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The Real Lit Environment: Measurements from NRC's POE of Green Buildings project

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National Research Council Canada
Conseil national de recherches Canada

Canada

Abstract

Paper #7

The real lit environment: Measurements from NRC's POE of Green Buildings project

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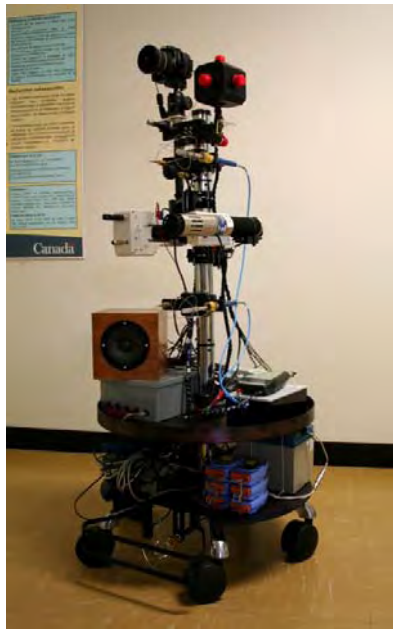
As part of a larger project on the post occupancy evaluation of buildings, we measured a range of parameters associated with the lit environment across 19 buildings. At 70 work stations, the reflectance of work station surfaces were measured, and lighting levels (and other parameters) logged over several days. General work station characteristics were also noted (e.g. luminaire and lamp type). At nearly 700 work stations, a "snapshot" measure was made of the desktop illuminance, illuminance on the sides of a cube at head position and HDR images taken of the occupant's field of view. The work station characteristics (window location, orientation, shading, etc.) were also noted. Accompanying the physical measures was an online survey about environmental satisfaction and other issues that was completed by nearly 1600 building occupants. We report the results of these measurements and discuss their implications to related lighting fields (modeling, design, systems control etc.).

NRC's POE of Green Buildings Project

- Demonstrate the value of green building practices in terms of:
  - Improved indoor environmental quality
  - Decreased energy use

- Physical measurements and surveys performed across 19 buildings
  - Commercial (private and public sectors)
  - Canada and Northern US



Lighting Related Measures

- Surface reflectances
- Illuminance levels – Desktop, Cubic
- Luminances with HDR imaging
- Office location, window availability, blind use

- Lighting satisfaction questions on survey

Results to Date

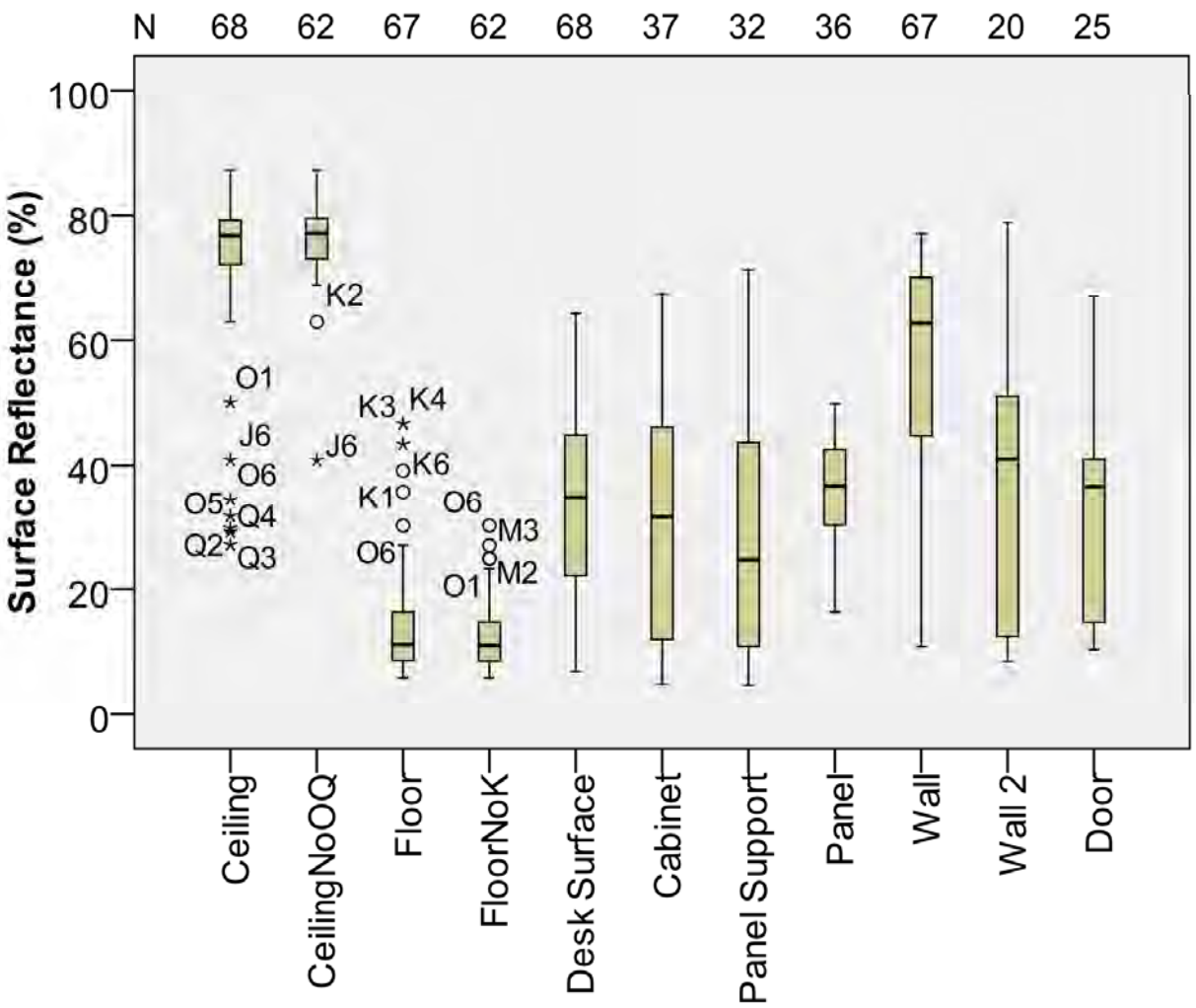
- We report the results of these measurements and discuss their implications to related lighting fields
  - Modeling
  - Design
  - Systems control
- Results shown are across all buildings

Work Station Surface Reflectances

- Spectral reflectance measured on several surfaces in 70 locations
  - Ceiling, floor, wall, desk surface etc.

- A range of reflectances observed

Observed Surface Reflectances



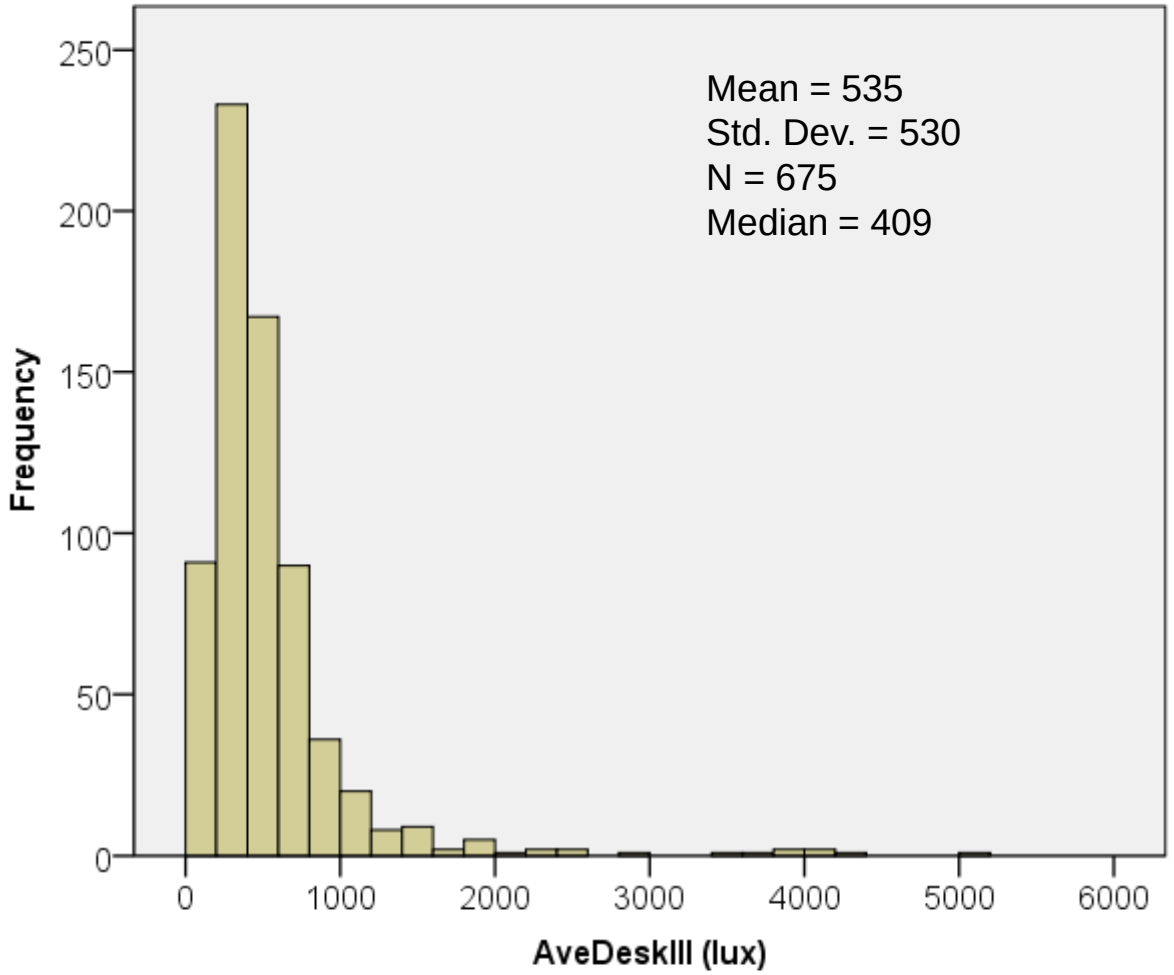
- Typical practice: 80/50/20
- Unless surfaces are known it might be better to use 80/50/10?

Lighting Measurements

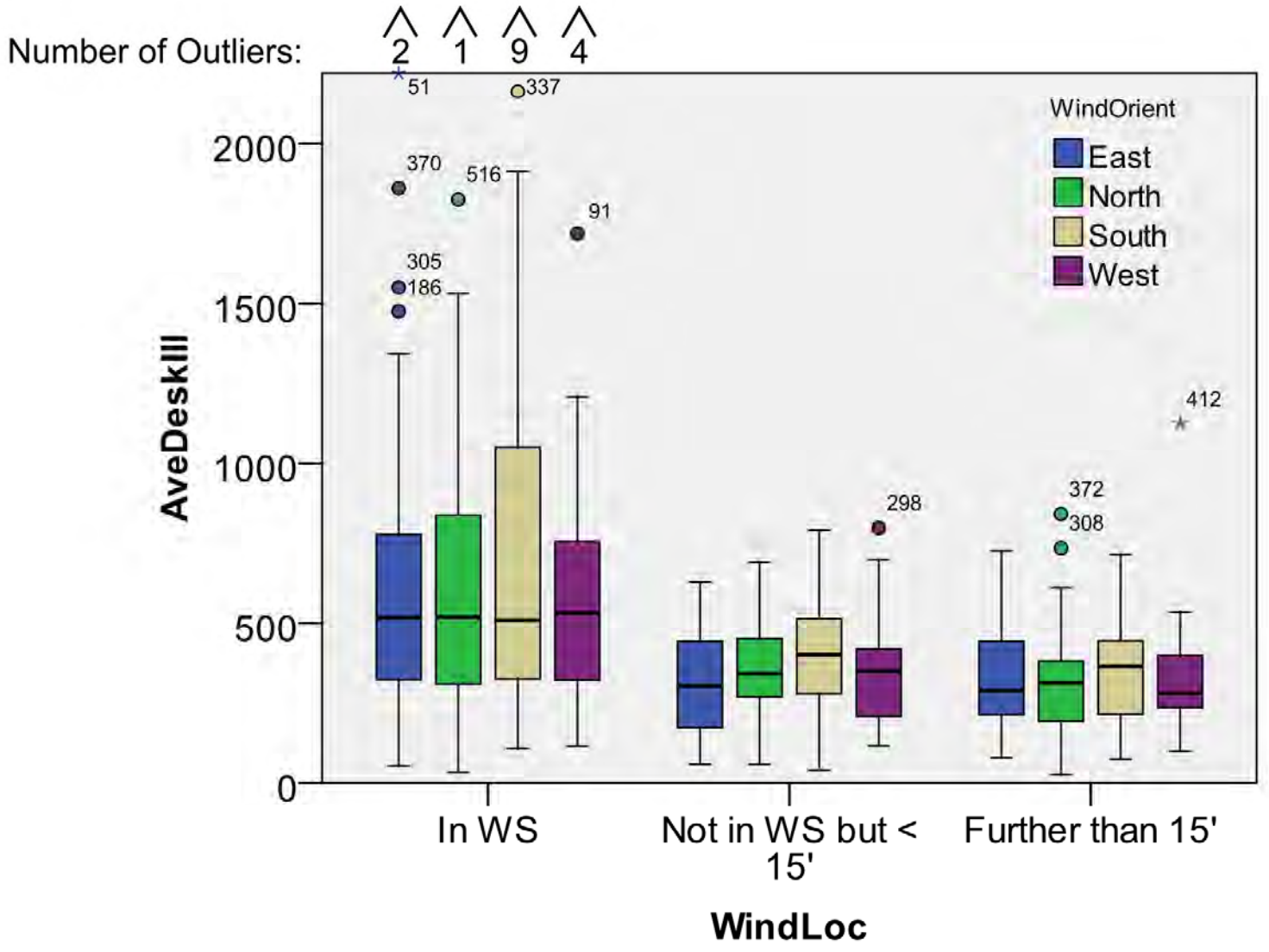
- A snap shot of lighting conditions were taken at 697 locations
  - Desktop illuminance measured at 2 locations
    - 600 mm from edge of monitor
    - 200 mm from edge of desk
  - Cubic illuminance
    - 655 mm from monitor (centre of cube)
    - 1315 mm off ground (centre of cube)
  - Luminance measured from a HDR image

- Work station characteristics also recorded at time of measurement

Range of Illuminance Levels Observed



Light Levels and Window Location

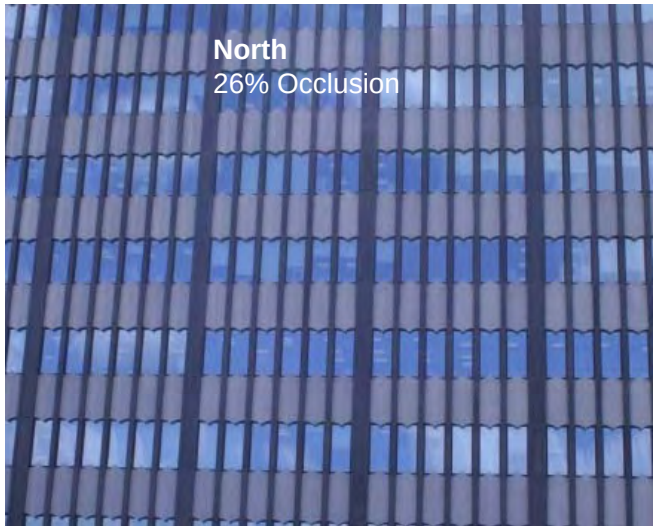


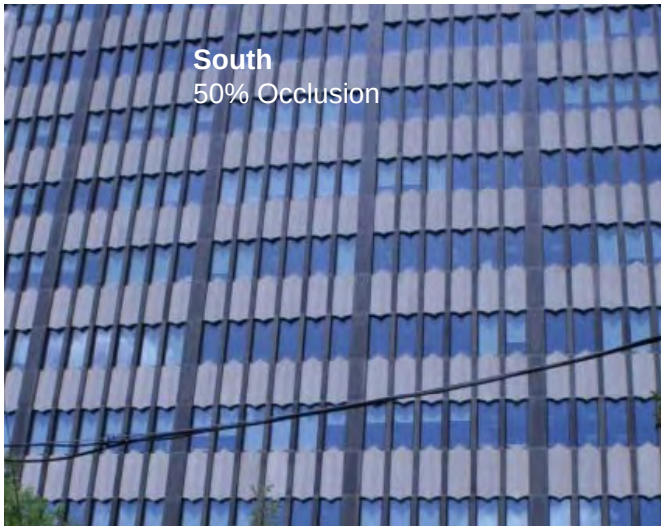
Use of Blinds

WindOrient * ShadeSetting Crosstabulation

% within WindOrient

		ShadeSetting				
		Closed	Partially open	Open	Fully Retracted	Total
WindOrient	North	3.4	39.3	32.6	24.7	100.0
	South	23.2	49.1	20.5	7.1	100.0
	East	21.2	41.2	18.8	18.8	100.0
	West	8.8	43.8	25.0	22.5	100.0
Total		14.8	43.7	24.0	17.5	100.0





Regression Analysis

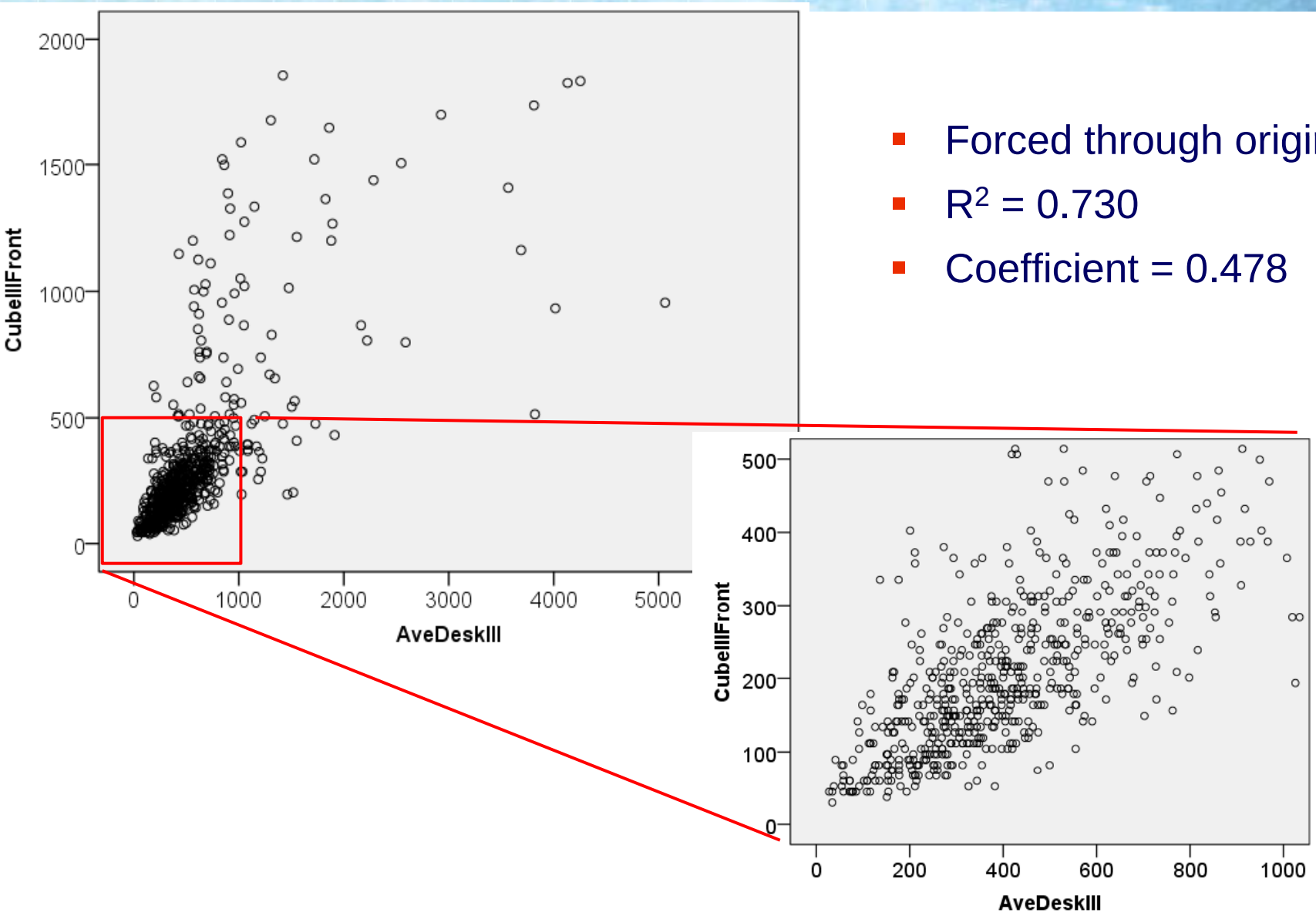
- Prediction of desktop illuminance
- Core WS is base
- Use of dummy variables
- $R^2 = .248$

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	196	76		2.581	.010
	NorthMorn	229	104	.091	2.214	.027
	NorthMid	137	151	.036	.913	.361
	NorthAft	182	119	.062	1.532	.126
	SouthMorn	204	117	.069	1.742	.082
	SouthMid	865	111	.311	7.816	.000
	SouthAft	634	104	.245	6.068	.000
	EastMorn	498	113	.176	4.429	.000
	EastMid	414	144	.113	2.882	.004
	EastAft	115	121	.038	.945	.345
	WestMorn	170	114	.059	1.488	.137
	WestMid	176	136	.051	1.298	.195
	WestAft	684	127	.212	5.363	.000
	PartCloud	387	65.7	.251	5.890	.000
	Clear	162	60.9	.113	2.656	.008
	ShadeRetract	-7.3	89.3	-.004	-.081	.935
	ShadeOpen	145	87.6	.085	1.661	.097
	ShadePartOpen	-38.3	71.9	-.028	-.532	.595

a: dependent variable - AveDeskIll

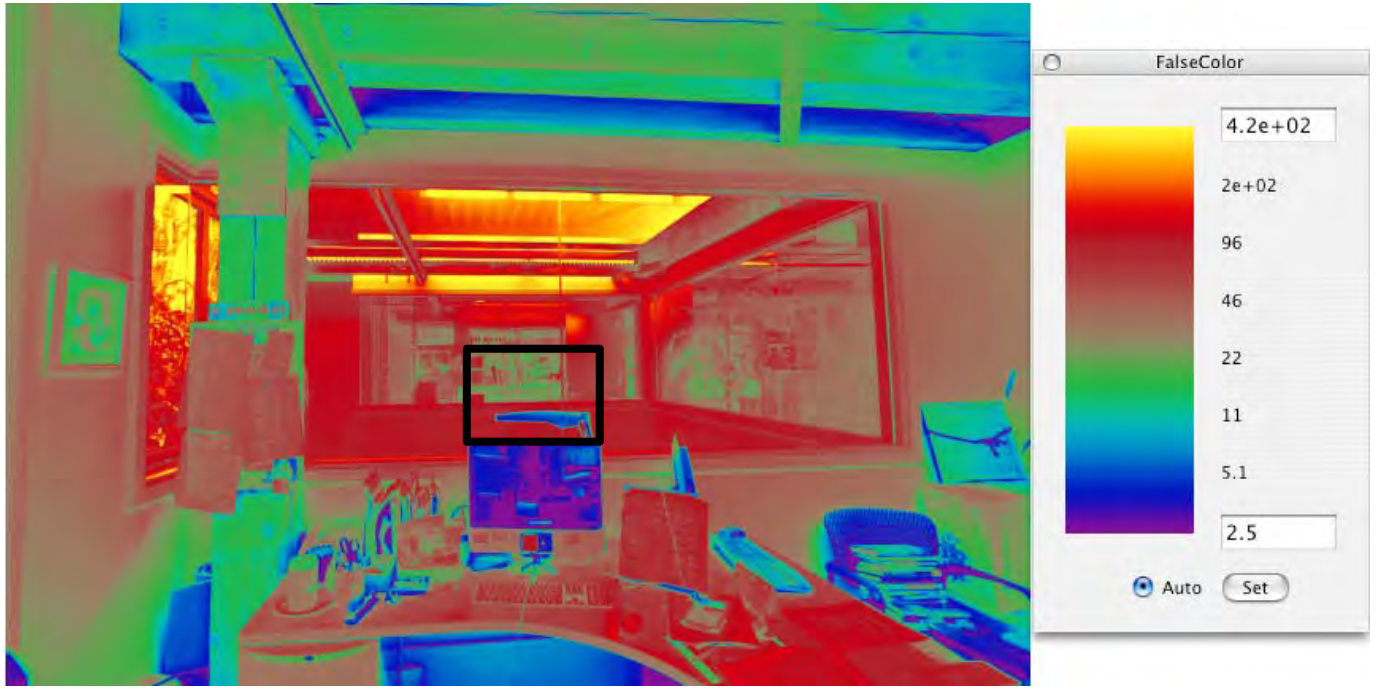
Light Levels Received at Eye?



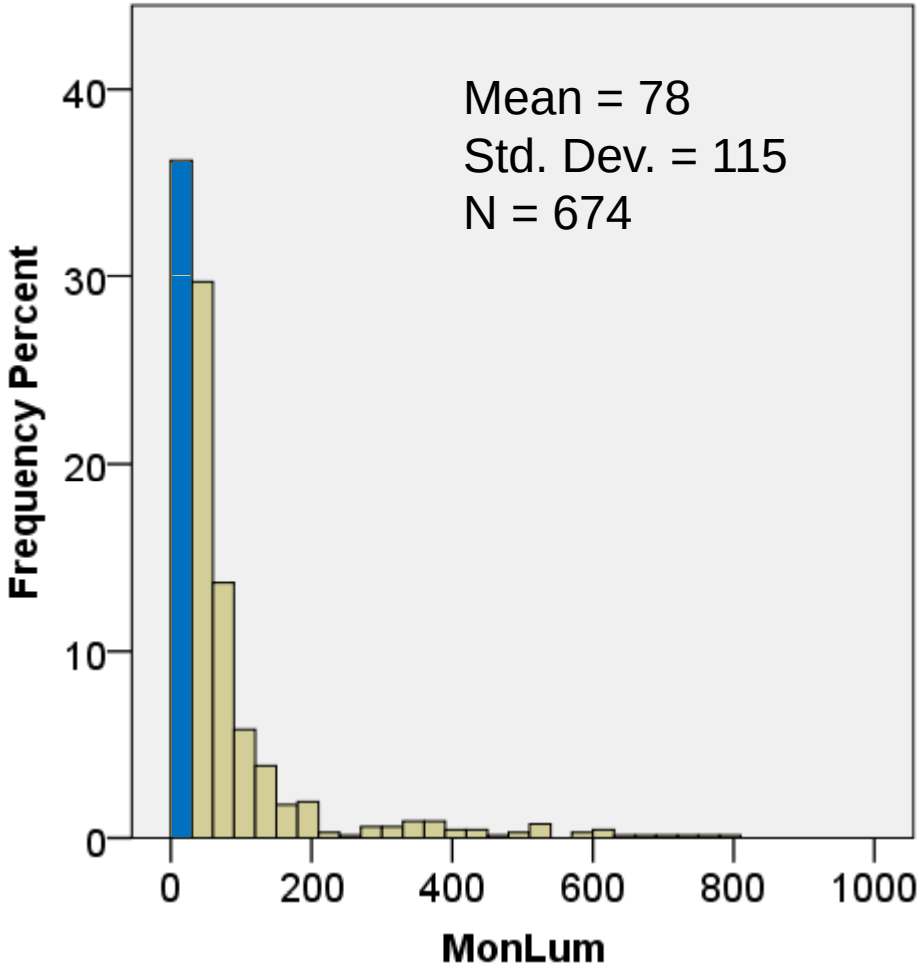
- Forced through origin
- $R^2 = 0.730$
- Coefficient = 0.478

Luminance Levels in Field of View

- 15 images taken with a calibration target in field of view
- Not calibrated for vignetting effects
- Average luminance, above monitor are shown



Measured Luminance Above Monitor

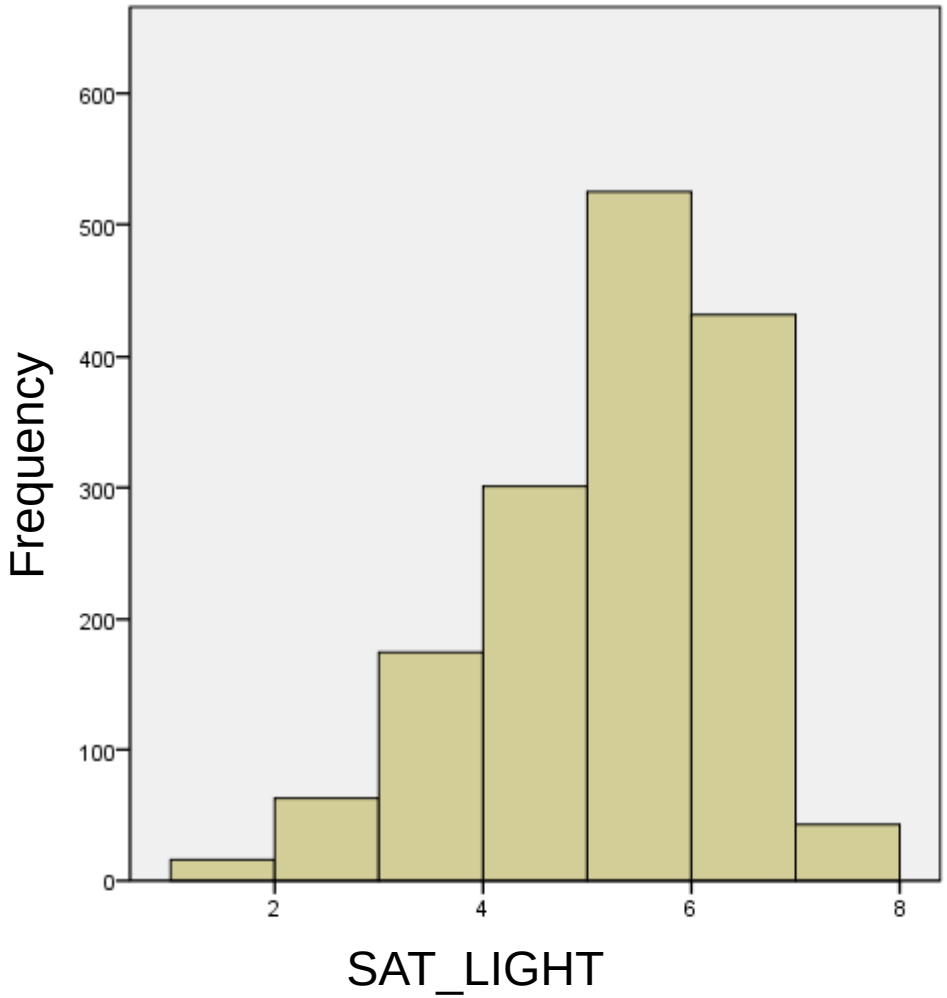


- Proposed minimum in RP1 is 30 cd/m^2
- 36% < 30 cd/m^2

POE Survey – Lighting Satisfaction

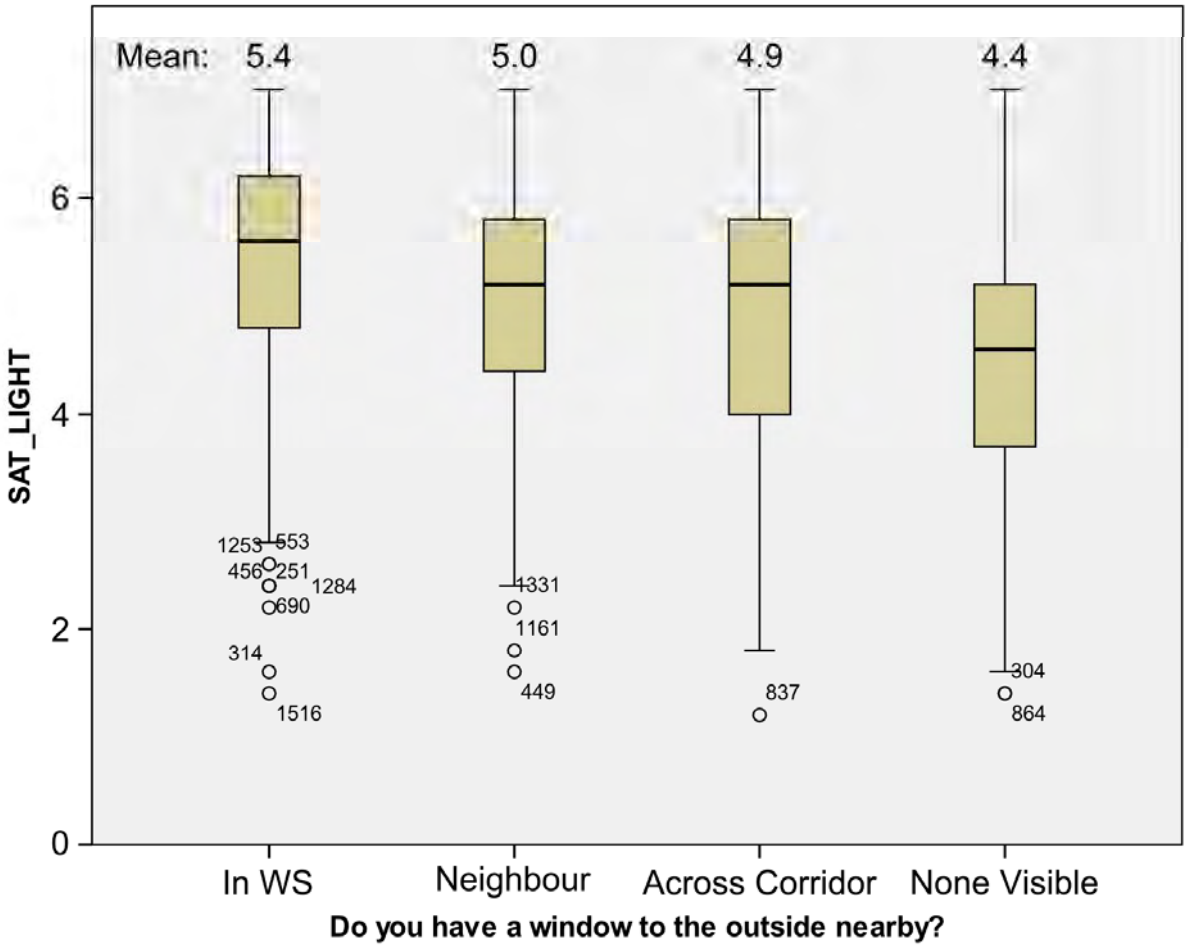
- 7 point scale from very unsatisfactory to very satisfactory
- Satisfaction level with:
  - Amount of lighting on desktop
  - Amount of light for computer work
  - Amount of reflected light or glare on the computer screen
  - Your access to view of outside from where you sit
  - Quality of lighting in your work area

Satisfaction with Lighting



Mean = 5.1
Std. Dev. = 1.2
N = 1 555

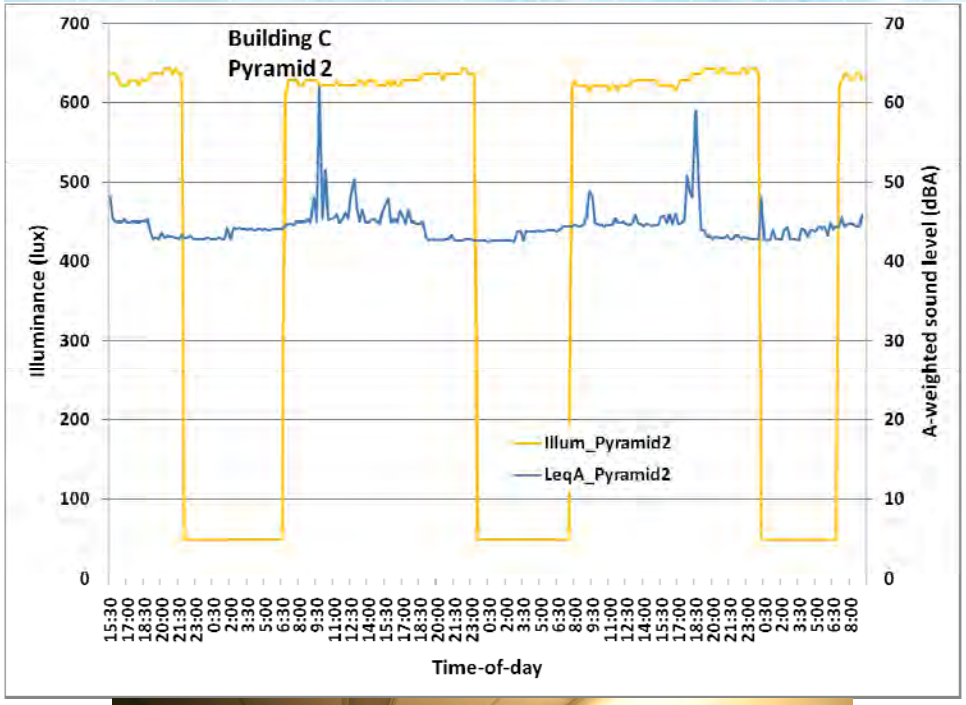
Satisfaction with Lighting and Window Location

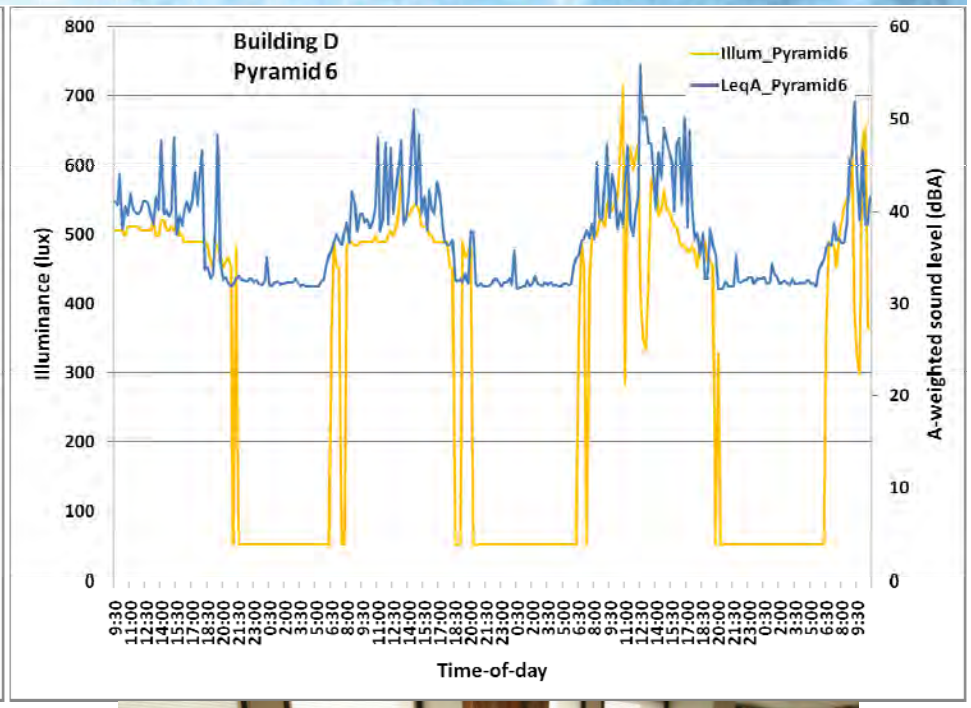


- As you move in to the core of the building satisfaction decreases

Longitudinal Lighting Measurements

- Pyramids measured several variables over the course of the site visit (2-3 days)
- Lighting level and acoustic levels were recorded every 15 minutes


Building C
Pyramid 2
Illuminance (lux)
A-weighted sound level (dBA)
Illum_Pyramid2
LeqA_Pyramid2
Time-of-day


Building D
Pyramid 6
Illum_Pyramid6
LeqA_Pyramid6
Illuminance (lux)
A-weighted sound level (dBA)
Time-of-day

Conclusions

- Surface reflectance
  - Potentially change values used in modeling (80/50/10)
- Illuminance levels
  - Some above, some below recommended practices
  - Real world data informs daylight simulation
- Luminance levels
  - 36% under proposed recommendation
- Satisfaction with lighting
  - People generally satisfied
  - Those closer to window have greater satisfaction

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