Simulating the Performance of UV Systems

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LTI Optics

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overview

"design" method?

general lighting design method

benefits of simulation approach

fixture level performance

room level performance

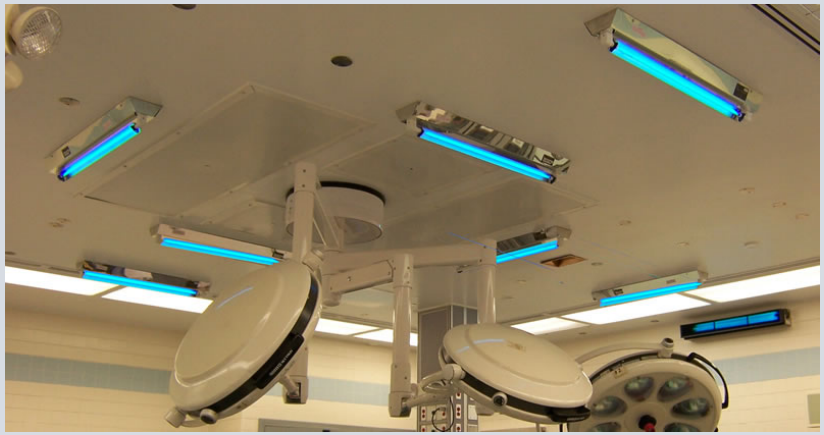
summary

“design” method?

“design” method?

the questions:

“we need 50 µW/cm² to kill…
how many UV sources do we need?
what power should they have?
where do they need to be placed?
how long should they be on?”



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“design” method?

the questions:

“we need 50 μW/cm^2 to kill…
how many UV sources do we need?
what power should they have?
where do they need to be placed?
how long should they be on?”

and we should know this before we’ve spent any money on purchasing a device

“design” method?

example recommendations for upper room uvgi:

1) 30W lamp per each 200 sqft floor area
2) 6.3W lamp per 1m^3 of *upper* room volume

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“design” method?

example recommendations for upper room:

1) 30W lamp per each 200 sqft floor area
2) 6.3W lamp per 1m^3 of *upper* room volume

these “rule of thumb” methods are imprecise and don’t address the actual energy and where it is placed in the room.

this can lead to over or under design that isn’t discovered until the space is finished and measurements are taken.

general lighting

general lighting design method history

1604

Kepler – Inverse Square Law

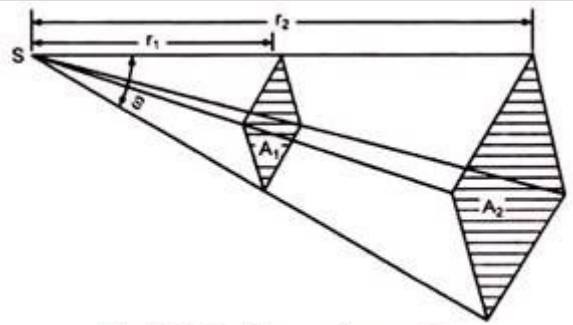

Fig. 7.6 (*a*). *Inverse Square Law*

$$I = I_o/r^2$$

"there is as much light in the narrower spherical surface, as in the wider, thus it is as much more compressed and dense here than there".

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general lighting design method history

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Inverse Square Cosine Law

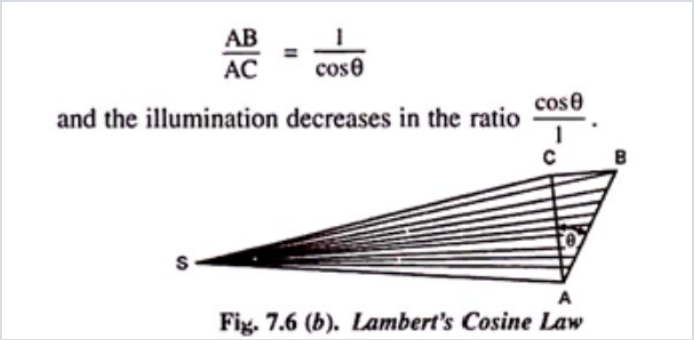

Fig. 7.6 (*b*). *Lambert's Cosine Law*

$$E = I \cos(\xi)/d^2$$

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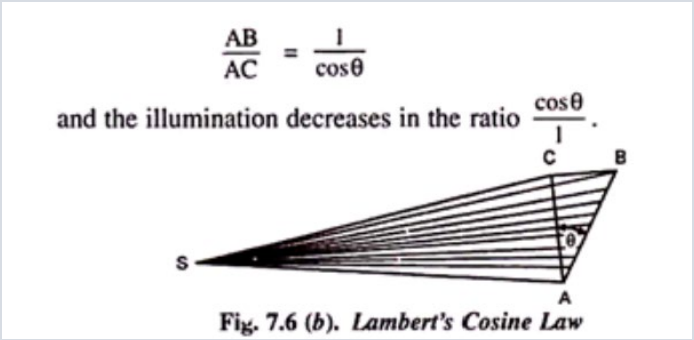

Fig. 7.6 (*b*). *Lambert's Cosine Law*

$$E = I \cos(\xi)/d^2$$

distance & orientation matter
& there's an equation for it

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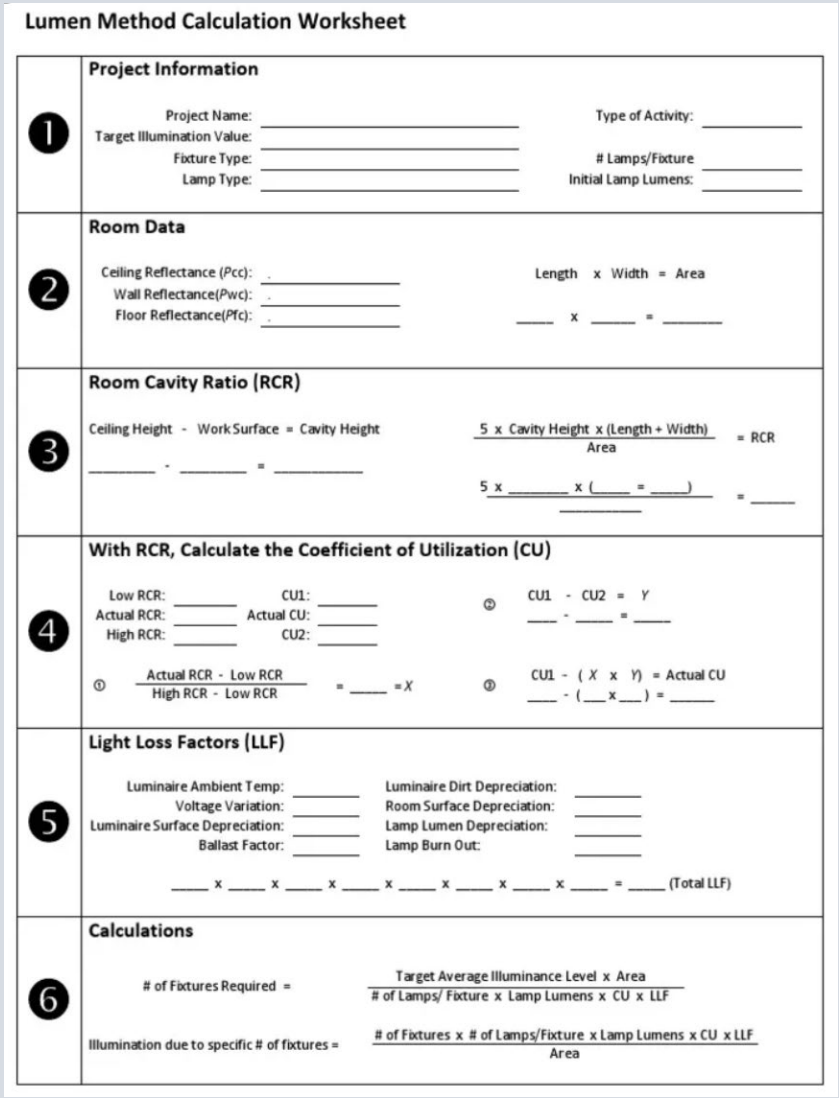
….

1960's

lumen method - average



Lumen Method Calculation Worksheet

1 Project Information

Project Name: _____ Type of Activity: _____
Target Illumination Value: _____
Fixture Type: _____ # Lamps/Fixture _____
Lamp Type: _____ Initial Lamp Lumens: _____

2 Room Data

Ceiling Reflectance (*Pcc*): _____
Wall Reflectance(*Pwc*): _____
Floor Reflectance(*Pfc*): _____

Length x Width = Area
____ x ____ = ____

3 Room Cavity Ratio (RCR)

Ceiling Height - Work Surface = Cavity Height
____ - ____ = ____

$$\frac{5 \times \text{Cavity Height} \times (\text{Length} + \text{Width})}{\text{Area}} = \text{RCR}$$

$$\frac{5 \times \_\_\_\_ \times (\_\_\_\_ = \_\_\_\_)}{\_\_\_\_} = \_\_\_\_$$

4 With RCR, Calculate the Coefficient of Utilization (CU)

Low RCR: _____ CU1: _____
Actual RCR: _____ Actual CU: _____
High RCR: _____ CU2: _____

① $\frac{\text{Actual RCR - Low RCR}}{\text{High RCR - Low RCR}} = \_\_\_\_ = X$

② CU1 - CU2 = Y
____ - ____ = ____

③ CU1 - (X x Y) = Actual CU
____ - (___ x ___) = ____

5 Light Loss Factors (LLF)

Luminaire Ambient Temp: _____ Luminaire Dirt Depreciation: _____
Voltage Variation: _____ Room Surface Depreciation: _____
Luminaire Surface Depreciation: _____ Lamp Lumen Depreciation: _____
Ballast Factor: _____ Lamp Burn Out: _____

____ x ____ x ____ x ____ x ____ x ____ x ____ x ____ = ____ (Total LLF)

6 Calculations

$$\text{\# of Fixtures Required} = \frac{\text{Target Average Illuminance Level} \times \text{Area}}{\text{\# of Lamps/ Fixture} \times \text{Lamp Lumens} \times \text{CU} \times \text{LLF}}$$

$$\text{Illumination due to specific \# of fixtures} = \frac{\text{\# of Fixtures} \times \text{\# of Lamps/Fixture} \times \text{Lamp Lumens} \times \text{CU} \times \text{LLF}}{\text{Area}}$$

general lighting design method history

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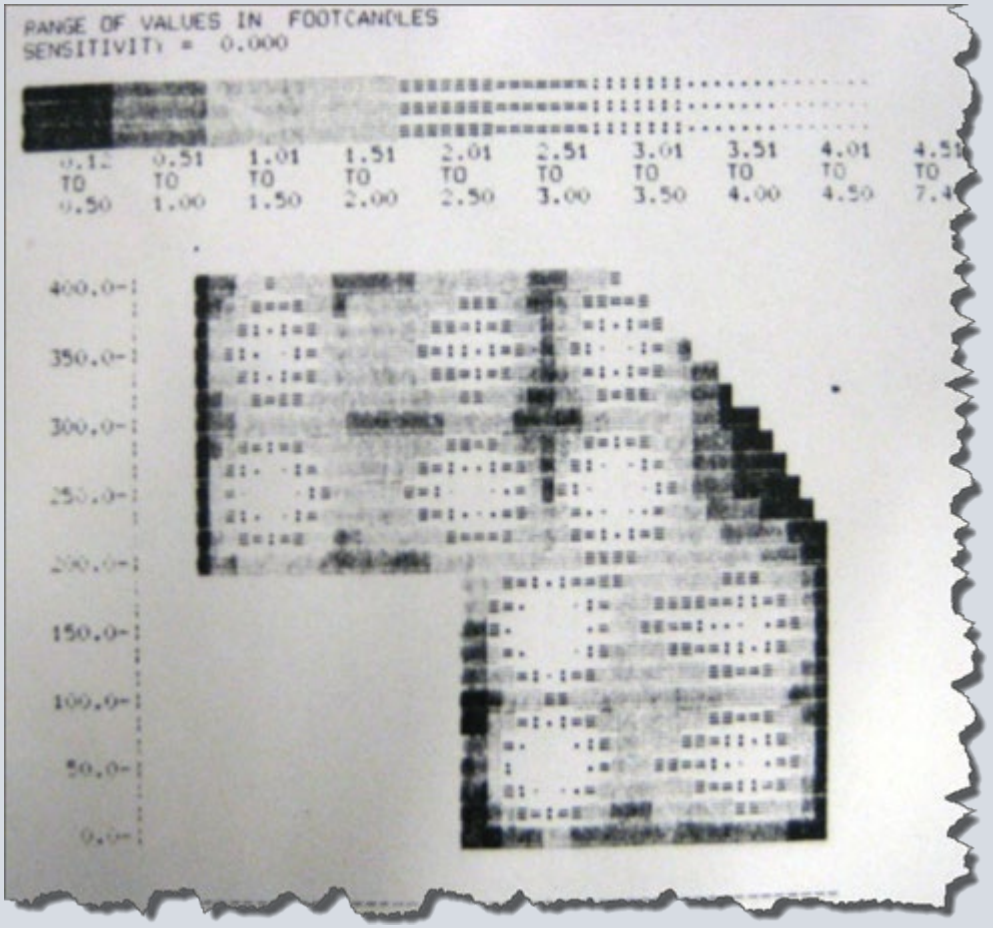
1960's

lumen method - average

1980's

computer point by point



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lumen method - average

1980's

computer point by point

1990's

computer interior calcs

there is as much light in the narrower spherical surface, as in the wider, thus it is as much more compressed and dense here than there

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lumen method - c

1980's

computer point by po t

1990's

computer interior calcs

UV for HAI is about here

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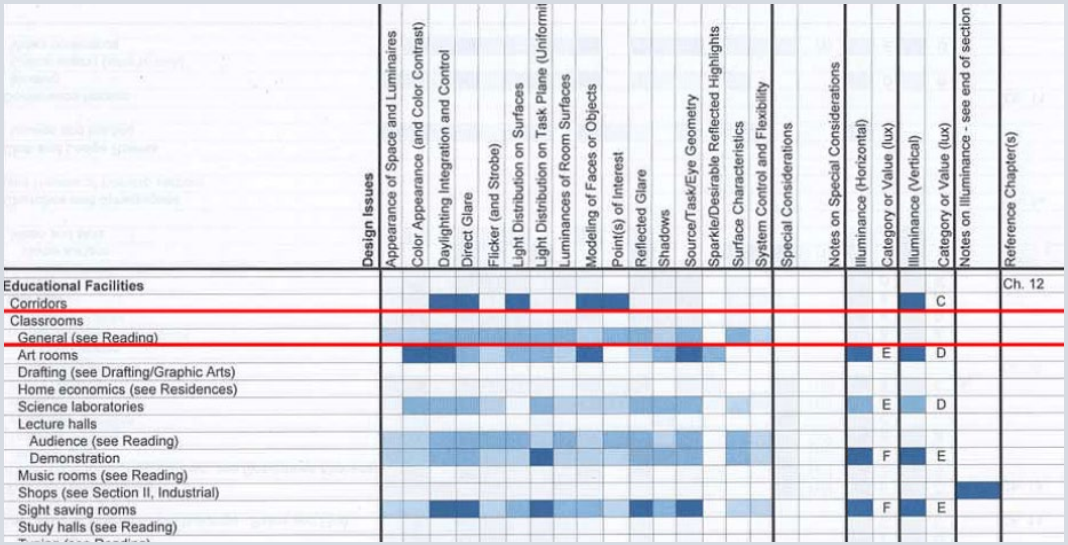
general lighting design method history

IES recommends light levels:
30fc for general office space

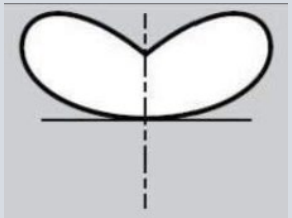


Design Issues	Appearance of Space and Luminaires	Color Appearance (and Color Contrast)	Daylighting Integration and Control	Direct Glare	Flicker (and Strobe)	Light Distribution on Surfaces	Light Distribution on Task Plane (Uniformi	Luminances of Room Surfaces	Modeling of Faces or Objects	Point(s) of Interest	Reflected Glare	Shadows	Source/Task/Eye Geometry	Sparkle/Desirable Reflected Highlights	Surface Characteristics	System Control and Flexibility	Special Considerations	Notes on Special Considerations	Illuminance (Horizontal)	Category or Value (lux)	Illuminance (Vertical)	Category or Value (lux)	Notes on Illuminance - see end of section	Reference Chapter(s)
Educational Facilities																								Ch. 12
Corridors																						C		
Classrooms																								
General (see Reading)																								
Art rooms																				E		D		
Drafting (see Drafting/Graphic Arts)																								
Home economics (see Residences)																								
Science laboratories																				E		D		
Lecture halls																								
Audience (see Reading)																								
Demonstration																				F		E		
Music rooms (see Reading)																								
Shops (see Section II, Industrial)																								
Sight saving rooms																				F		E		
Study halls (see Reading)																								

general lighting design method

IES recommends light levels:
30fc for general office space (lumens/sqft)

gather IES file and luminaire output
physical test or simulation



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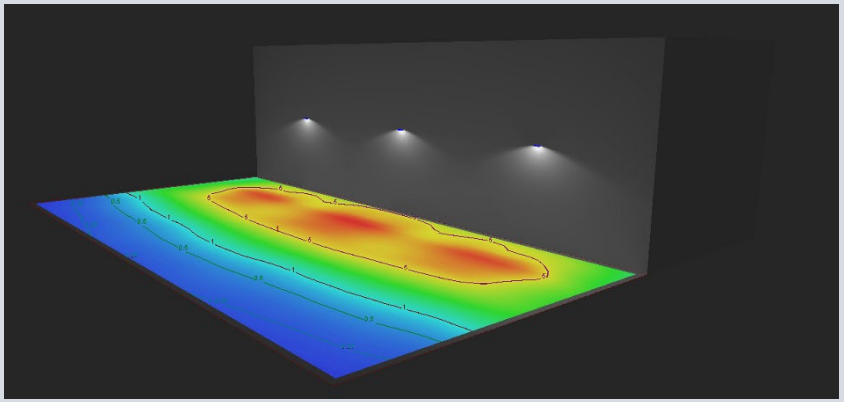
general lighting design method

IES recommends light levels:
30fc for general office space (lumens/sqft)

gather IES file and luminaire output
physical test or simulation

simulate room to determine fc



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benefits of simulations

benefits of simulations

fixture level simulations (raytracing software)

room level simulations (application software)

Predict amount and location of energy

Improve uniformity of energy

Improve efficiency of fixtures

Minimize fixtures and energy, while hitting specs

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fixture level performance

how much energy comes out?
and where does it go?

fixture level performance

output watts
&
.ies file

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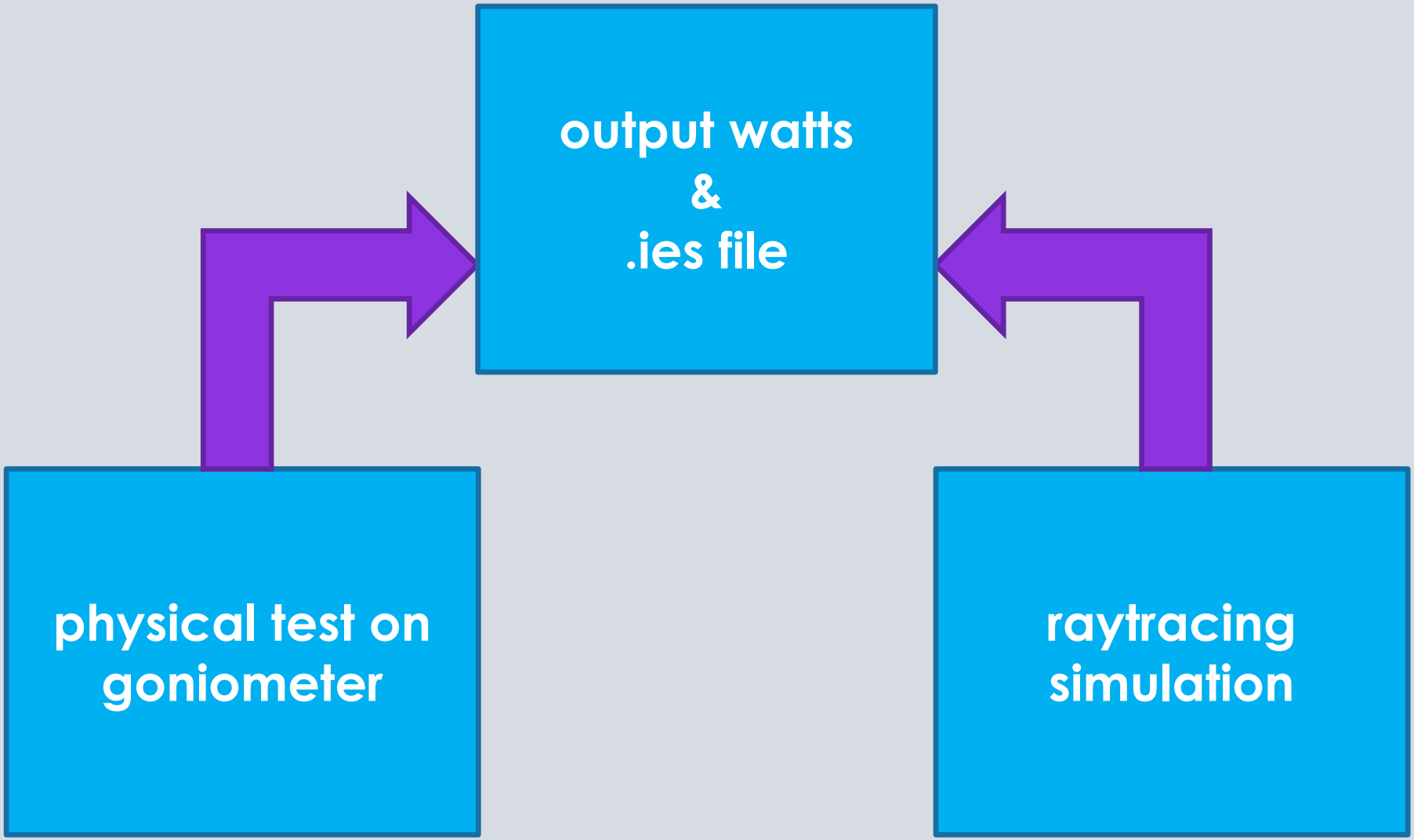
fixture level performance



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fixture level performance

physical test on goniometer

fixture must be built

limited design iterations

absolute performance

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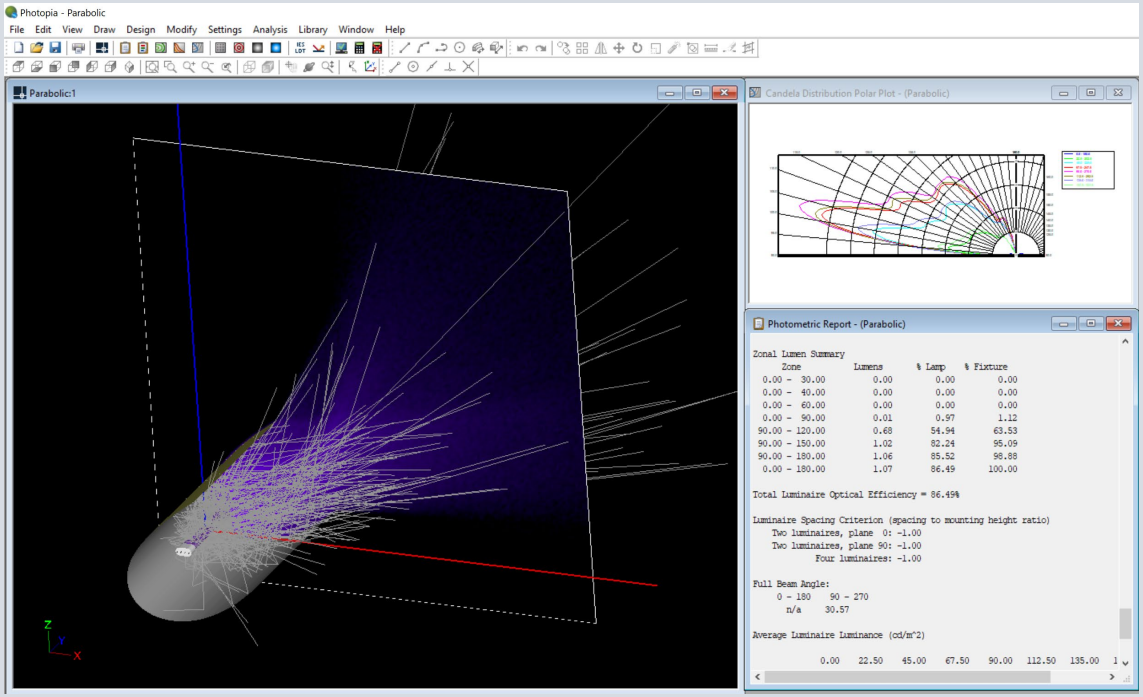
fixture level performance



raytracing simulation

photopia®

indirect uplight with elliptic reflector
full cutoff at horizon
86% fixture efficiency

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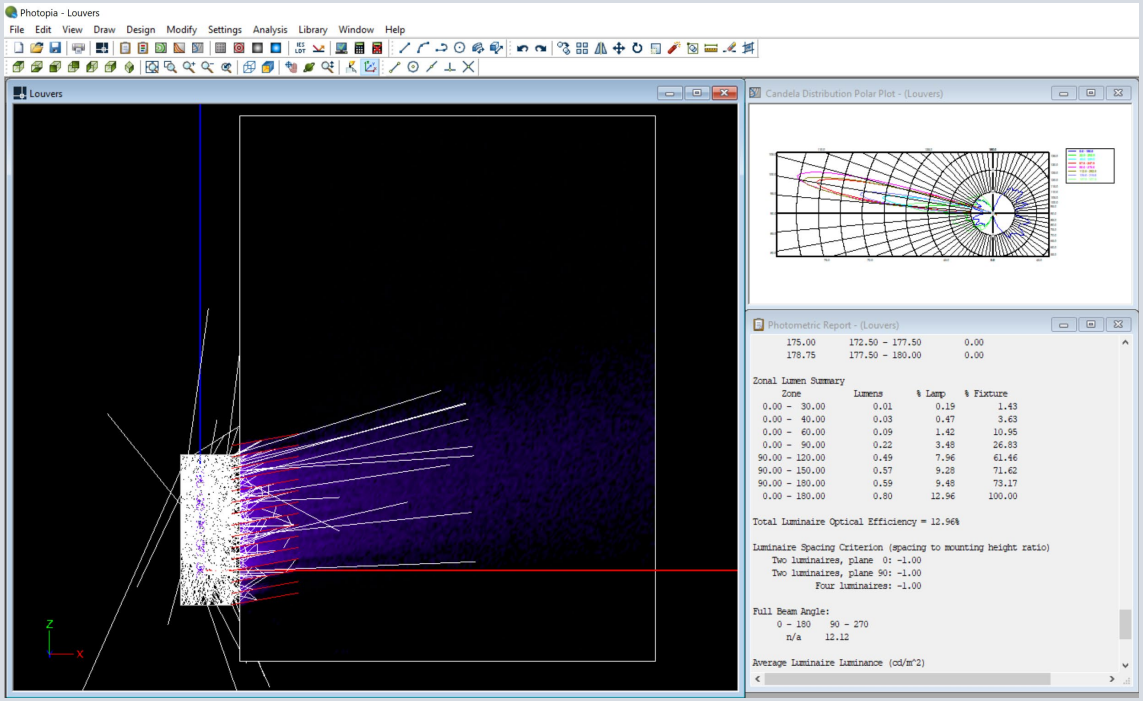
fixture level performance



raytracing simulation

photopia®

indirect uplight with black louvers
full cutoff at horizon
13% fixture efficiency

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fixture level performance

raytracing simulation

40W Lamp
86% eff
34W out

40W Lamp
13% eff
5.2W out

photopia®

example recommendations:

1) 30W lamp per each 200 sqft floor area
?? so 1 of each fixture ?? probably not adequate

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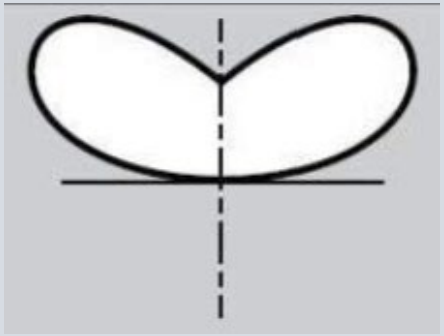
room level performance

how is the energy distributed in the space?

room level performance

.ies file



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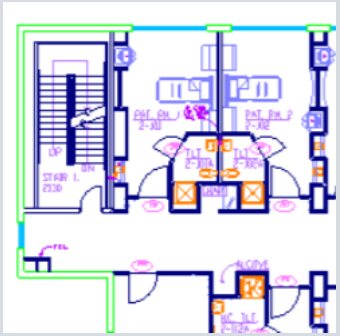
CAD model of room



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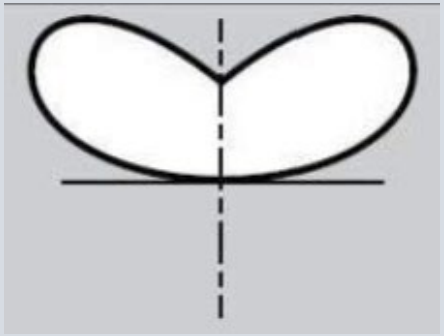
room level performance

.ies file



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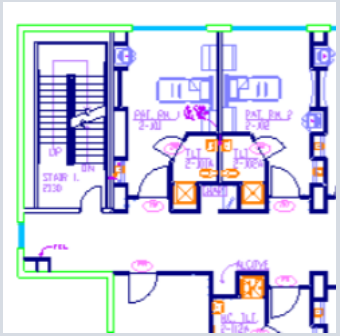

irradiance [w/m^2]

fluence [w/m^3]

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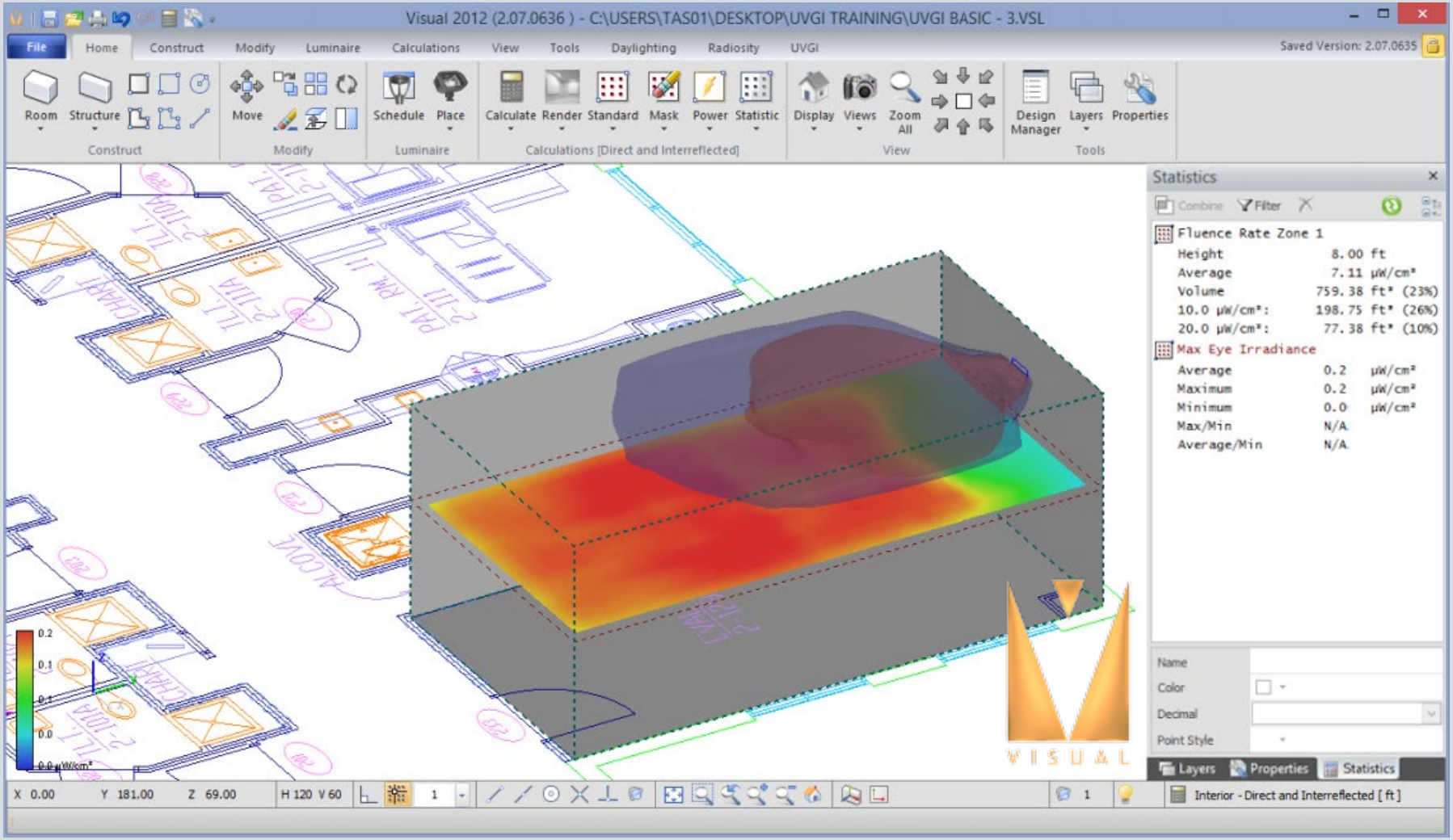
room level performance



AcuityBrands.

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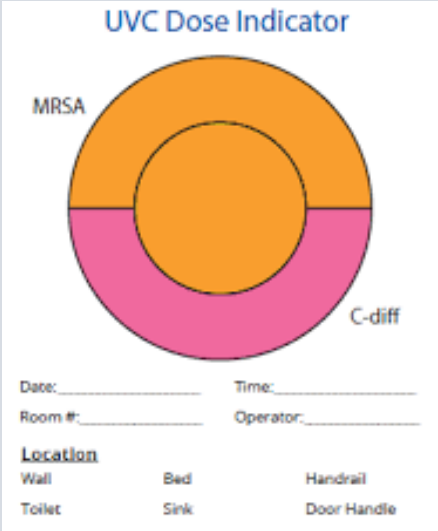
summary

measure a system



purchased
installed
operated

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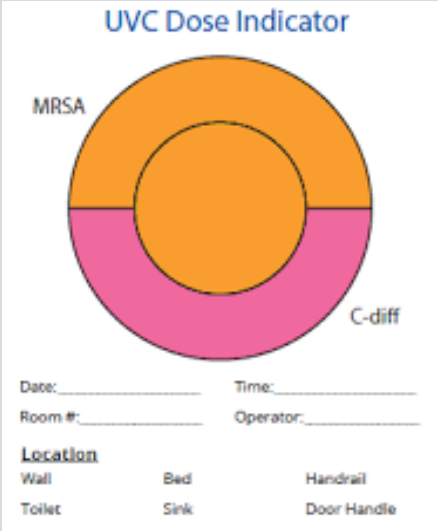
summary

measure a system



purchased
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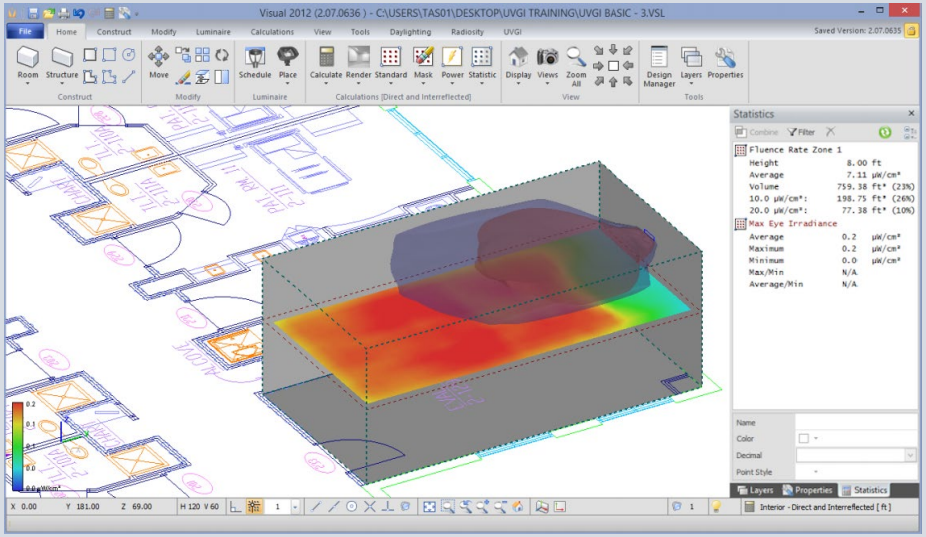
design a system



simulated

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summary

Simulating fixture level performance can allow for the design of more efficient fixtures.

Simulating room level performance can allow for the optimal design of adequate UVGI levels in spaces during the design phase.

Fixture Level Researchers:
Photopia team at LTI Optics
Room Level Researchers:
Richard L Vincent, Icahn School of Medicine at Mount Sinai
Visual software team at Acuity Brands Lighting

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