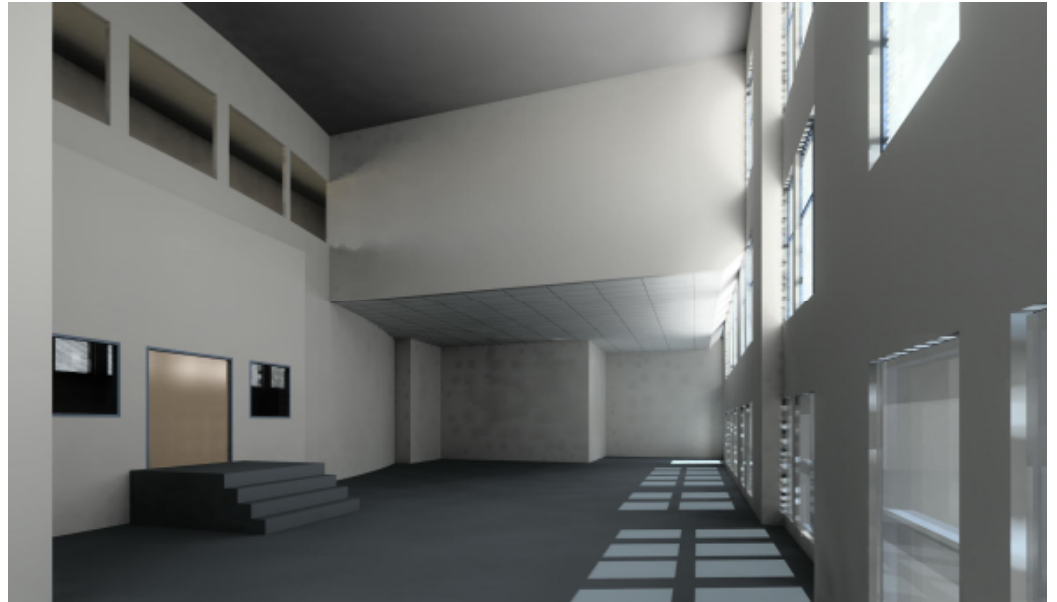
- Work done at Architectural Energy Corporation
- Balance daylight from dominant east window wall
- Lightshelf used to help distribute east daylight
- Solatubes sized and spaced to provide balanced daylight throughout
- Egg shape intentional symbol, centered within school with a green roof! One of the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

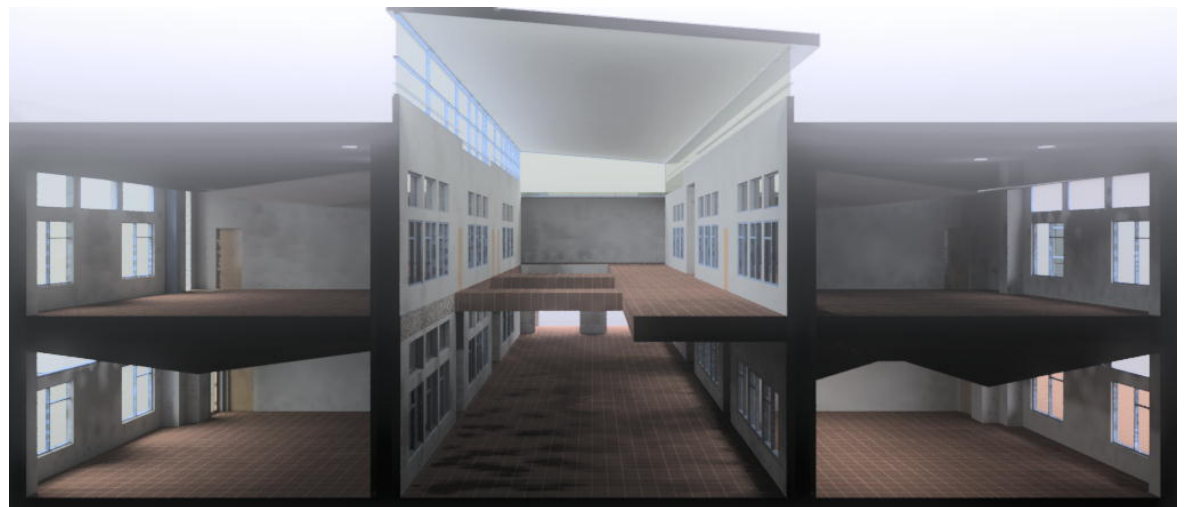
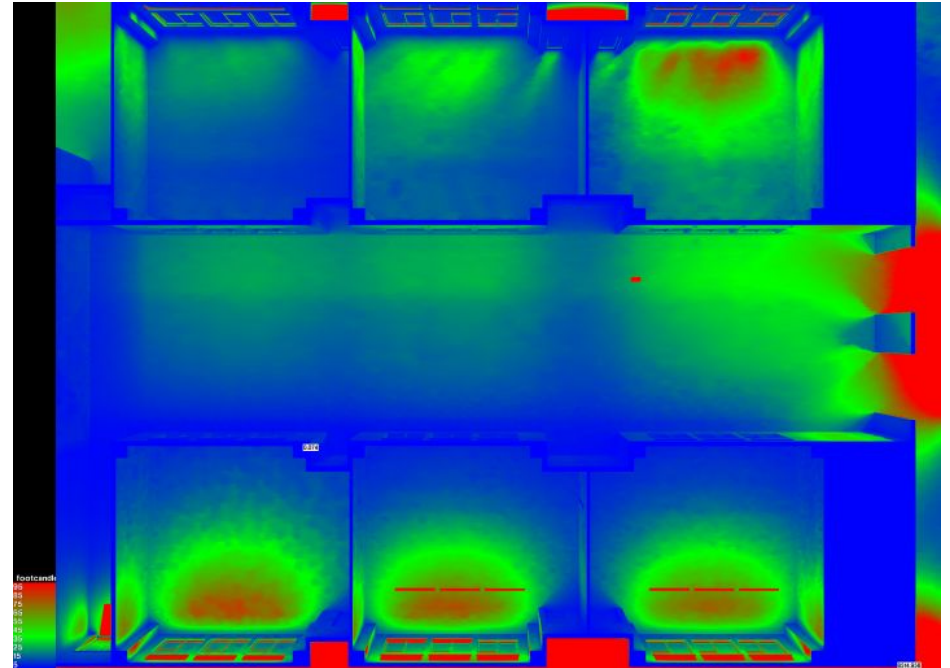
- Ceiling slopes studies to improve contrasts
- Bris soleil provided and optimized to minimize hot Las Cruces sun



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

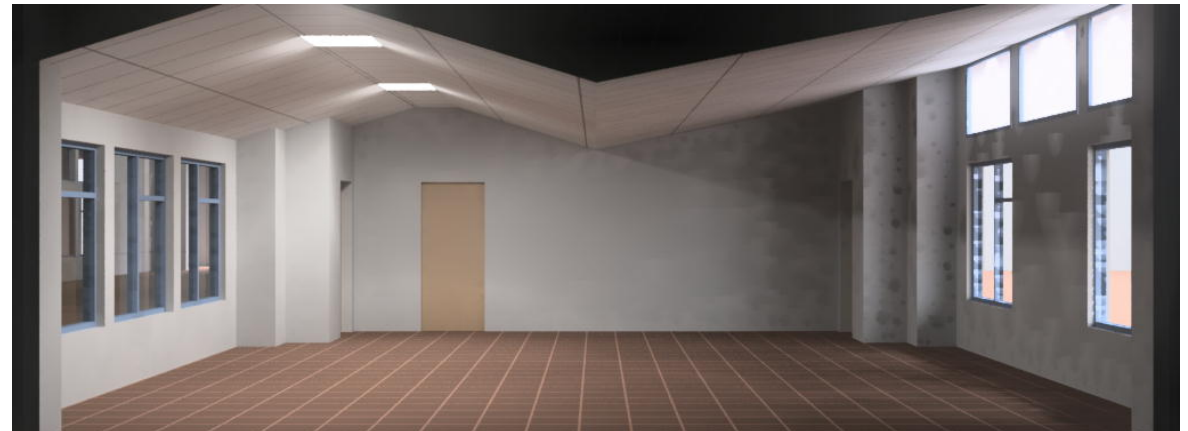
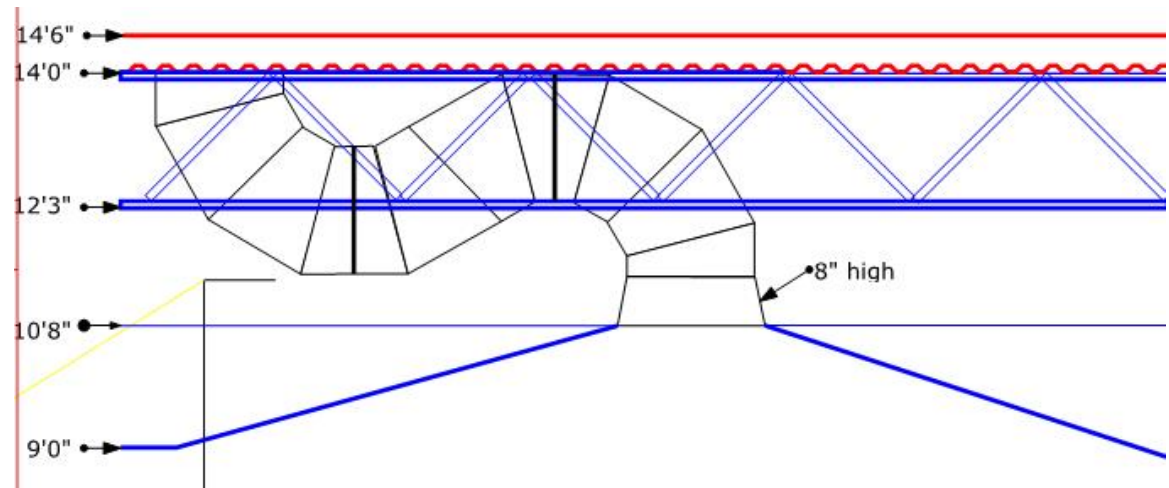


Downtown Education Center

Classroom studies



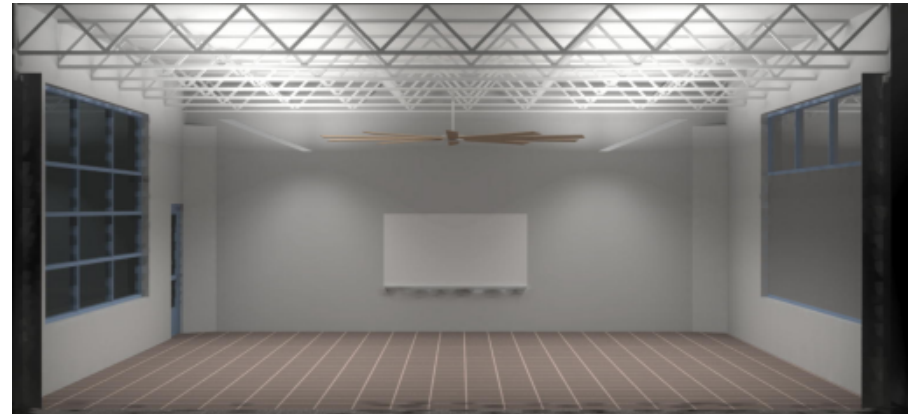
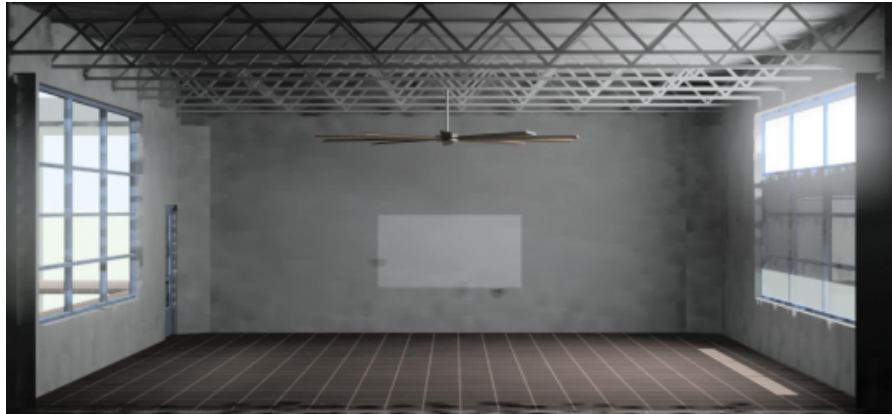
- Solatubes considered for dimmest 1st floor south classrooms
- When coordinated with trusses, solatube lens can be centered with a 3'6" plenum depth
- 6' lightwells in commons walkway provide borrowed daylight in lieu of solatubes
- 30% translucent glazing for south daylight windows, louvered overhang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

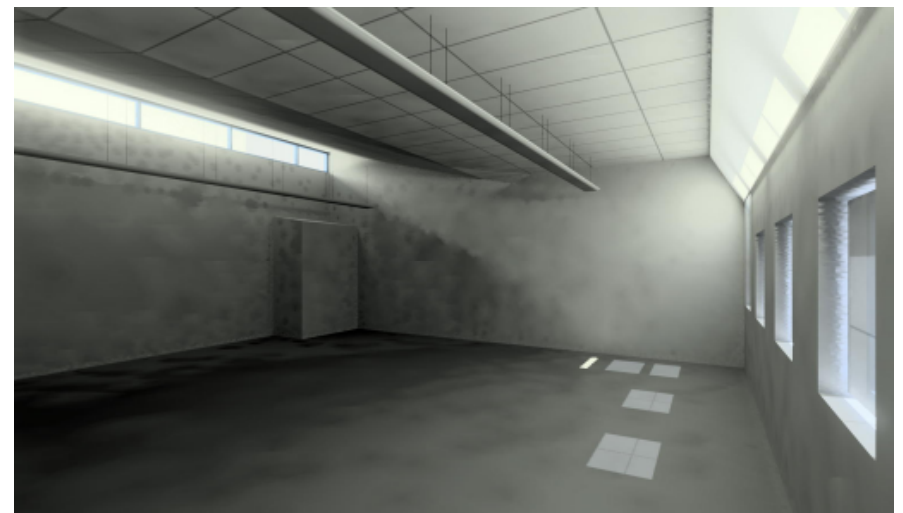


Fossil Ridge Glare Studies

South Classrooms



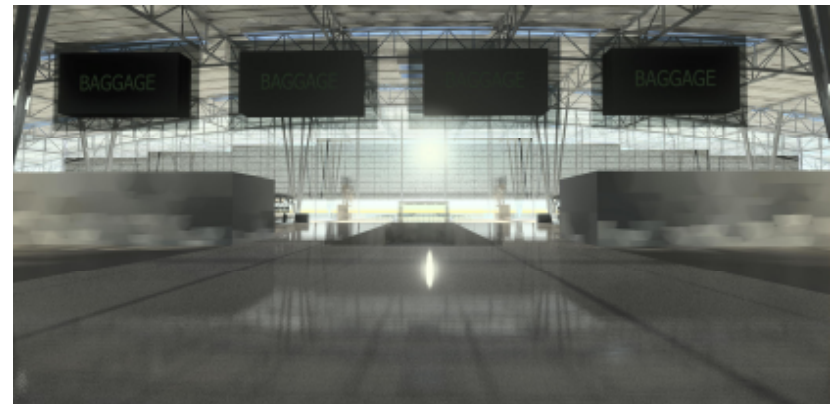
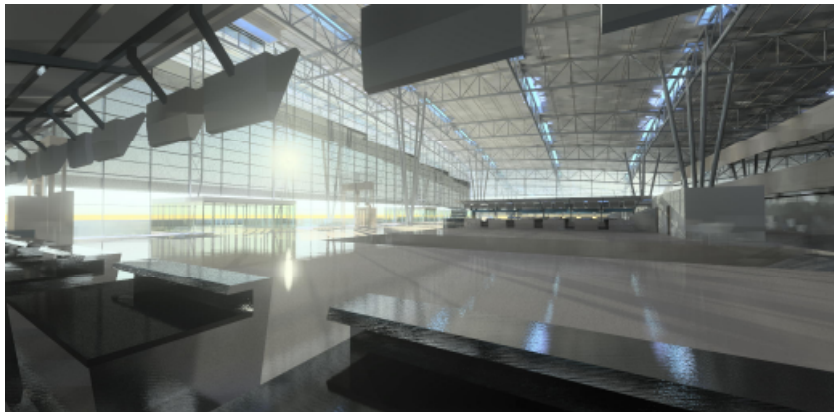
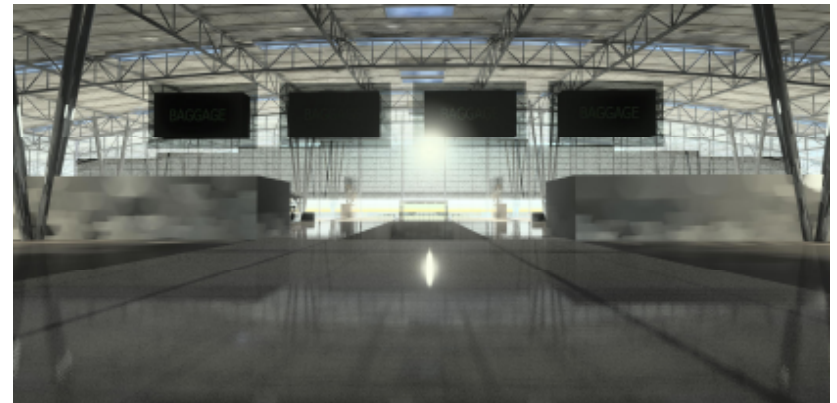
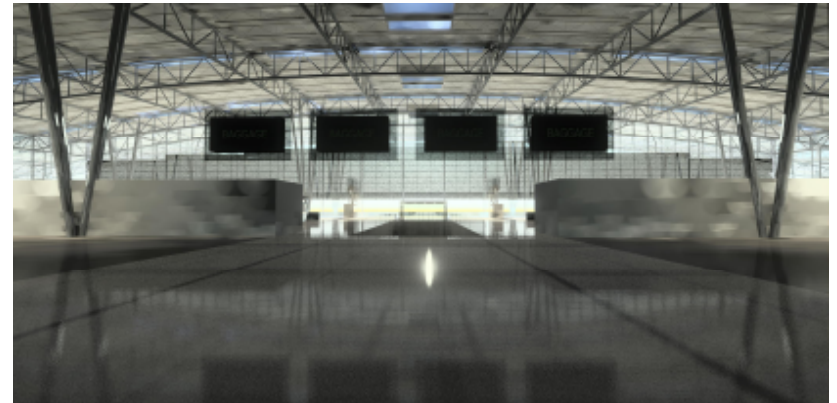
- Daylighting: The devil's in the details
- Winter time glare and projection visibility complaints
- Stretched translucent fabric with metal frame chosen retrofit option
- Proper overhang sizing and detailing critical! North clerestory glare off of corrugated metal! Painted a light grey diffuse material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



Indianapolis Airport Midfield Terminal

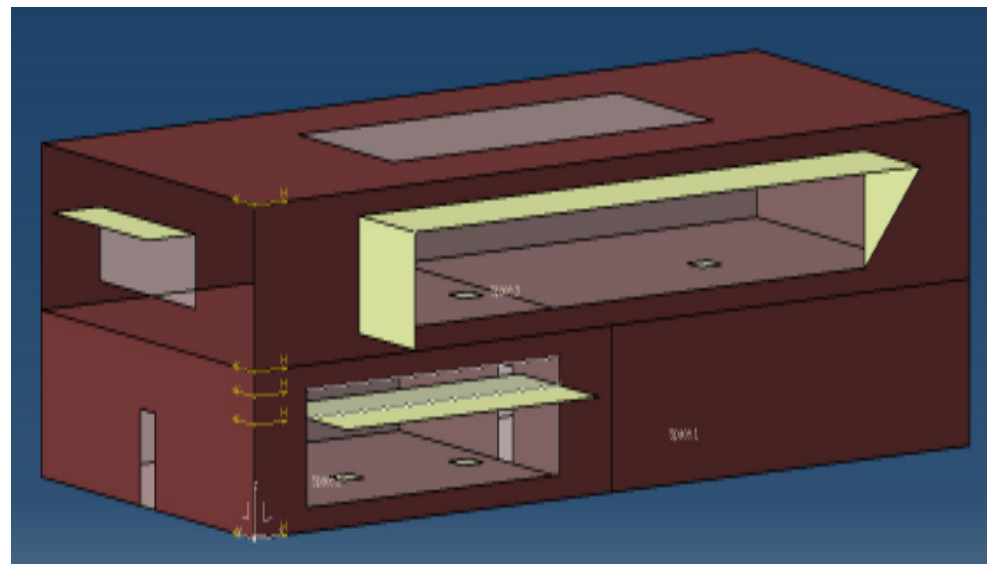
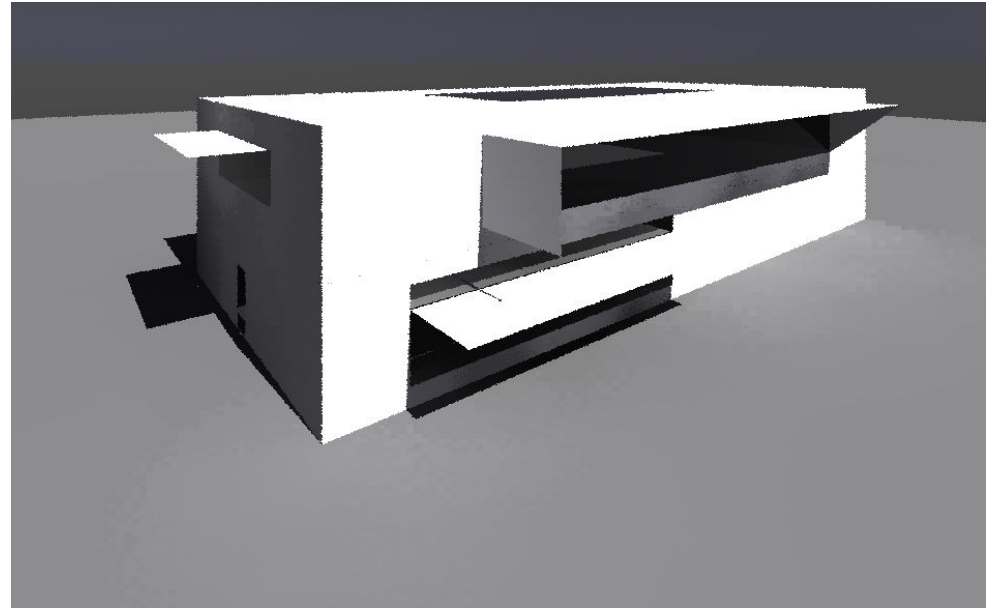
Glare Issues

- 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)

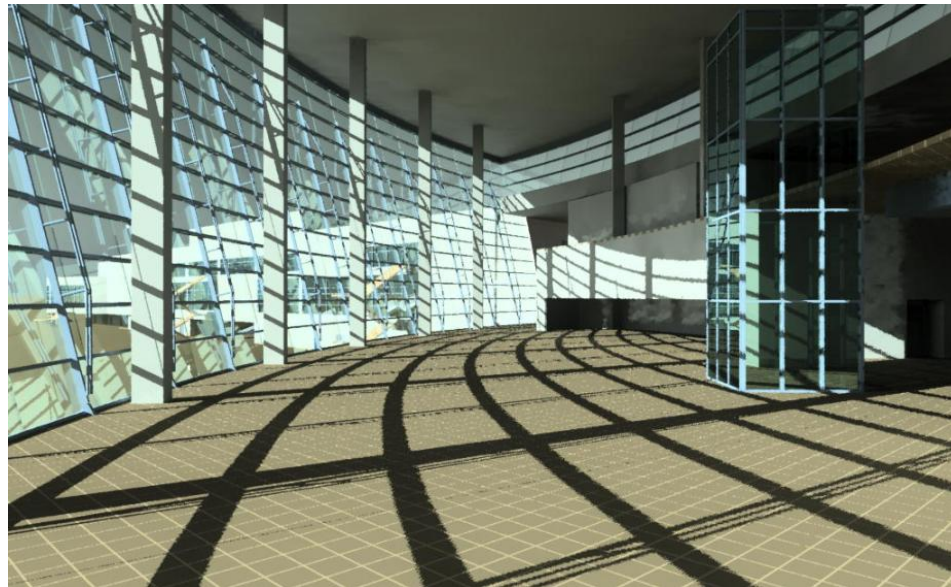
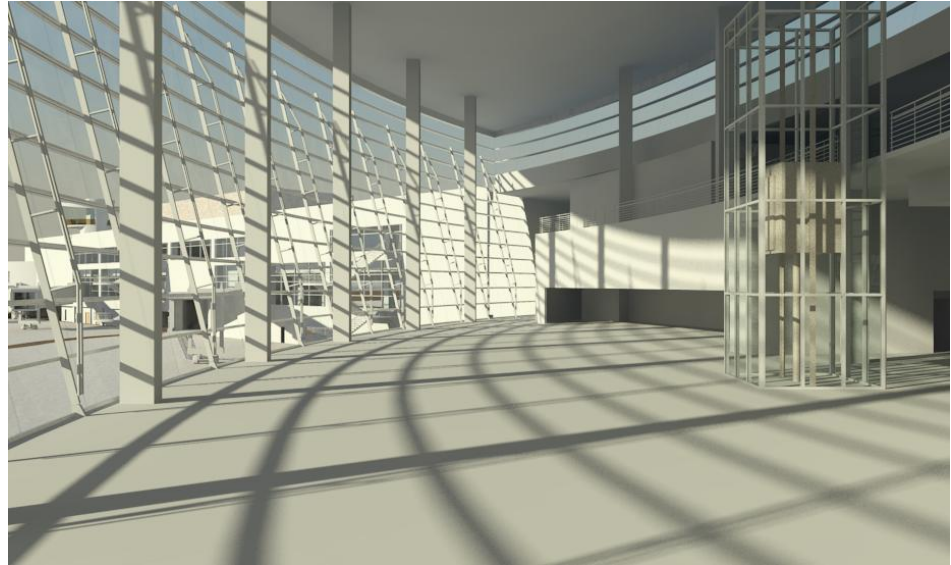
- Built off optimization engine used for structural design in the aerospace industry
- Digital Project CAD modeler exports to IFC file format (Industry Foundation Classes)
- Scripts create Energy Plus files, Radiance files, and structural information from IFC files
- DAYSIM daylight coefficient method 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

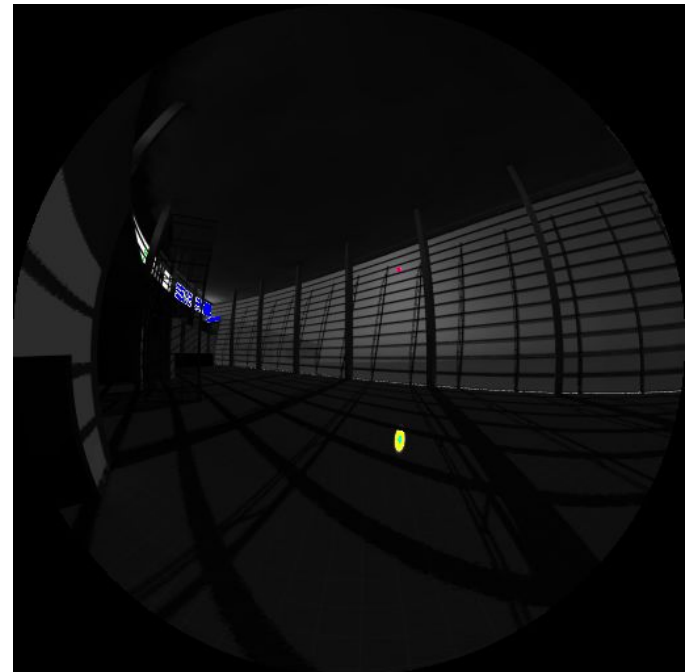
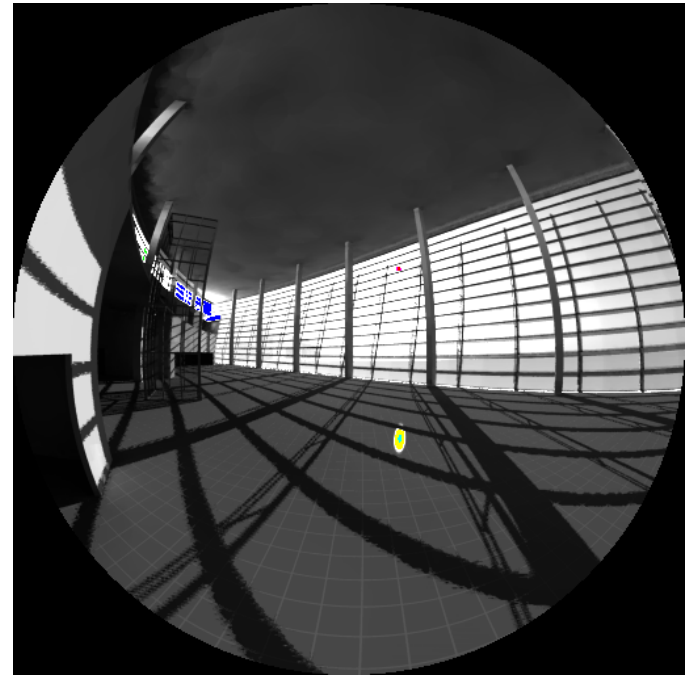
Radiance vs. mental ray

- 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?

8th Annual Radiance Conference
Harvard Graduate School of Design
October 22nd, 2009
Zack Rogers
Integrated Design Associates, Inc.

