Design for Daylight Performance

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University of Minnesota, Folwell Hall, Room 105

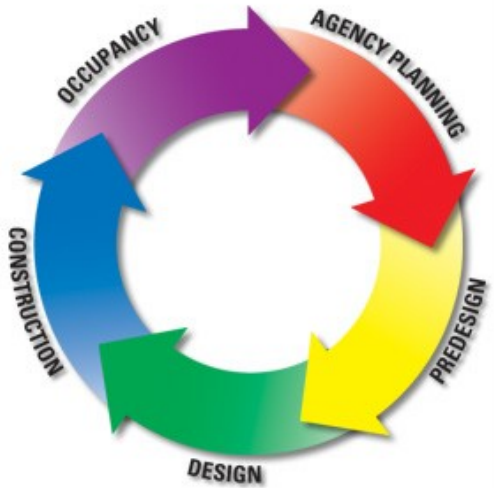
Agenda

- Background on B3 revisions and timeline
- Approach and intent of Daylighting Requirements
- Guideline I.5 Lighting and Daylighting
- Defining regularly occupied spaces
- Metrics used under B3 Guidelines
- Available Tools
- Discussion and questions

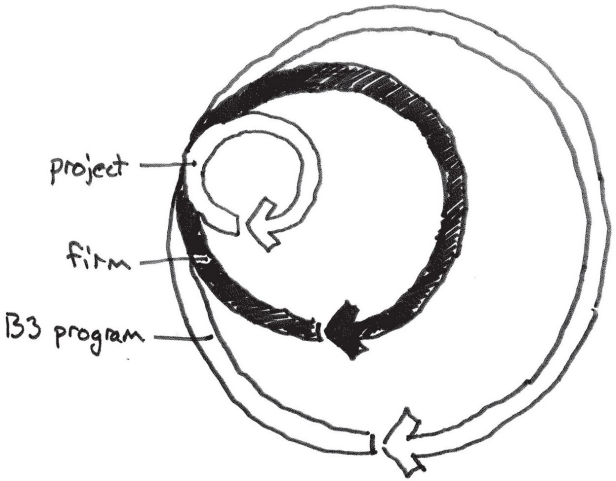
Learning Objectives

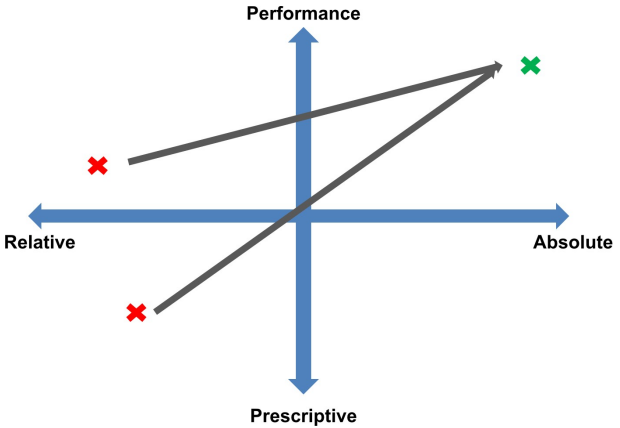
- Understand the daylight requirements of version 3.1 of the B3 Guidelines
- Understand the daylighting metrics used in the guidelines
- Understand the general process of creating and interpreting daylighting metrics
- Understand the process of developing a design in response to daylighting metrics

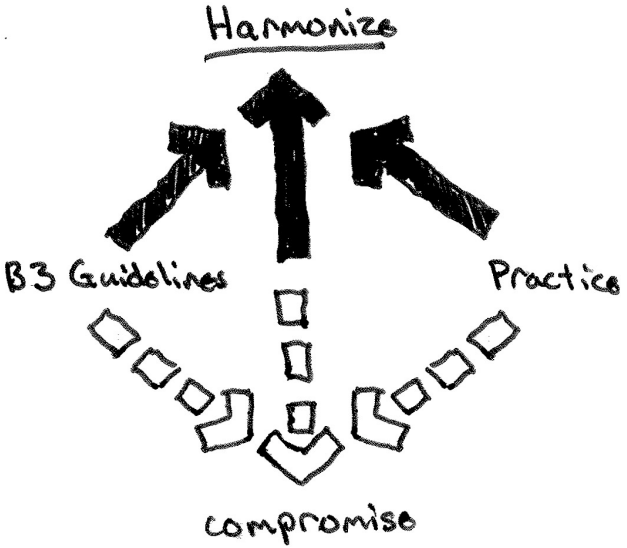
B3 Process – providing a feedback loop



Which works at different scales



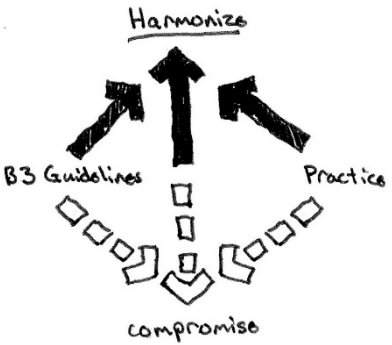




Adapted from Bill Reed

Intent of Guideline Revisions

- Bring B3 up-to-date with the latest national standards and green rating systems
- Revise performance standards and requirements to reflect the current state of the building industry in Minnesota
- Reduce the administrative burden for project teams
- Improve the sustainable performance of projects in the future



Timeline of Guideline Revisions

- New Construction projects funded after in 2004 required to use B3
- 1.1, 2.0, 2.1 (version 2.1 had the tracking Tool replacing workbook)
- Major Renovations were added to projects receiving funding after 2009
- Version 2.2 - 2013
- Version 3.0 - 2017
    - Revisions in overall process and in-depth revisions to process management and materials
    - Goal of streamlining tracking while maximizing positive benefit
- Version 3.1 - required for projects signing up for predesign in the tracking tool on or after January 1, 2019. Includes updates to :
    - Indoor Environmental Quality
    - Site and water
- B3 Version 3.2 - scheduled for January 1, 2020. Includes updates to:
    - Energy and Atmosphere

Guideline development

Initial guideline approaches were developed based on the principles above and brought to focus groups for discussion on applicability, threshold of required performance and feasibility. Comments were solicited on subsequent drafts and incorporated into the final version of the guidelines.

Guideline I.5 Lighting and Daylighting

Intent

To promote occupant comfort by providing adequate levels of natural and artificial light to maintain sufficient light levels for tasks being performed. Quality lighting can also support cognitive function, mental health, and social interaction while being aesthetically pleasing and complementing the design of the space.

I.5A: Light Levels

1. Provide adequate light levels according to Illuminating Engineering Society (IES) guidelines not including daylighting contributions for regularly occupied spaces. These light levels shall be:
    i. Measured at task plane.
    ii. Maintain contrast levels by demonstrating one of the following:
        (1) Average wall surface to average work surface illuminance level ratio: 1:3.
        (2) Average ceiling surface to average work surface illuminance level ratio: 1:10.

I.5B: Lamp Specifications

1. Use light sources with a color rendering index (CRI) of at least 80, unless necessary for special use.
2. All light sources should be Restriction of Hazardous Substances (RoHS) compliant following the most current European RoHS requirements

I.5C: Daylighting

1. On facades facing within 45 degrees of east, south or west: provide glare control devices with manual operation (or automatic with manual override) for 90% of all regularly occupied spaces.
2. Demonstrate daylight utilization with one of the following:
    i. Demonstrate achievement of spatial daylight autonomy (sDA) for at least 50% of regularly occupied space.
    ii. Demonstrate that daylight alone provides illuminance levels within 20% of IES recommendations for 75% of regularly occupied space at 9 a.m. and 3 p.m. on a clear-sky day at the equinox.
    iii. Demonstrate achievement of a daylight factor of at least 2% in 80% of regularly occupied space.

I.5D: Use CRI of at least 90 (Recommended)

Use light sources with a CRI of at least 90.

I.5E: Light Direction and Glare (Recommended)

Use direct-only overhead lighting for 25% or less of total connected lighting load in all regularly occupied spaces.

I.5E: Interior Surface Reflectance (Recommended)

Specify interior surfaces (walls, floors, ceilings, permanently installed furniture) for all regularly occupied spaces that meet or exceed the following area-weighted average reflectance values to maximize lighting efficiency and to increase the perceived brightness of spaces:

3. Ceilings: at least 85% average surface reflectance.
4. Walls: at least 60% average surface reflectance.
5. Floors: at least 25% average surface reflectance.
6. Furniture:
    i. At least 45% average surface reflectance for work surfaces.
    ii. At least 50% average surface reflectance for movable partitions.

Definitions of Regularly Occupied Spaces

Previously B3 Guidelines focused on a broader **continuously occupied spaces** – under version 3.1 that has been narrowed to just look at **regularly occupied spaces:**

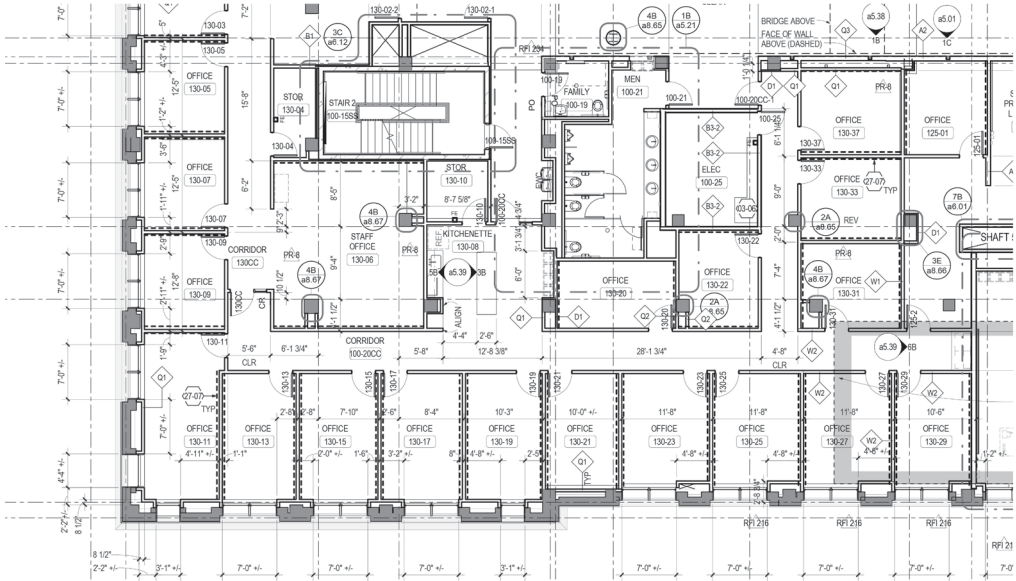
Any space that is occupied by one or more persons for more than one hour during days the building is in use. Note that this includes spaces which may be irregularly occupied but, when occupied, a typical occupant would spend more than one continual hour in the space.

Excluded from calculation of continuously occupied spaces are:

- Spaces with uses that only require minimal lighting and in which the primary activity intended for the space would be harmed by daylight (this exclusion does not apply to spaces with ultraviolet light concerns) – note that this only applies to the calculation of regularly occupied spaces with respect to the daylighting requirements.
- Spaces that do not meet the minimum occupancy outlined above during daylight hours – note that this only applies to the calculation of regularly occupied spaces for the daylighting criteria with respect to the daylighting requirements.
- Spaces where no individual occupant spends at least one continual hour during days the building is in use.

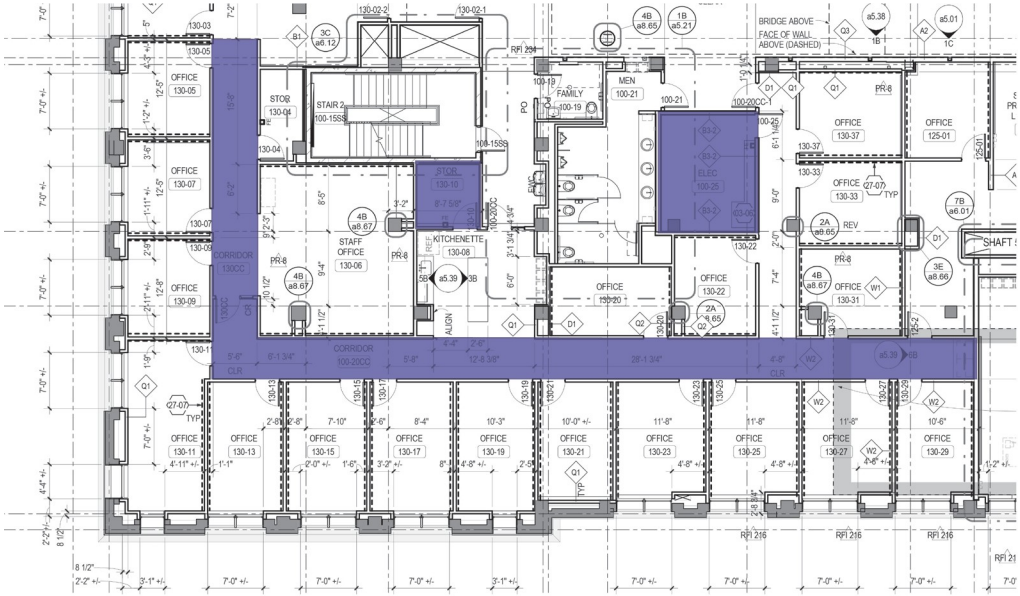
Space Listing Example

- Can be based on plans, program space lists, depending on project phase and process



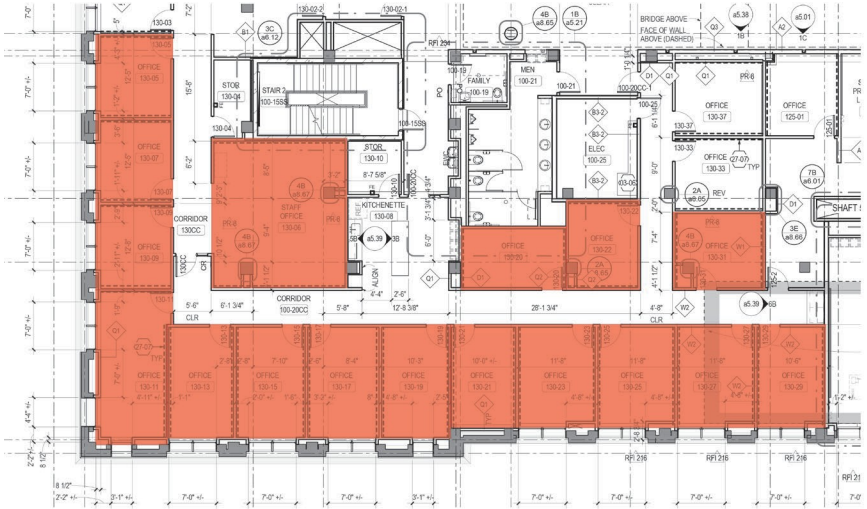
Space Listing Example

- Exclude clearly not ‘regularly occupied’ spaces – corridors, storage, mechanical rooms, etc.



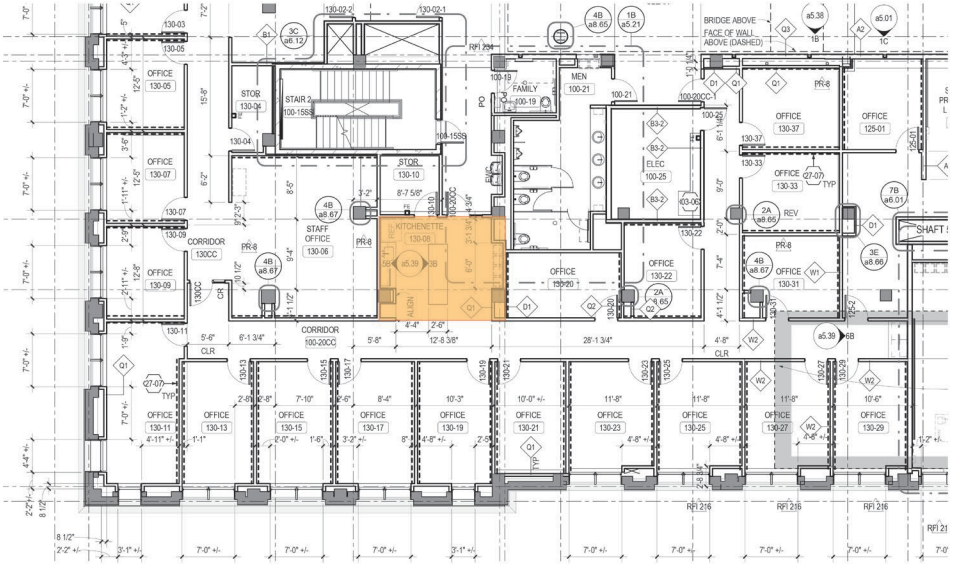
Space Listing Example

- Identify clearly regularly occupied spaces – offices, classrooms, etc.
  - Group similar size and location rooms – bank of private offices
  - Note different conditions related to daylight – fully interior rooms vs. perimeter rooms



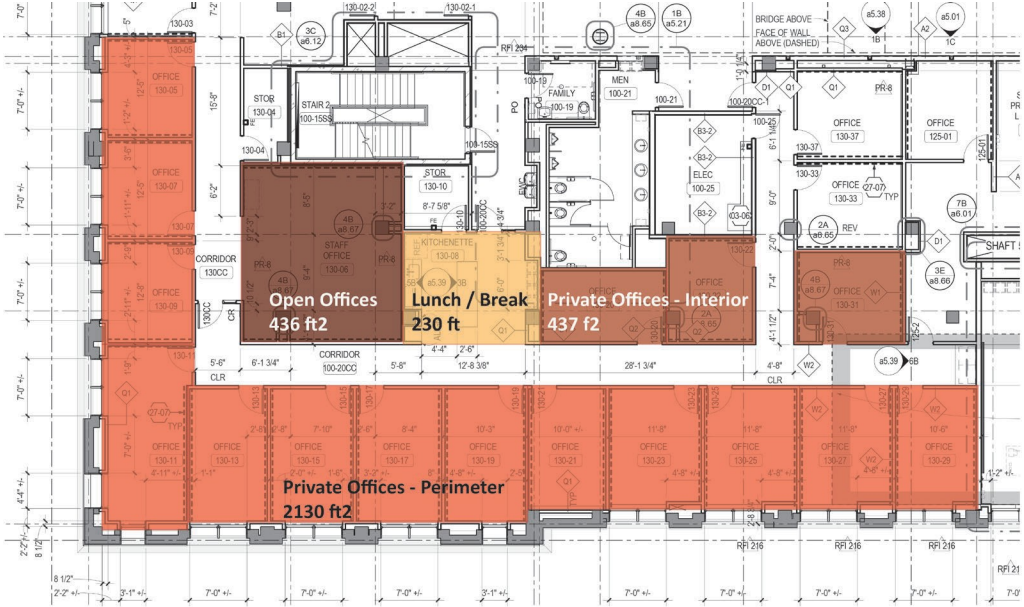
Space Listing Example

- Some spaces may be ambiguous – break rooms, reception areas. Clarify programming when possible to determine if space will qualify as ‘regularly occupied.’



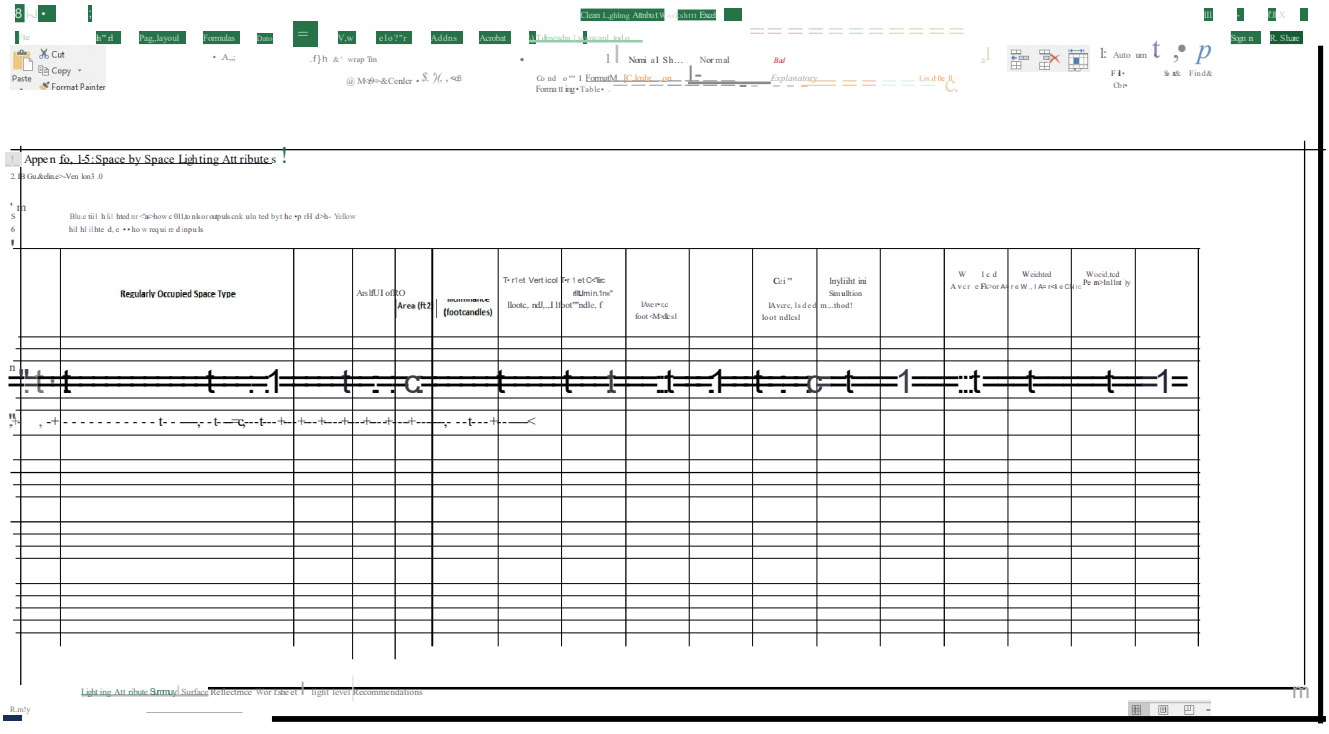
Space Listing Example

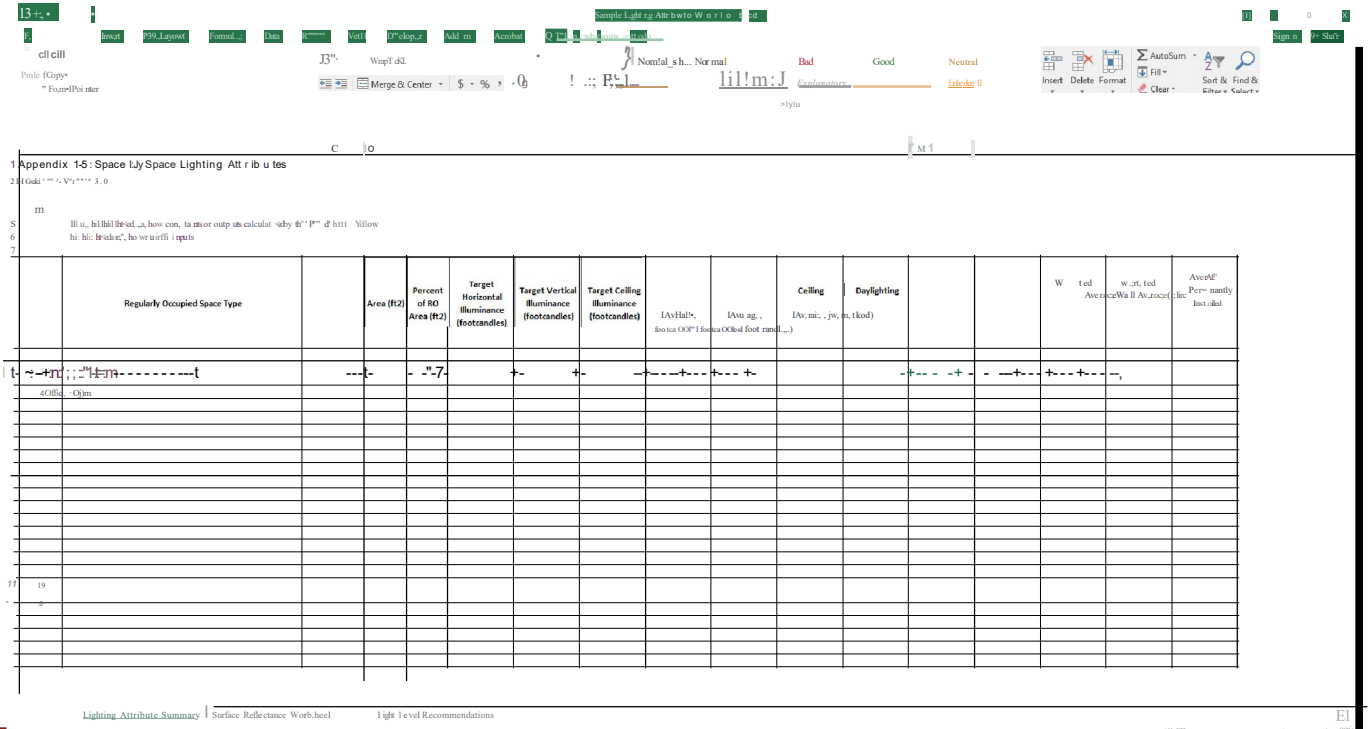
- Calculate approximate square footage for ‘regularly occupied’ spaces



Space Listing Example

- List regularly occupied spaces in the B3 ‘Lighting Attributes Worksheet’
  - Spreadsheet tool that will generate target light levels for electric lighting (Required Performance Criteria A)
  - Select and verify compliance daylight metric (Required Performance Criteria C)
  - Option to calculate surface reflectance for Recommended Performance Criteria F


Appen fo, 1-5: Space by Space Lighting Attribute s
Regularly Occupied Space Type
Area (ft2
(footcandles)
Lighting Attribute Summary
Surface Reflectance
Workplane
Light level Recommendations



Appendix 1-5 : Space by Space Lighting Attributes

Regularly Occupied Space Type | Area (ft2) | Percent of RO Area (ft2) | Target Horizontal Illuminance (footcandles) | Target Vertical Illuminance (footcandles) | Target Ceiling Illuminance (footcandles) | Ceiling | Daylighting

Lighting Attribute Summary | Surface Reflectance Worksheet | Light Level Recommendations

Lighting Attributes Worksheet

In I.5C – Three options to achieve sufficient daylighting

1. On facades facing within 45 degrees of east, south or west: provide glare control devices with manual operation (or automatic with manual override) for 90% of all regularly occupied spaces.
2. Demonstrate daylight utilization with one of the following:
   i. Demonstrate achievement of **spatial daylight autonomy (sDA)** for at least 50% of regularly occupied space.
   ii. Demonstrate that daylight alone provides **illuminance levels** within 20% of IES recommendations for 75% of regularly occupied space at 9 a.m. and 3 p.m. on a clear-sky day at the equinox.
   iii. Demonstrate achievement of a **daylight factor** of at least 2% in 80% of regularly occupied space.

Daylight Factor

Daylight factor is the ratio of daylight indoors as compared to the overall amount available outdoors.

$$\text{Daylight factor} = DF = \frac{\text{Illuminance indoors}}{\text{Illuminance outdoors}}$$

Illuminance Level Method

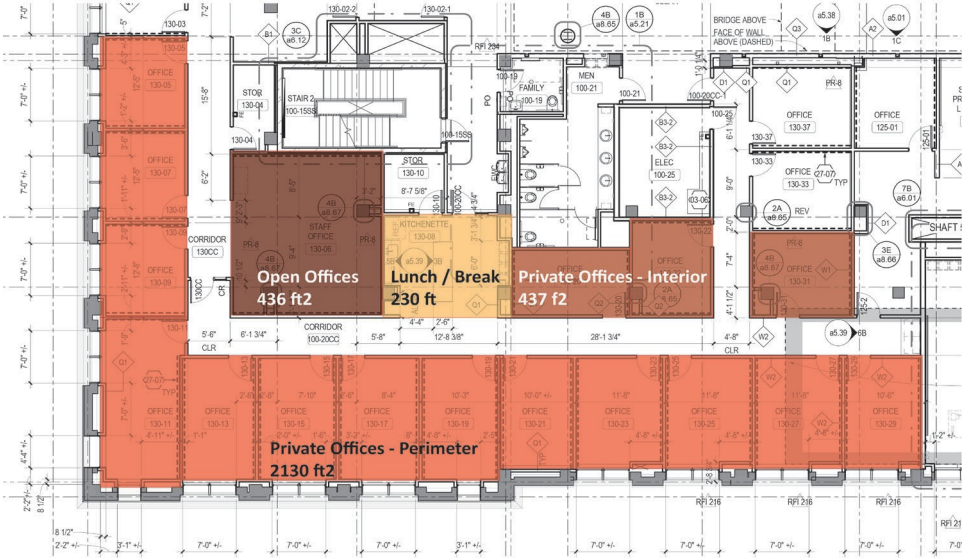
Illuminance level is the illuminance falling on the workplane, based on a simulation measured at 9am and 3pm on the equinox.

Spatial Daylight Autonomy

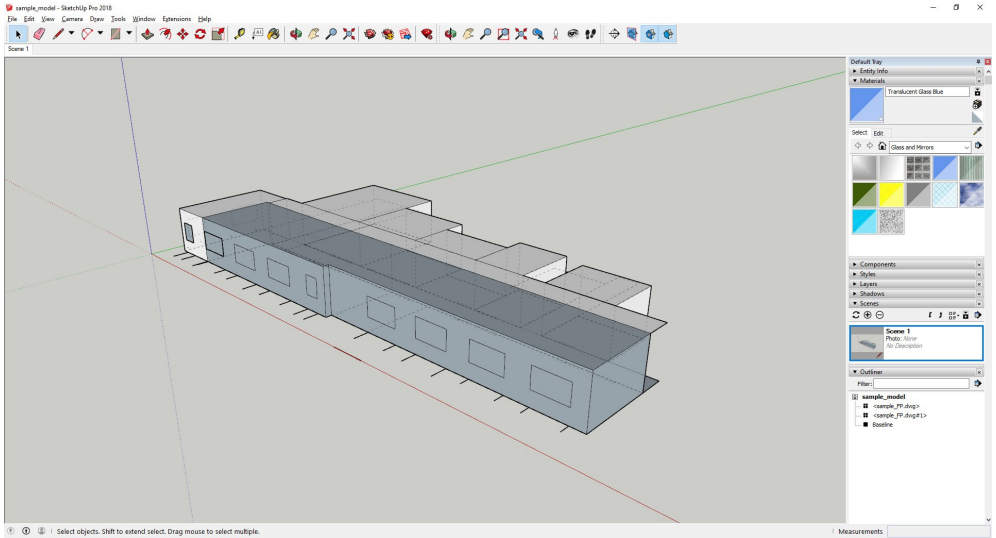
Spatial Daylight Autonomy (sDA) considered to be adequate daylight across a year, is the percentage of floor area that receives at least 300 lux for at least 50% of the annual occupied hours. Usually considered alongside Annual Sunlight Exposure (ASE) - avoiding direct sunlight for glare concerns, is the % of floor area that receives more than 1000 lux for at least 250 occupied hours

Reviewing these metrics in a daylight modeling software

Using Sefaira with Sketch Up

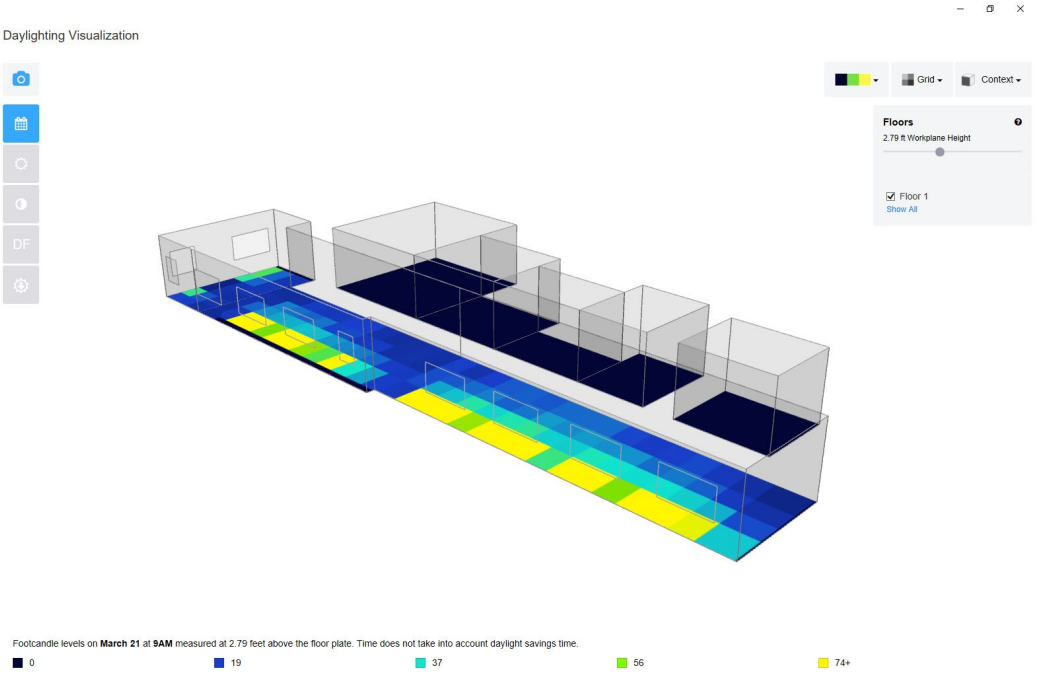


- Spaces are built in a simplified way in Sketchup – no wall thickness, window frame details, other materiality
- Internal walls and glazing are important for daylighting analysis
- Internal walls and subdivided floors will provide a better result for analysis



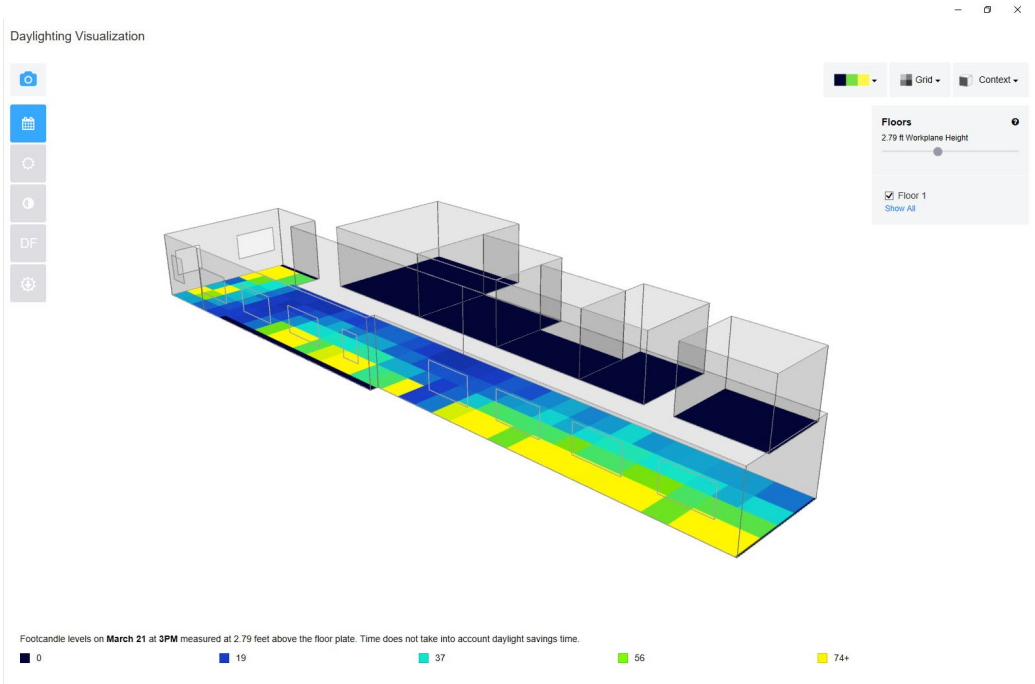
Baseline - Point in Time Illumination –

March 21, 9a

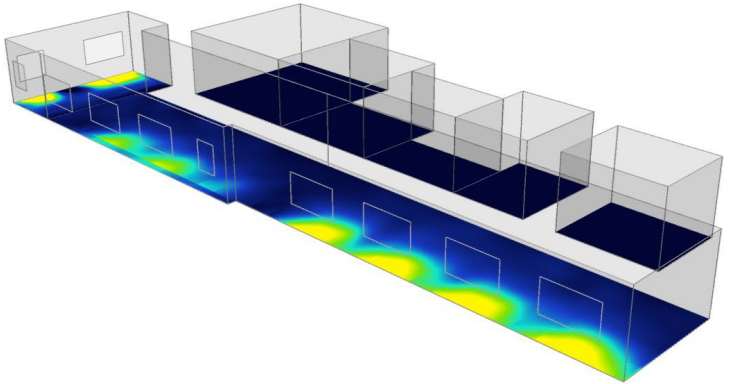


Baseline - Point in Time Illumination –

March 21, 3p



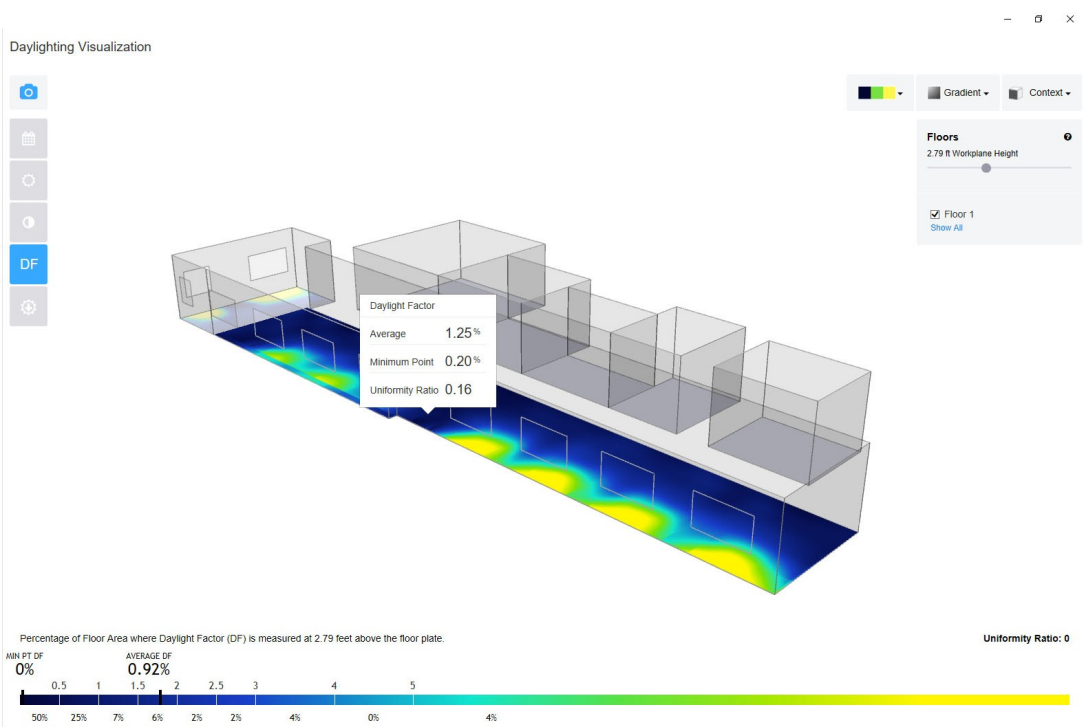
Baseline – Daylight Factor



Baseline – Daylight Factor

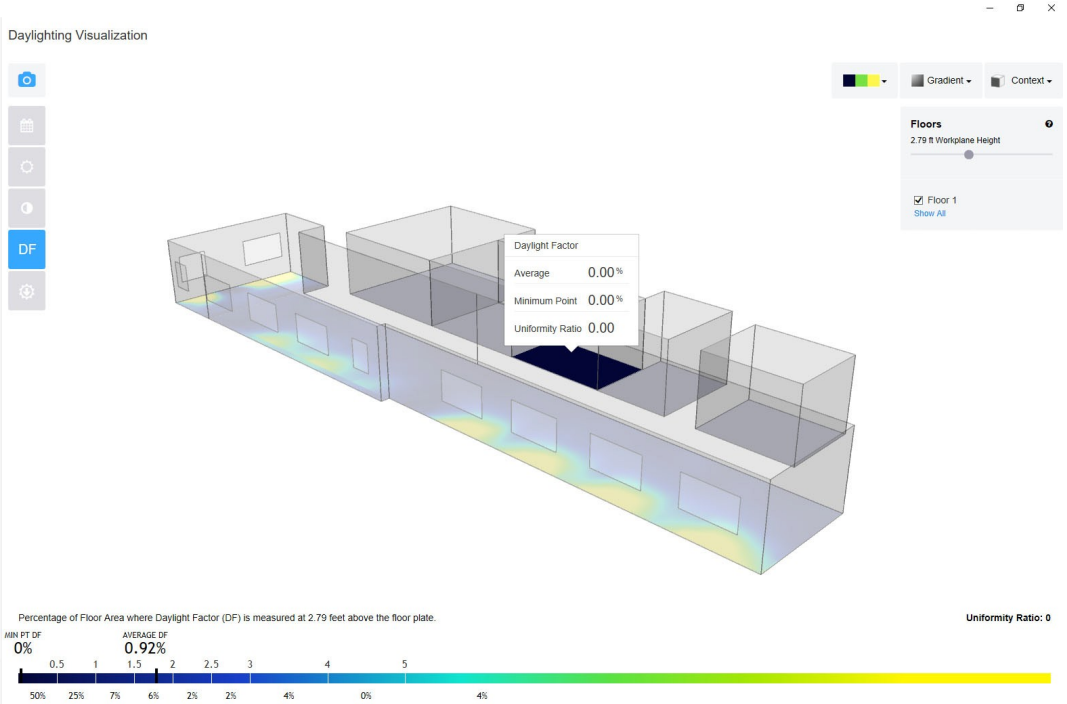
Perimeter Offices

(split floor plates allow examination of Daylight Factor in different areas)

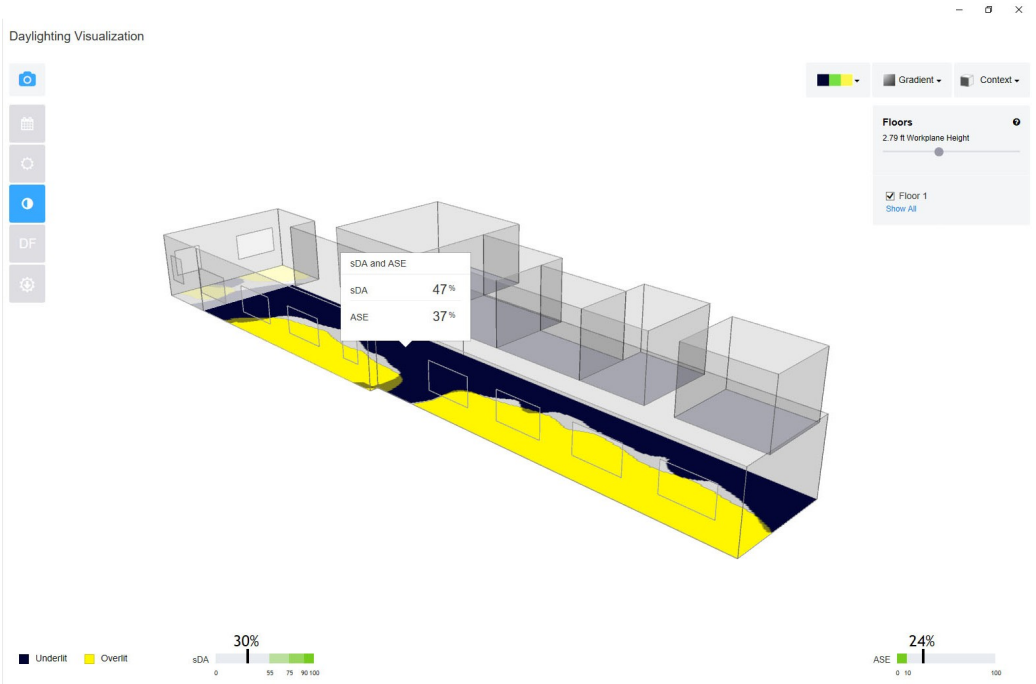


Baseline – Daylight Factor

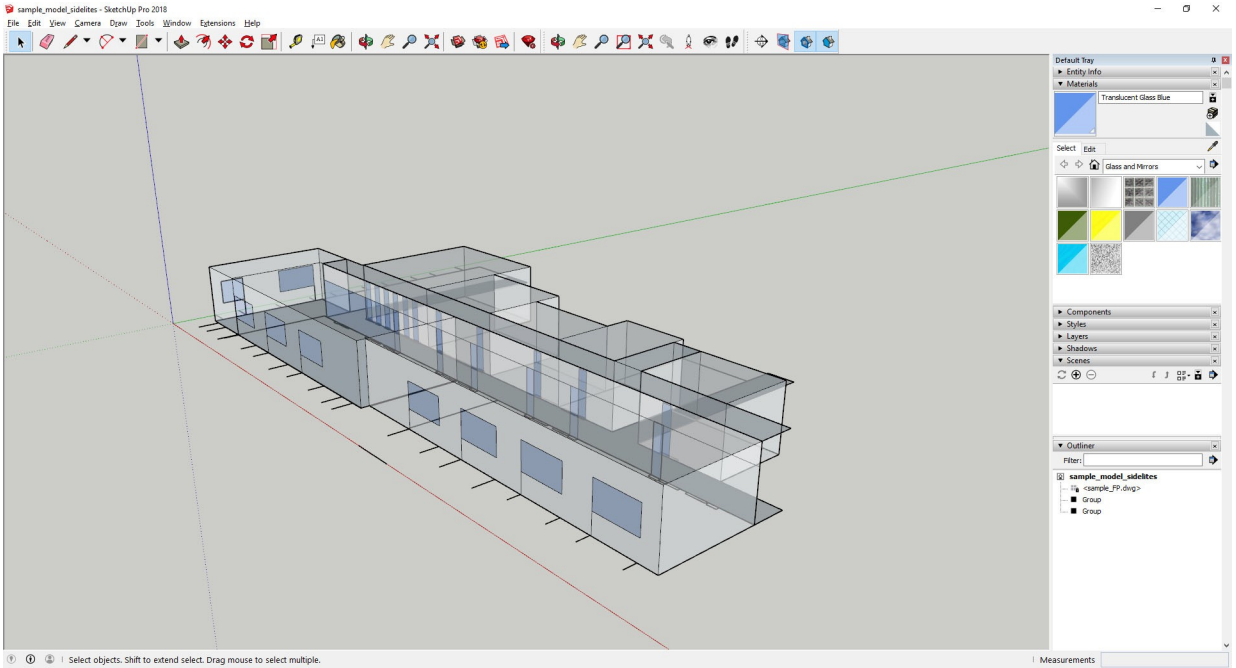
Interior Offices



Baseline - Spatial Daylight Autonomy

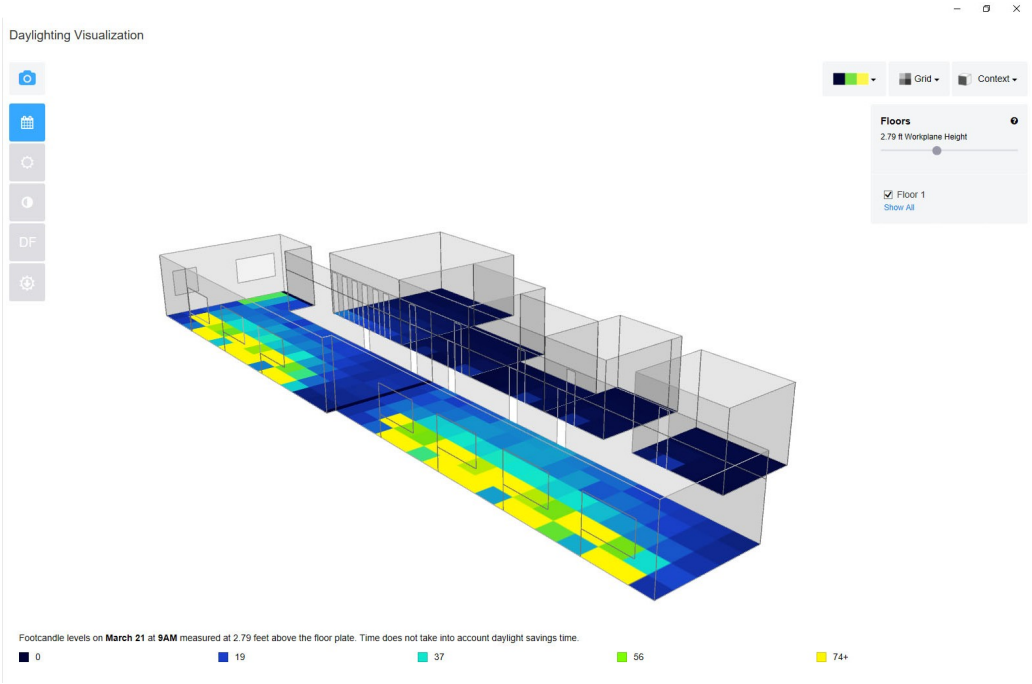


Test Case – Interior Glazing



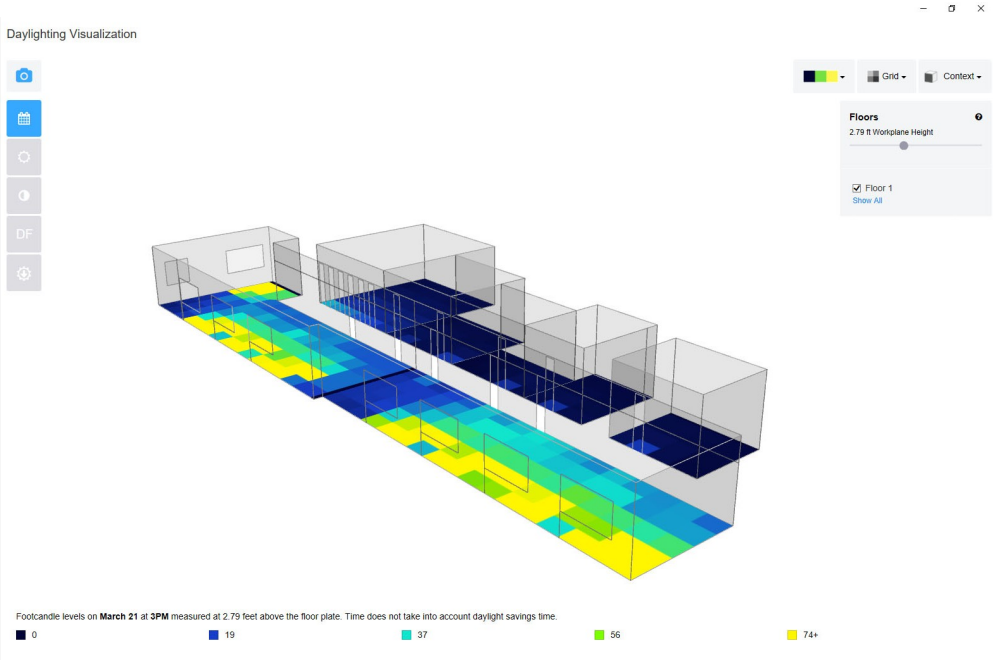
Test Case - Point in Time Illumination –

March 21, 9a

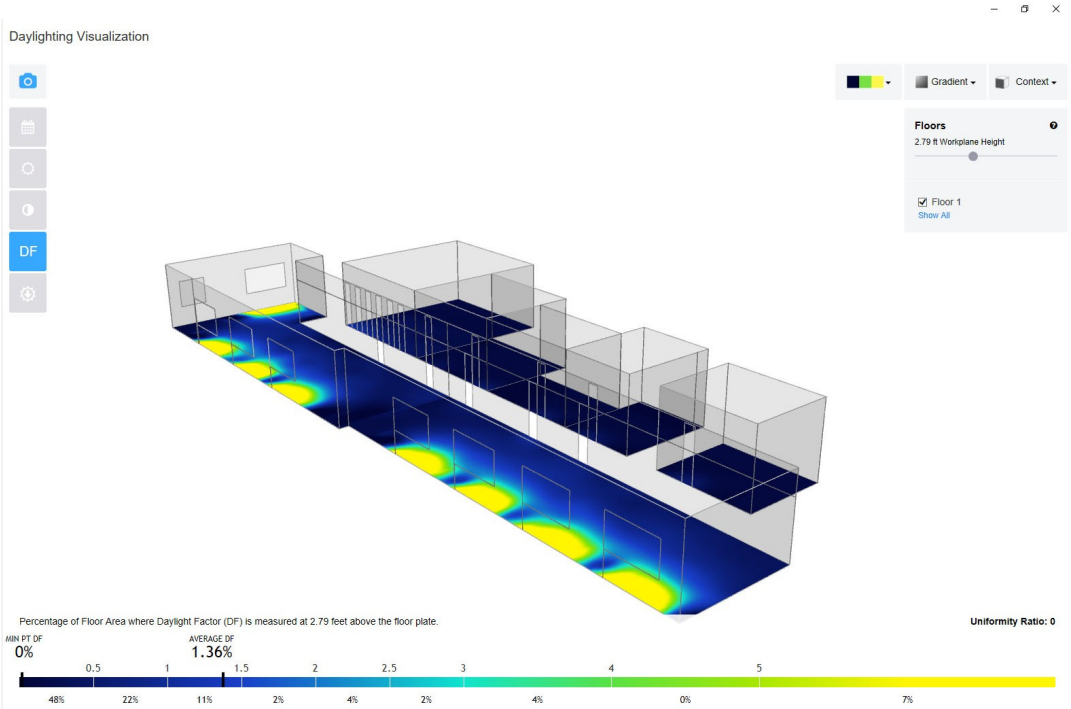


Test Case - Point in Time Illumination –

March 21, 3p

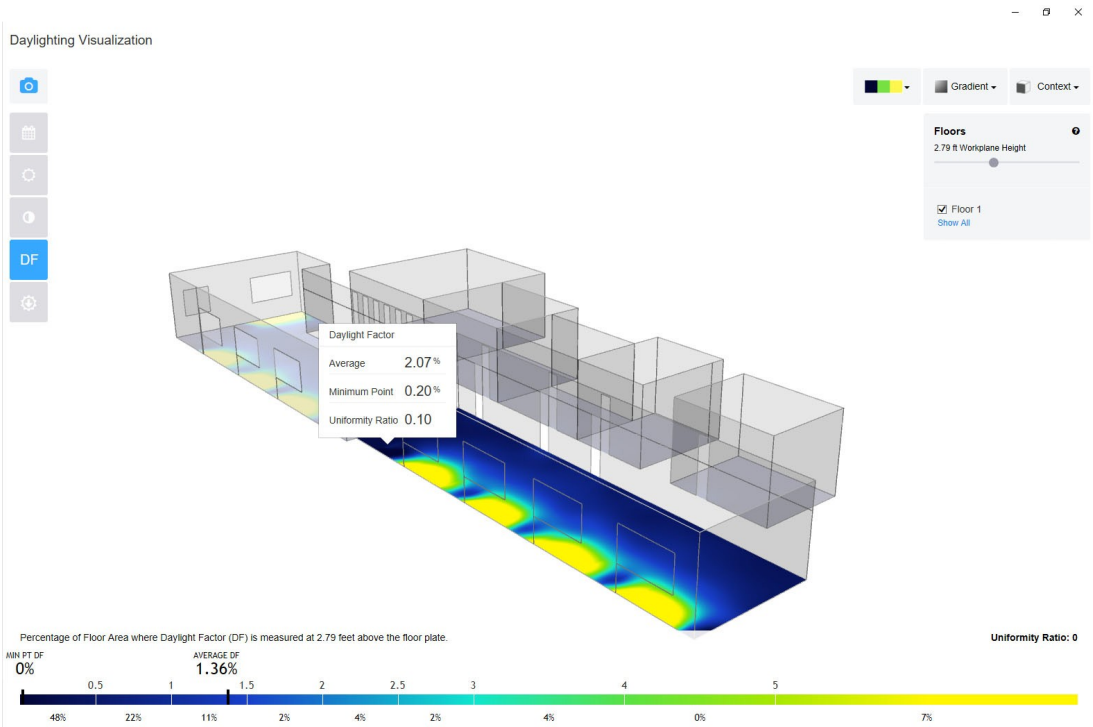


Test Case – Daylight Factor



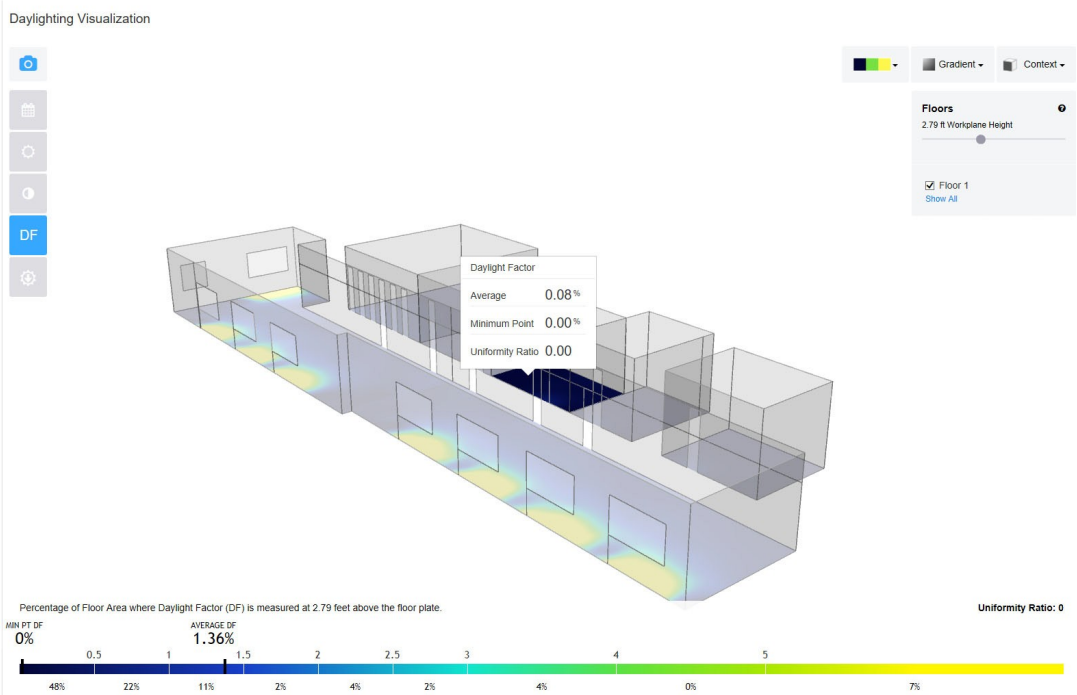
Test Case – Daylight Factor

Perimeter Offices

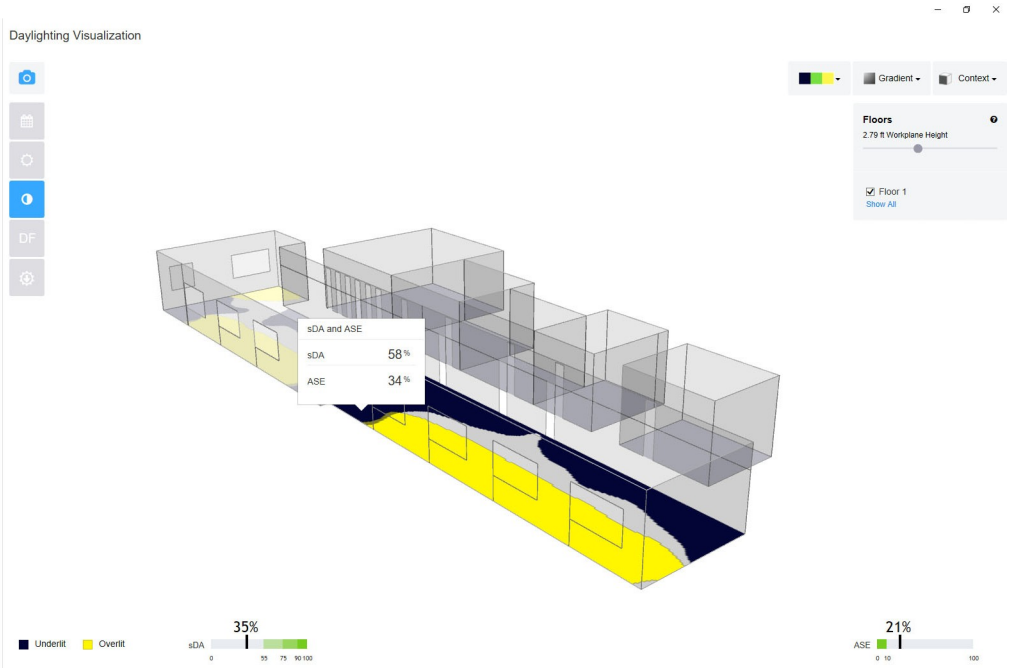


Test Case – Daylight Factor

Interior Offices



Test Case – Spatial Daylight Autonomy

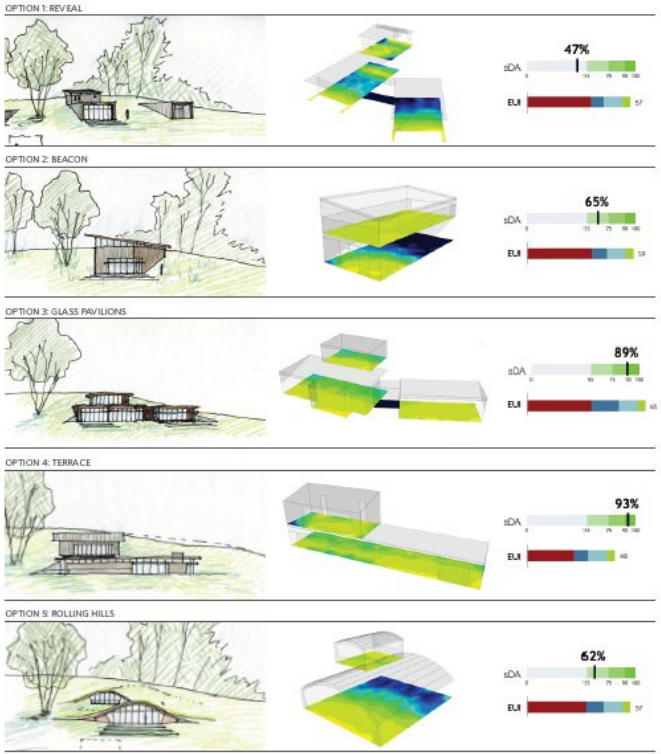


Case Study – Residential

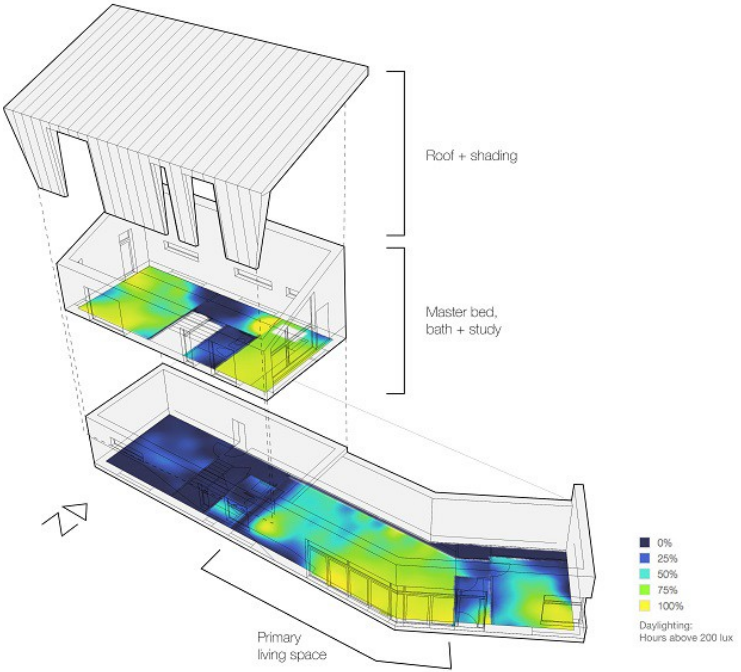
- Carl Sterner, Sterner Design
- Case study published by Sumele Aruofor for Sefaira (link)
- Single Family Home
- Iowa – Climate Zone 5
- 2400 ft2 on 2 stories
- Performance goals: net zero energy, good daylighting
- Building was to be built in to a hillside and be partially underground

Design goal – **“Enough daylight”** – 20 fc through daylight alone for at least 60% of the year in the primary living areas: living room, dining room, kitchen, and study.

Design goal – **Even distribution** – good distribution across the living spaces to avoid uncomfortably bright and dim areas, despite having windows primarily on one orientation.



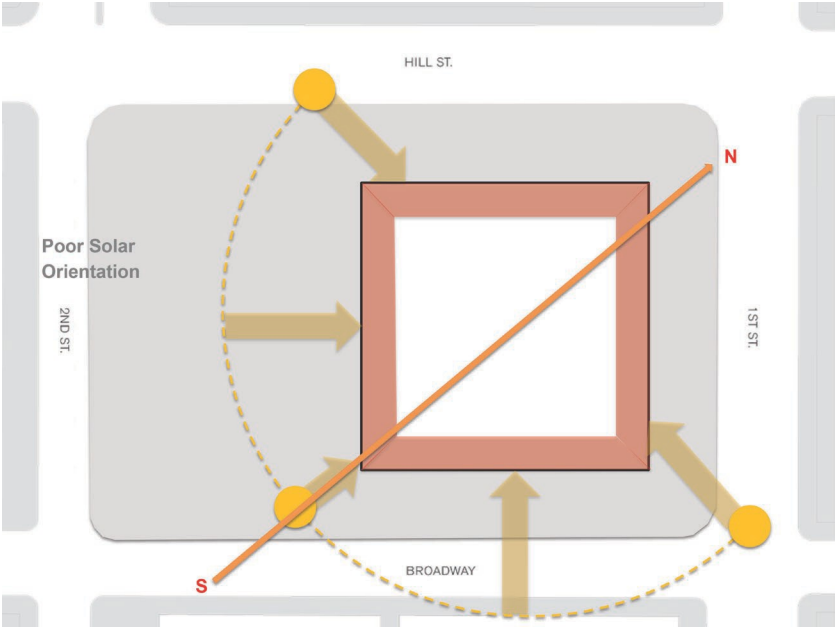
- Iterative analysis determined that a narrow floor plate (20 feet or less) gave best daylight and energy results
- Due to the limited exterior wall space for windows, creative solutions were used to achieve quality daylighting – without the cost and waterproofing problems of skylights
    - Taller windows
    - Light shelves
    - Light well through cabinetry



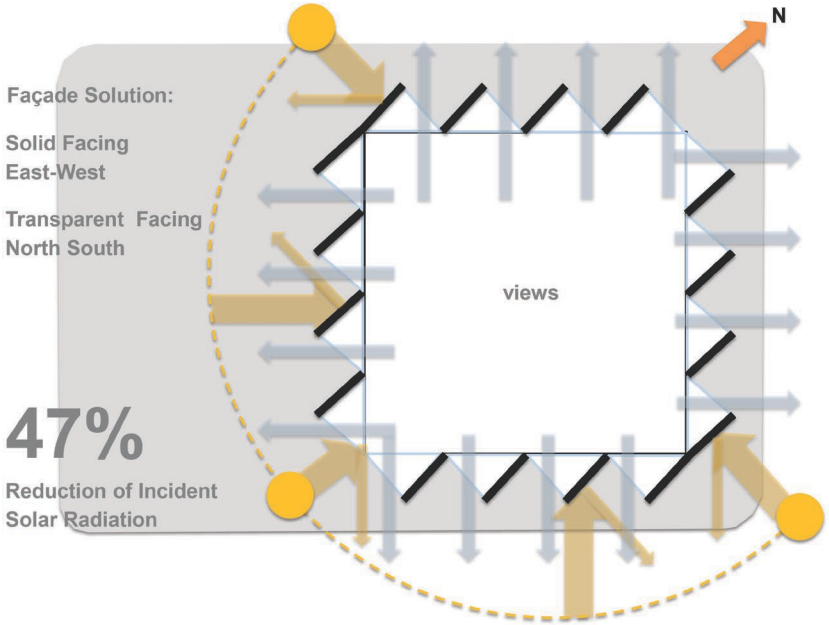
Case Study – Commercial – Us Courthouse Los Angeles

- Designed by SOM and AECOM
- Case study by Duane Allen of GSA
- AIA COTE Top 10 Winner
- Courts, chambers, support spaces
- 516,000 ft2 on 10 stories
- LEED Platinum
- GSA 2020 energy objective

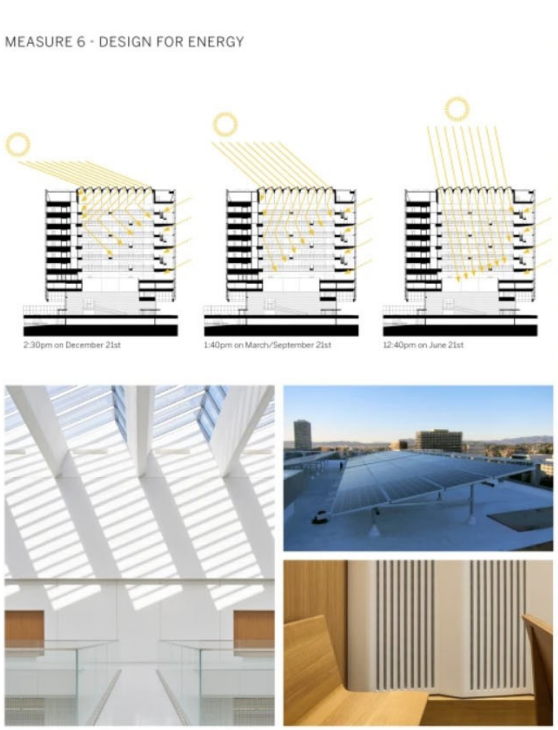
- Poor orientation due to LA's city grid
- High potential for overheating in this climate
- Direct solar exposure on all sides of building
- Deep floor plate makes even daylight distribution challenging

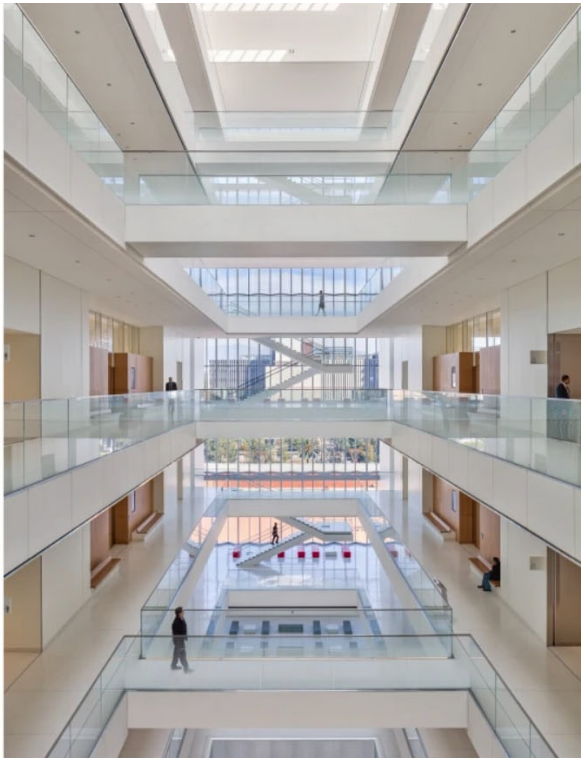


- Design solution – fragment the façade and strategically allow daylight in while blocking worst of solar gain.
- Maintain views to downtown

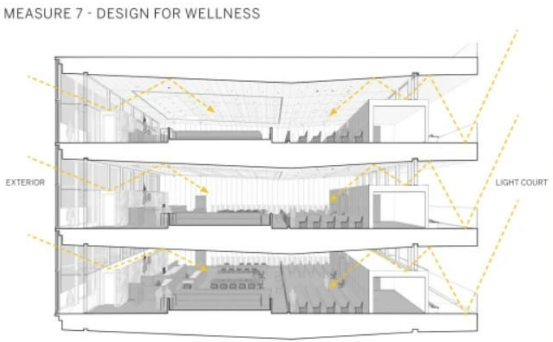


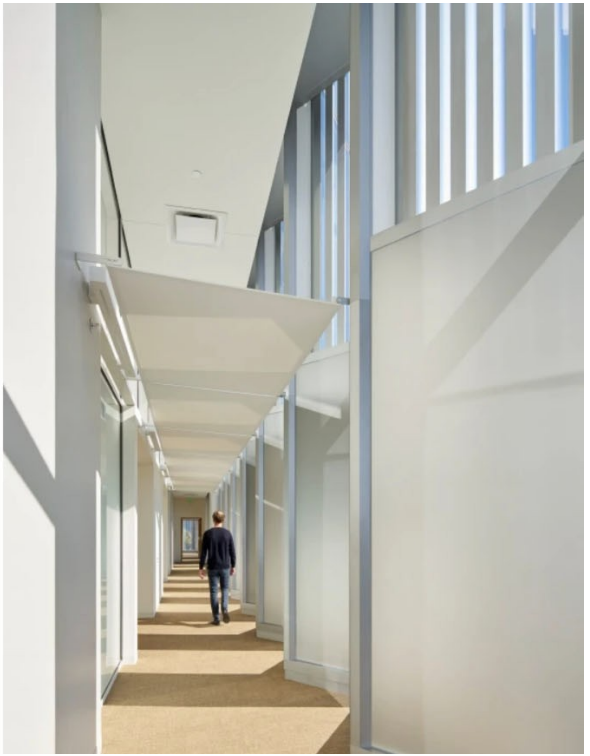
- Large open atrium brings daylight from top down through entire building





- Spaces are daylit from two directions –

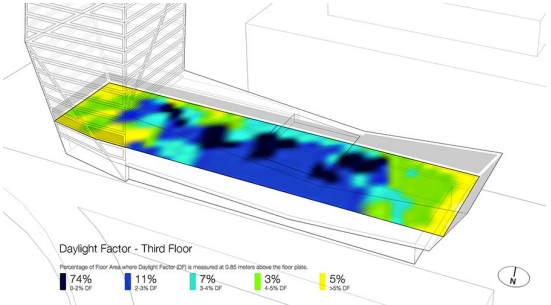




Available Tools for Daylighting Design and Analysis

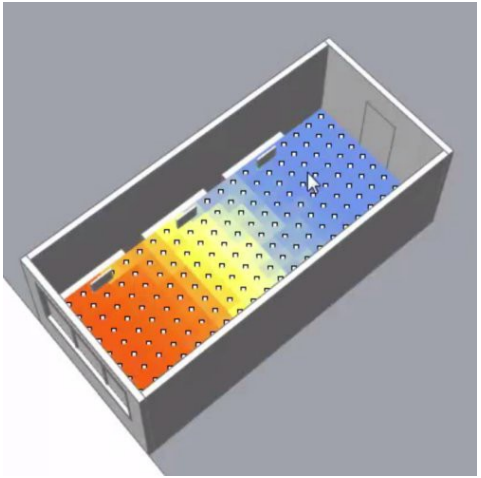
Sefaira

- Daylighting and energy modeling, software plugin and web based
- Works with Sketchup and Revit
- Radiance and Daysim engines
- Spatial daylight autonomy, daylight factor, point in time, annual sunlight exposure,
- Default surface reflectance, transparent glazing only



Diva for Rhino

- Daylighting and energy modeling inside Rhino
- Radiation maps, photorealistic rendering, climate-based daylighting metrics, annual and time step glare analysis, sun path maps, dynamic shading, point in time illuminance

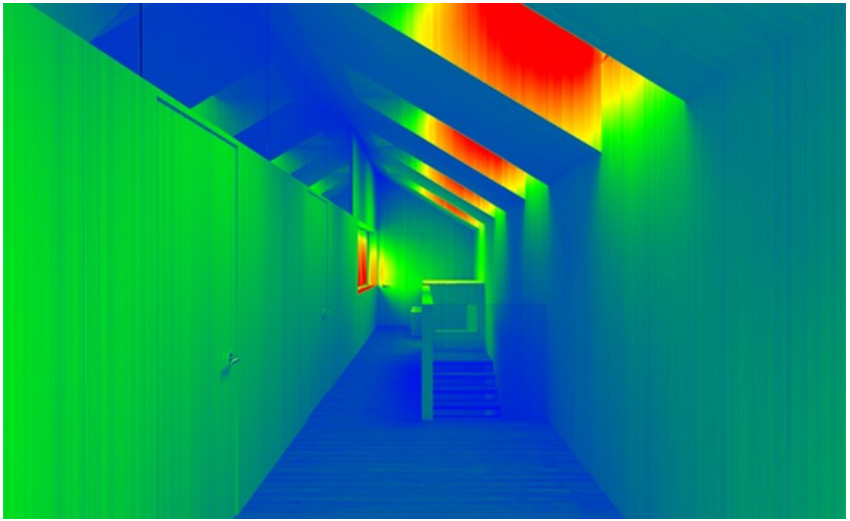


Autodesk Insight

- Daylighting analysis software portion of Autodesk Insight, runs in Revit
- sDa, ASE, point in time, solar access, illuminance renderings

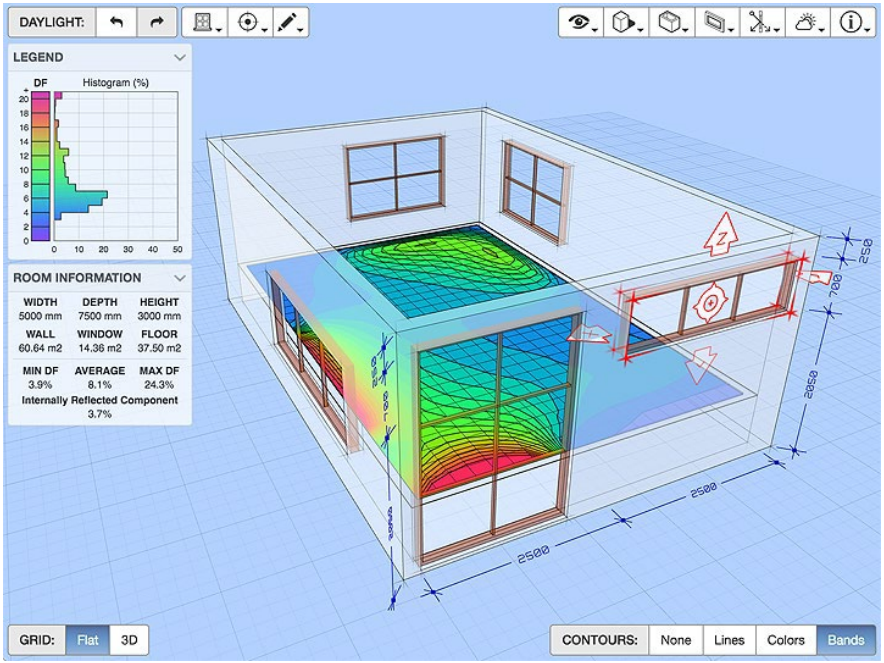
Velux

- Stand-alone product for simulating daylight conditions
- Daylight factor, point in time illumination, photorealistic and false color visualizations, animations



Andrew Marsh Software – Dynamic Daylighting

- Interactive web app for simple rectangular rooms
- Change room size, window configuration, analysis plane and see real time calculations
- Daylight calculated with split-flux model and validated with Radiance
- Simulate daylight factor only
- Can manipulate window frames, surface reflectance, glazing transmittance



Questions and Discussion