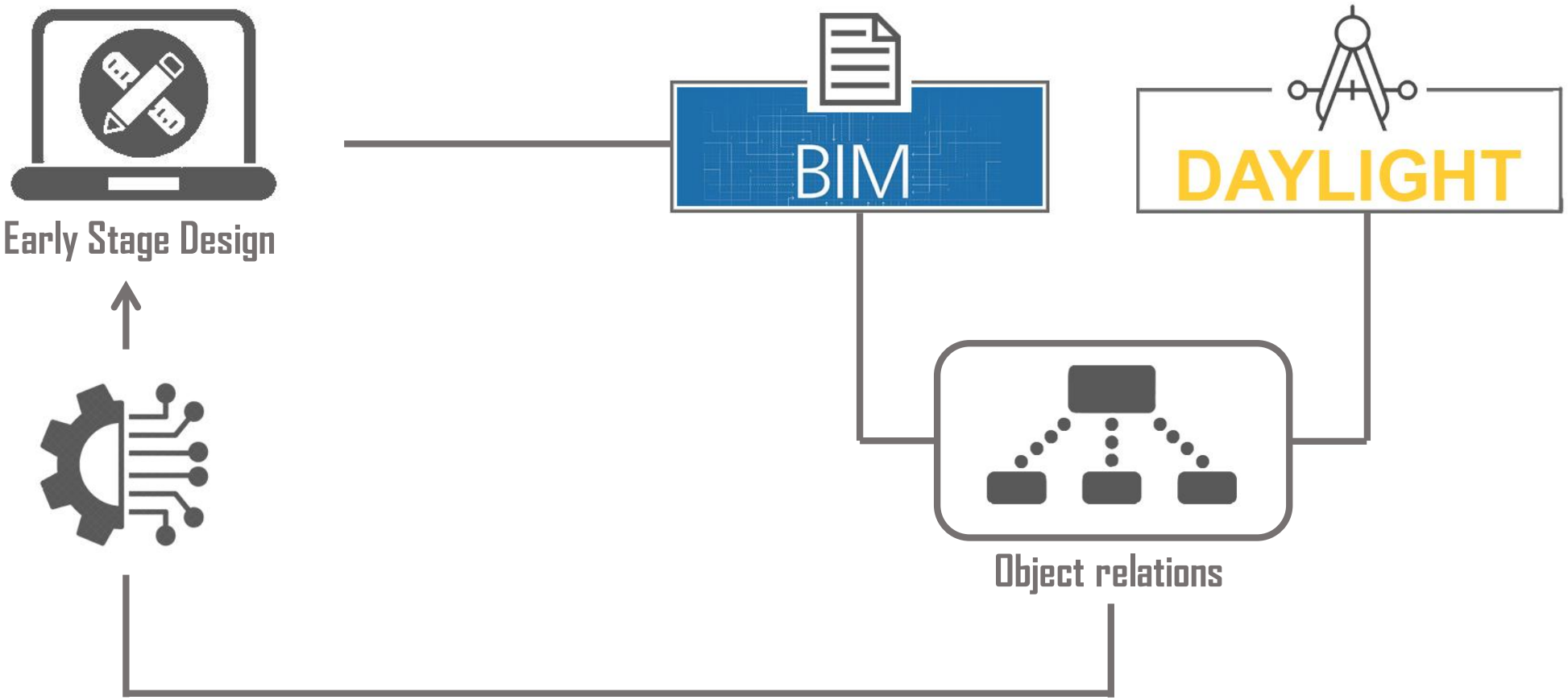
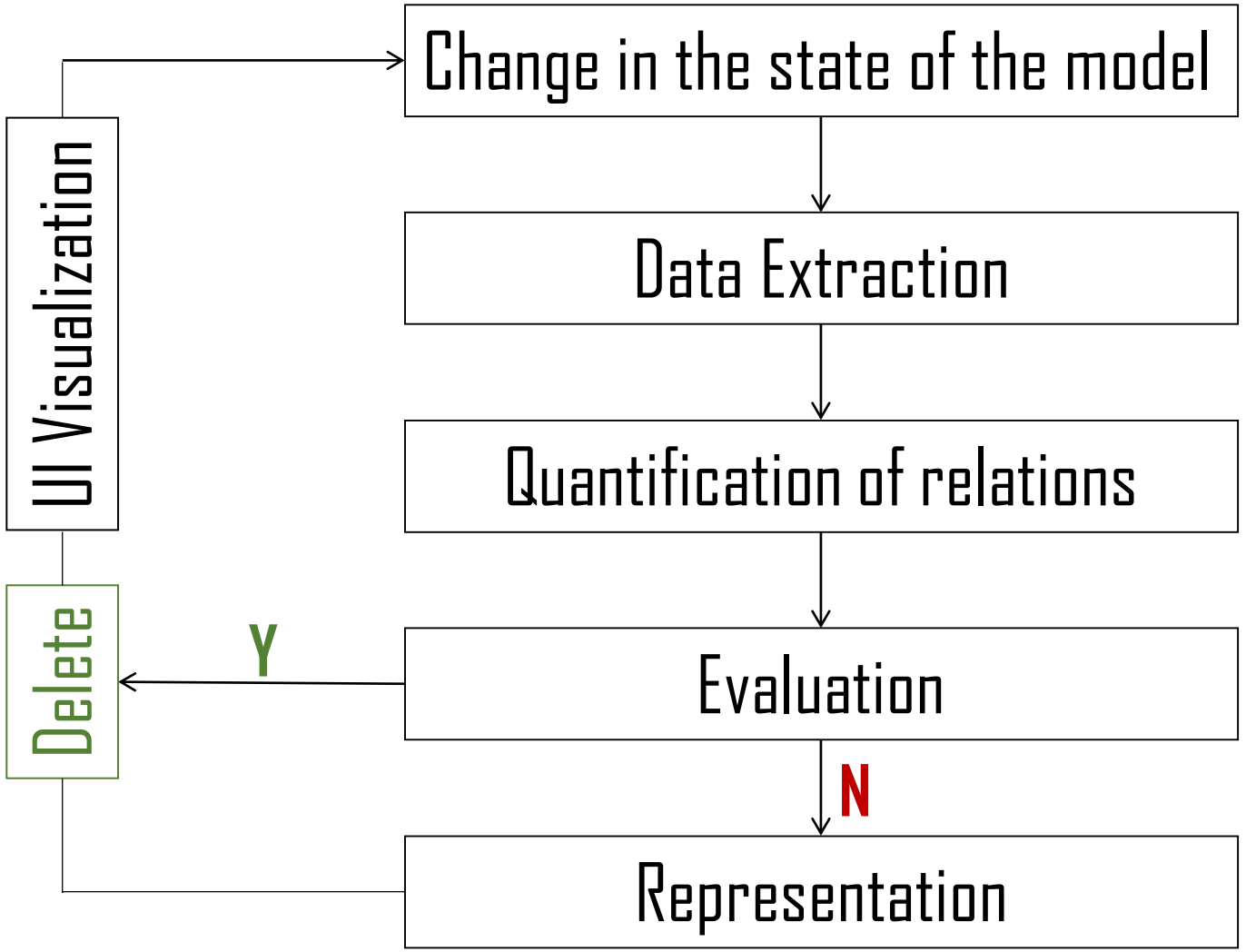
Daylight Control in the Early Stages of the Design, Integrated in a BIM Environment

OVERVIEW

COMPUTATIONAL TOOL



WORKFLOW


Change in the state of the model
Data Extraction
Quantification of relations
Evaluation
Y
N
Delete
UI Visualization
Representation

BACKGROUND

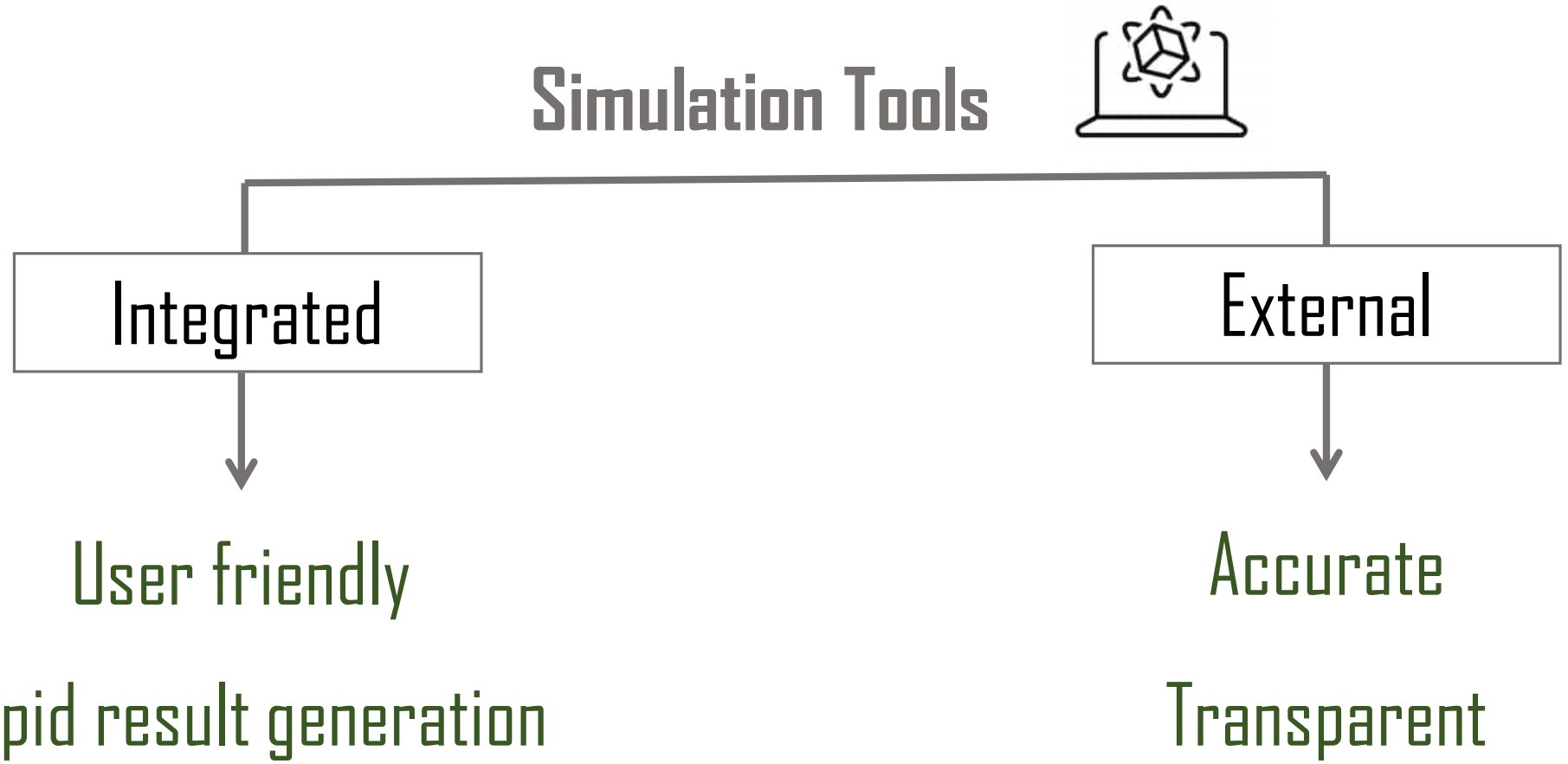
DAYLIGHT IN ARCHITECTURAL DESIGN

VISUAL QUALITY

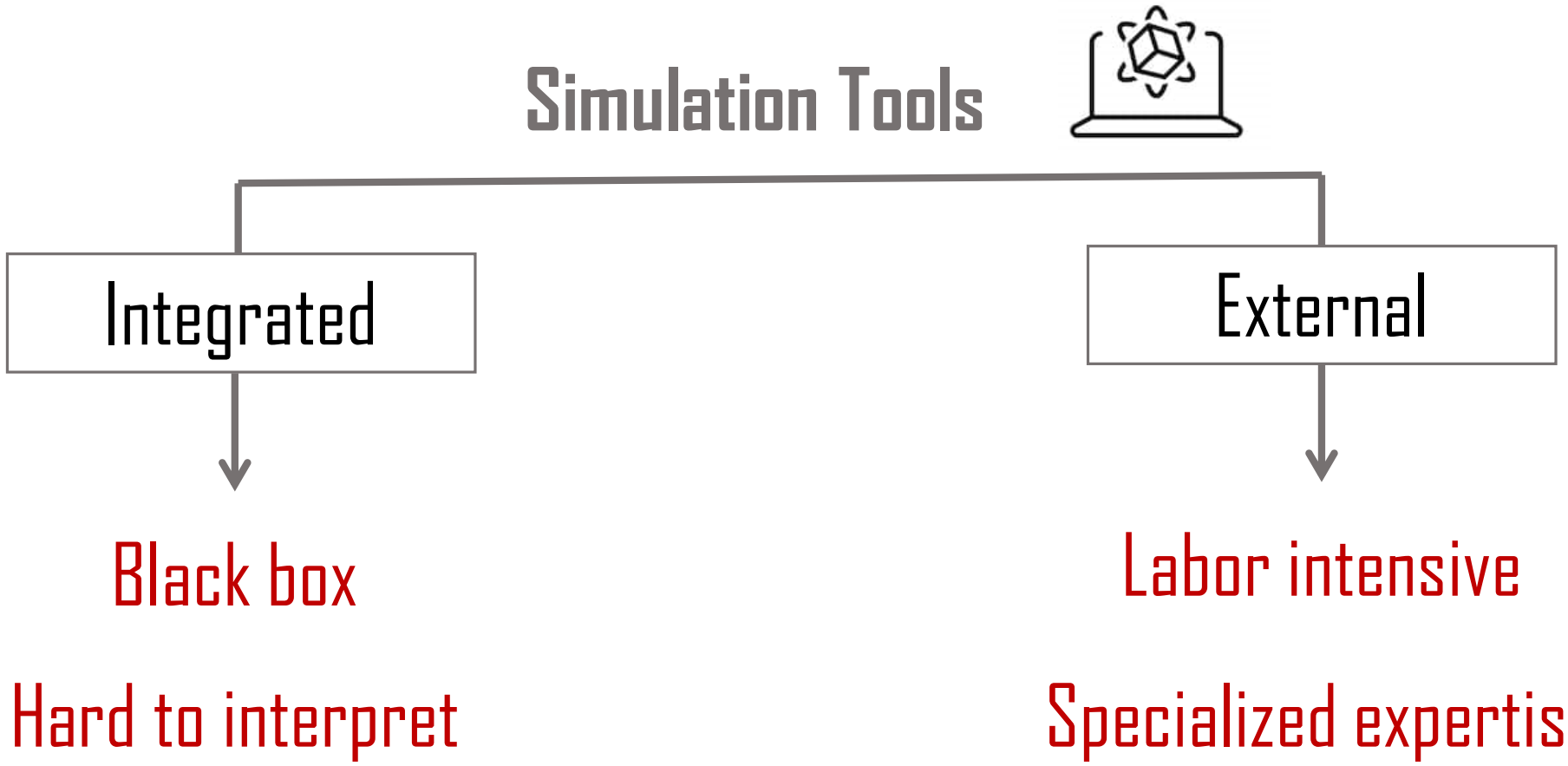
ENERGY CONSUMPTION

BUILDING ENVELOPE

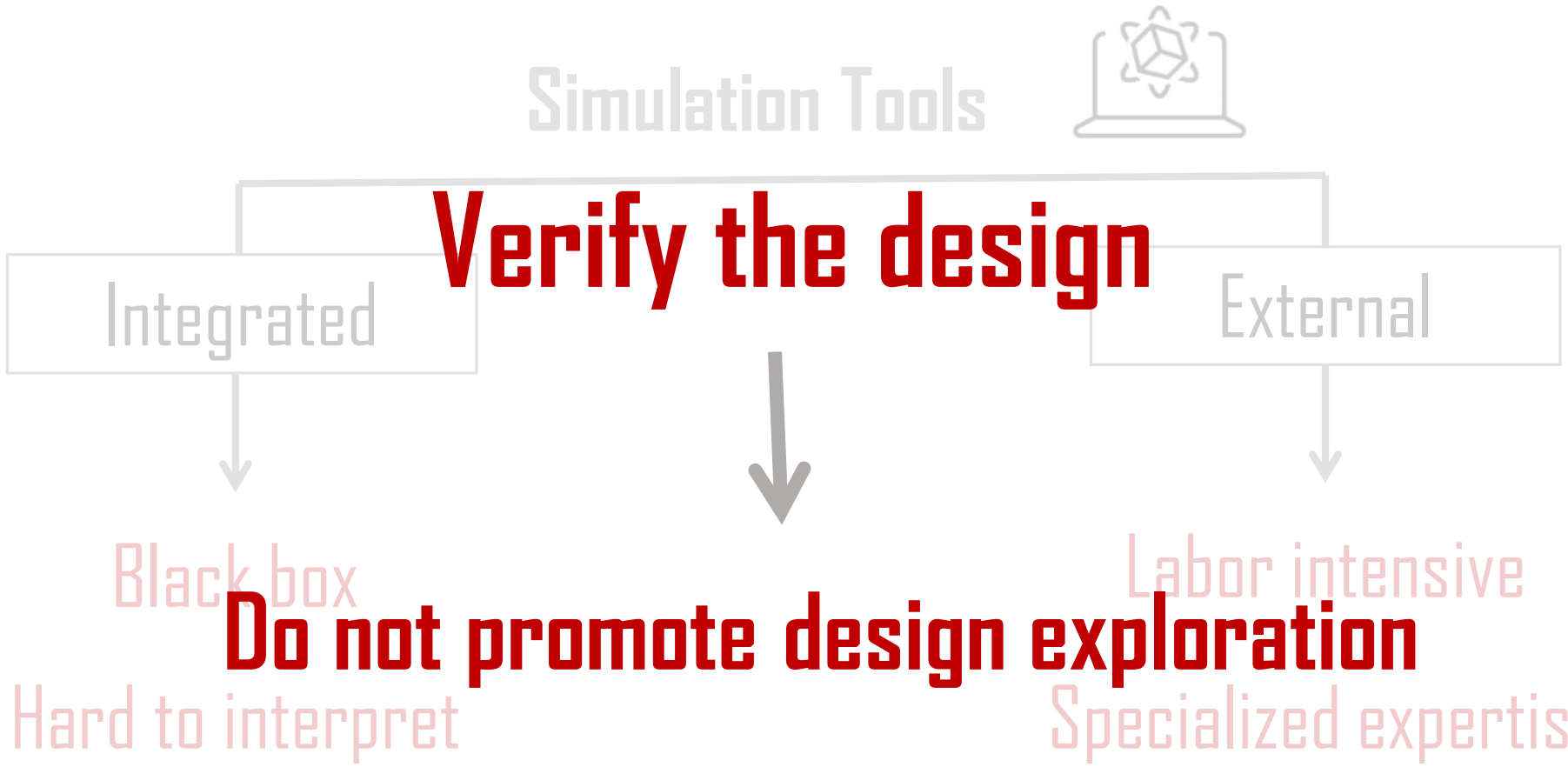
BUILDING PERFORMANCE OPTIMIZATION TOOLS



BUILDING PERFORMANCE OPTIMIZATION TOOLS

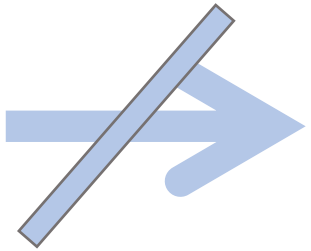


BUILDING PERFORMANCE OPTIMIZATION TOOLS



RESEARCH GAP

STUDIES CONSIDER
DESIGN A **UNITY**



EVALUATE
DESIGN ACTIONS

EVALUATE PERFORMANCE AT THE MOMENT OF ARCHITECTURAL COMPOSITION ?

WHAT IS BIM

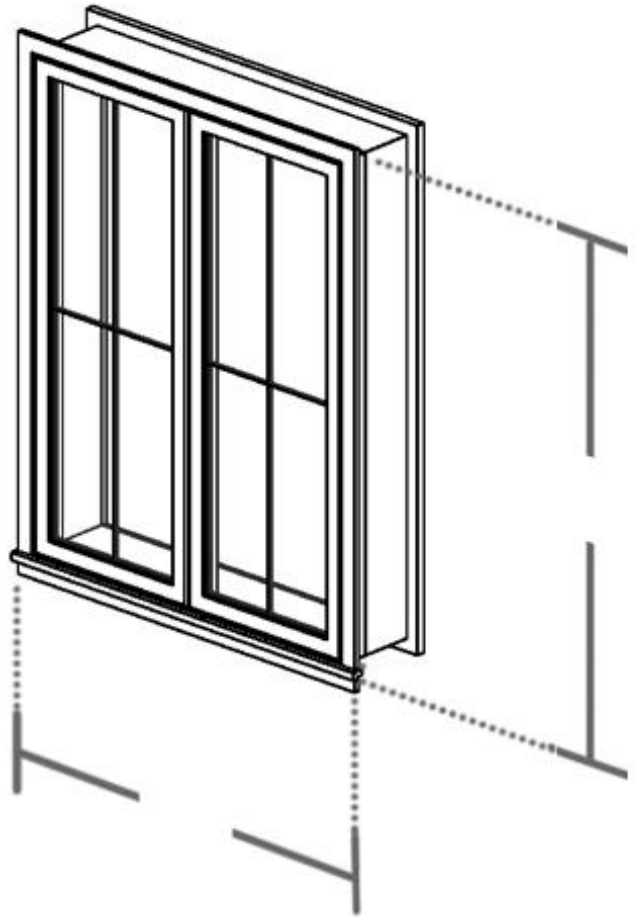
INTERRELATIONS BETWEEN OBJECTS

PROJECT INFORMATION

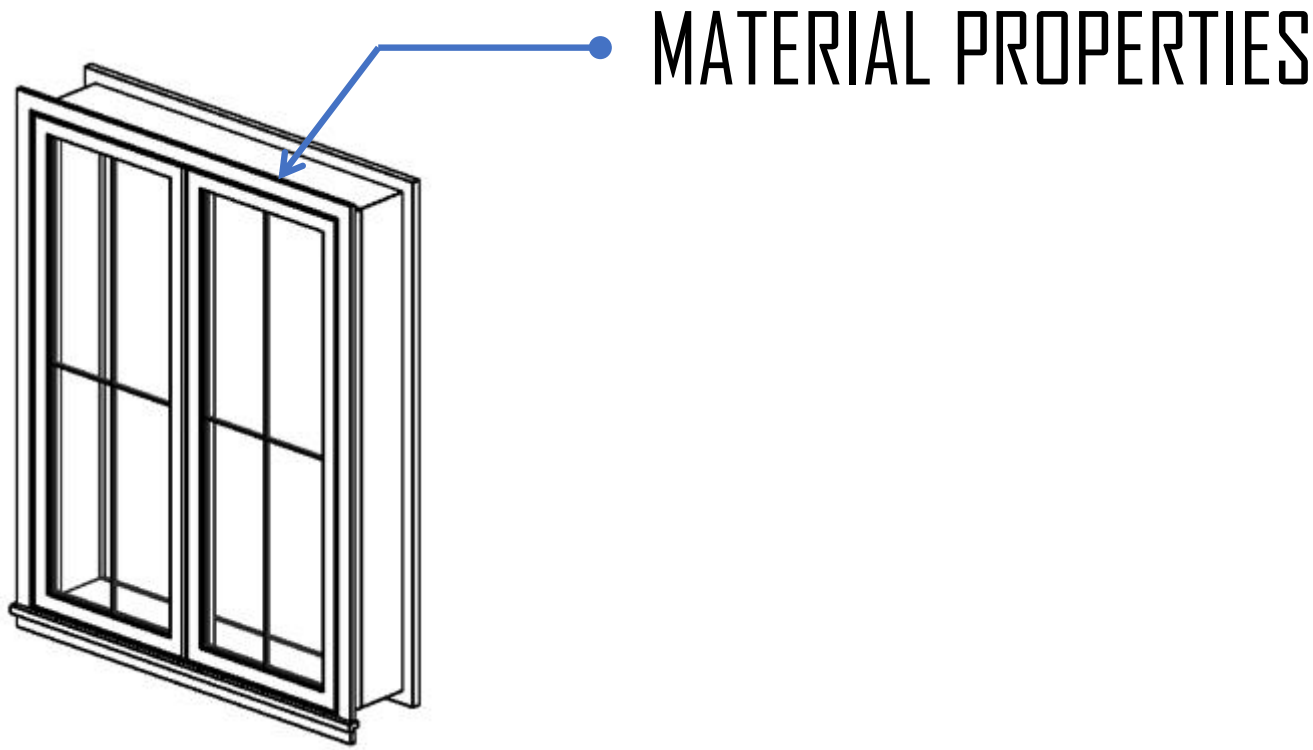
MULTIDISCIPLINARY DESIGN

BIM OBJECT PROPERTIES

GEOMETRIC PROPERTIES

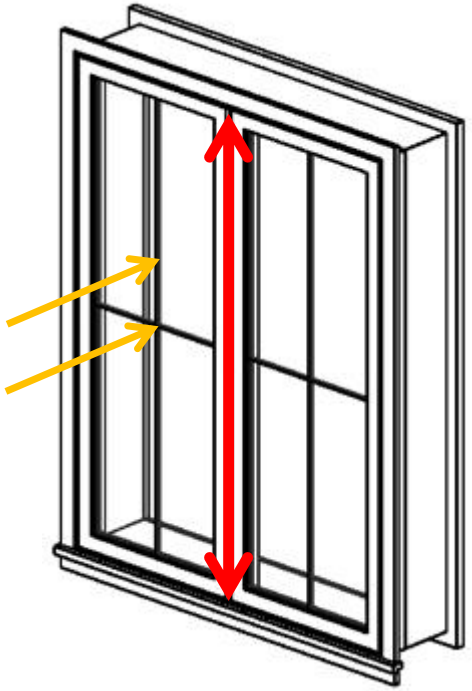


BIM OBJECT PROPERTIES



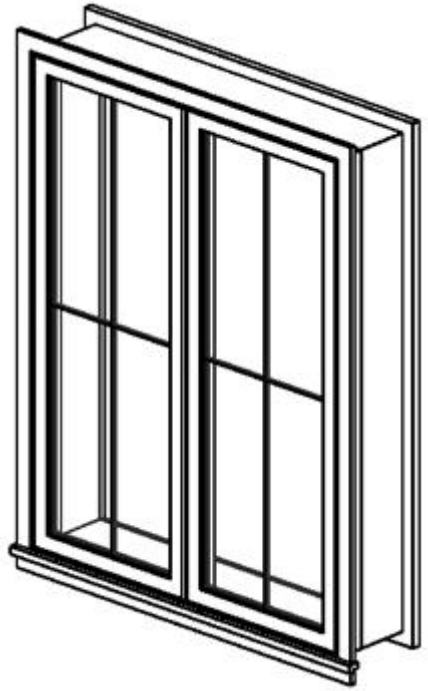
BIM OBJECT PROPERTIES

ANALYTICAL PROPERTIES



BIM OBJECT PROPERTIES

IDENTITY DATA



Specifications

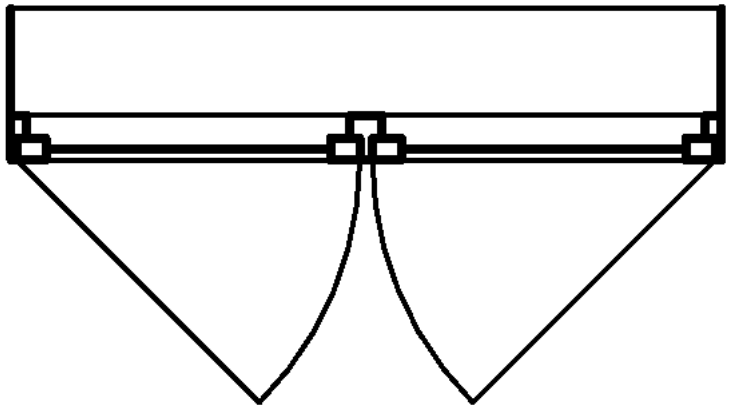
Manufacturer

Price

.....

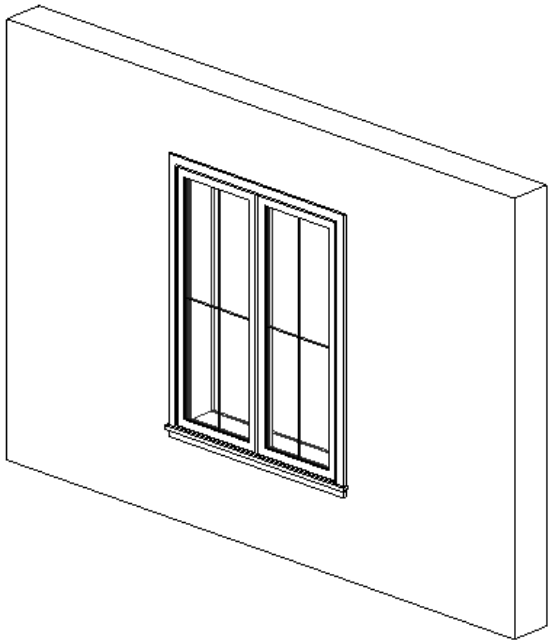
BIM OBJECT PROPERTIES

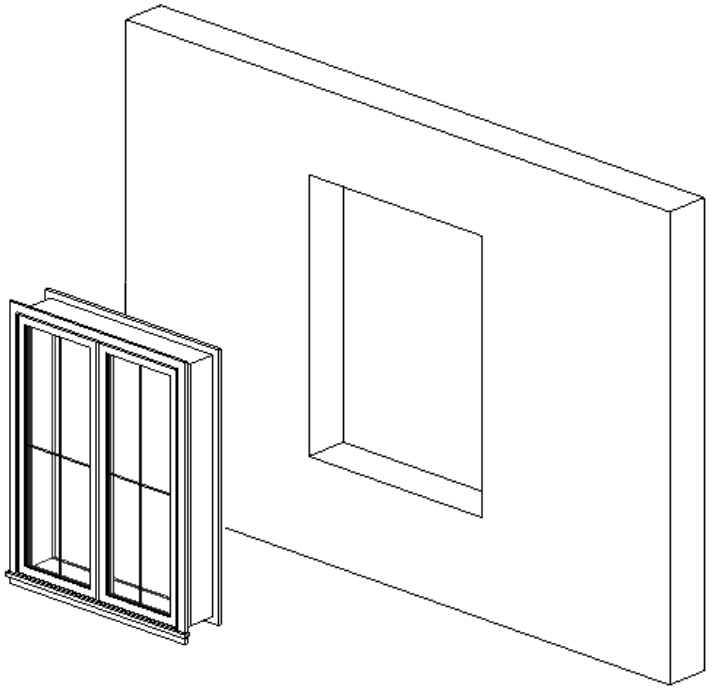
REPRESENTATION DATA



BIM OBJECT BEHAVIOR

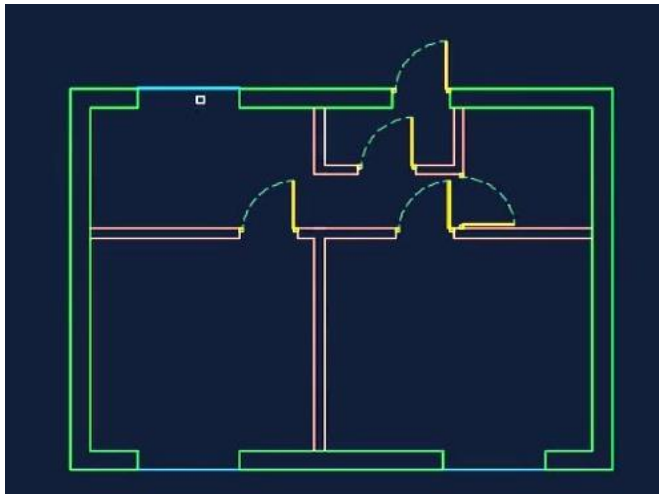
FUNCTION: IN-HOST OBJECT



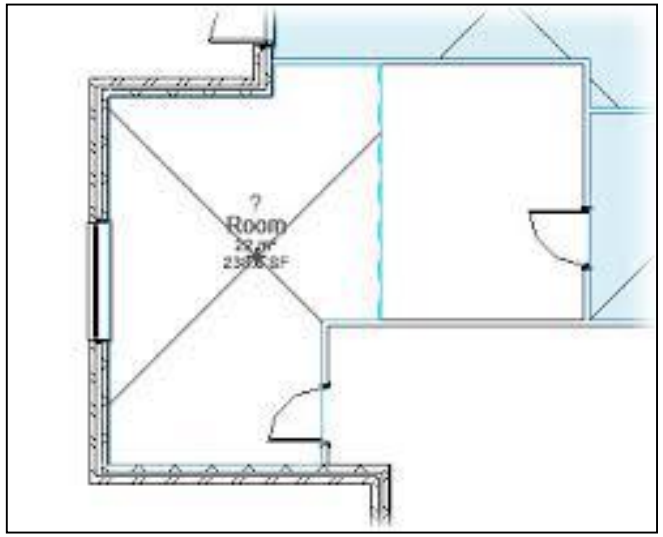


OBJECT RELATIONS

BIM & STAGE SPECIFICITY



CONVENTIONAL DESIGN



BIM DESIGN

- object selection
- no abstraction
- all information already there

DAYLIGHT REGULATIONS

THE BOUWBESLUIT REGULATIONS

NEN 2057 DAYLIGHT REGULATIONS

Equivalent Daylight Area (Ae)

$$A_{e,i} = A_{d,i} \cdot C_{b,i} \cdot C_{u,i} \cdot C_{LTA}$$

- $A_{d,i}$ effective area of daylight opening
- $C_{b,i}$ obstruction factor
- $C_{u,i}$ external reduction factor
- C_{LTA} level of transparency of external geometry

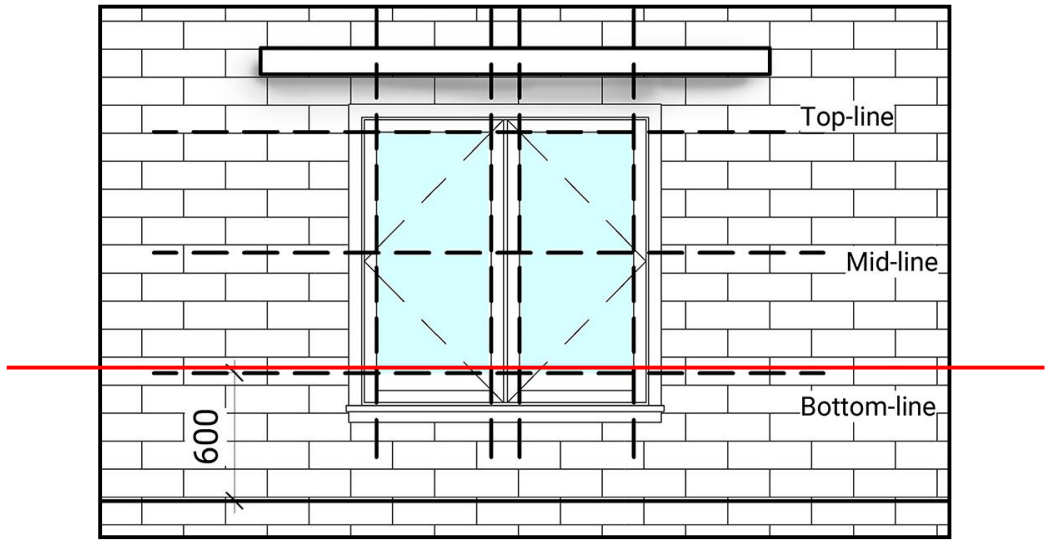
Total Equivalent Daylight Area

$$A_e = \sum_{i=1}^{n} A_{e,i}$$

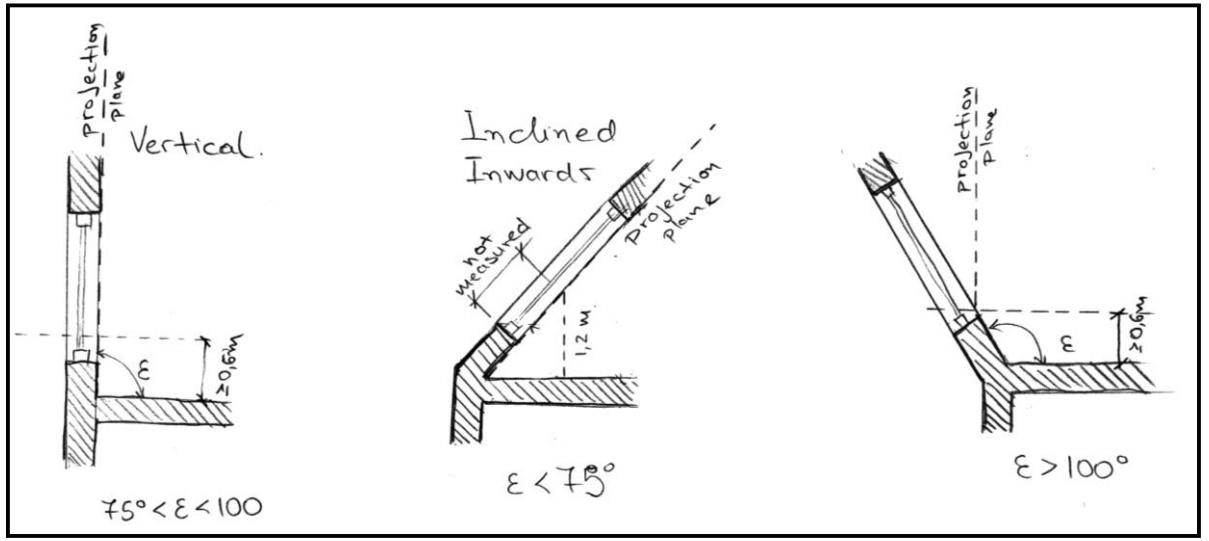
DESCRIPTION

DAYLIGHT OPENING AREA ($A_{d,i}$)

Effect of Sill Height



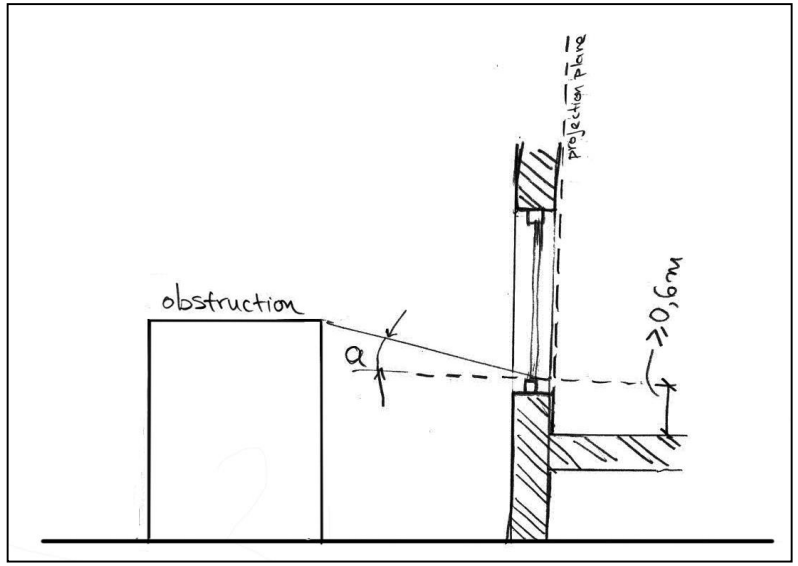
Effect of Wall Inclination



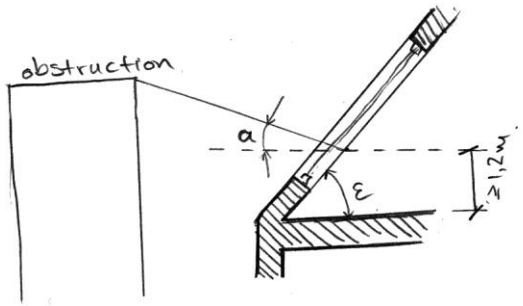
DESCRIPTION

OBSTRUCTION FACTOR ($C_{b,i}$)

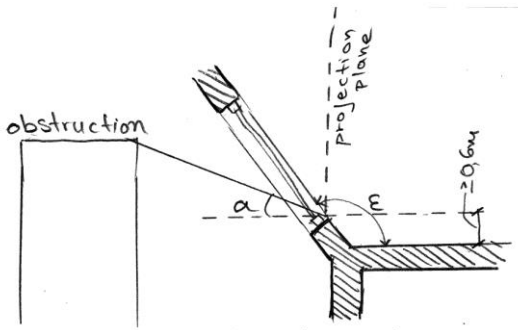
Angle α



Vertical opening

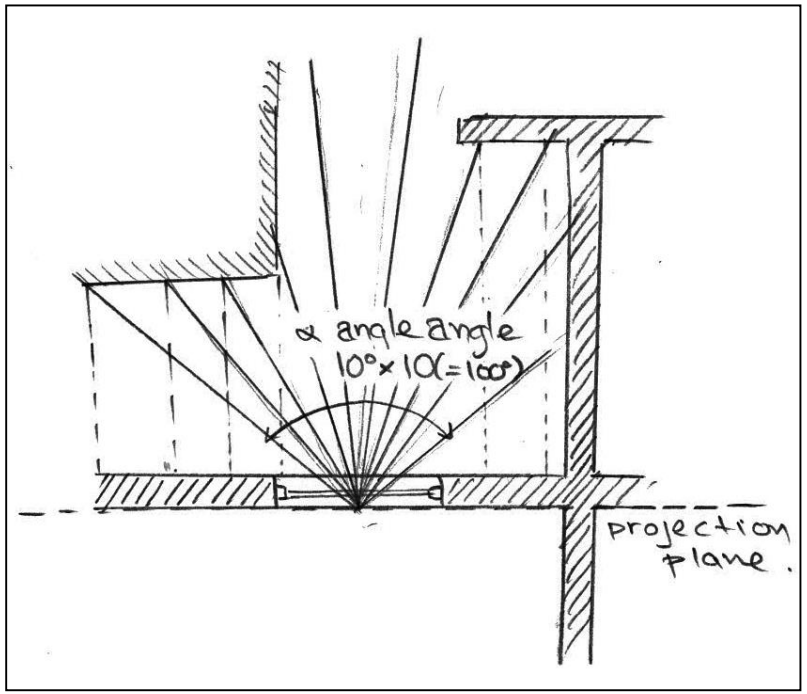


inclined inwards



inclined outwards

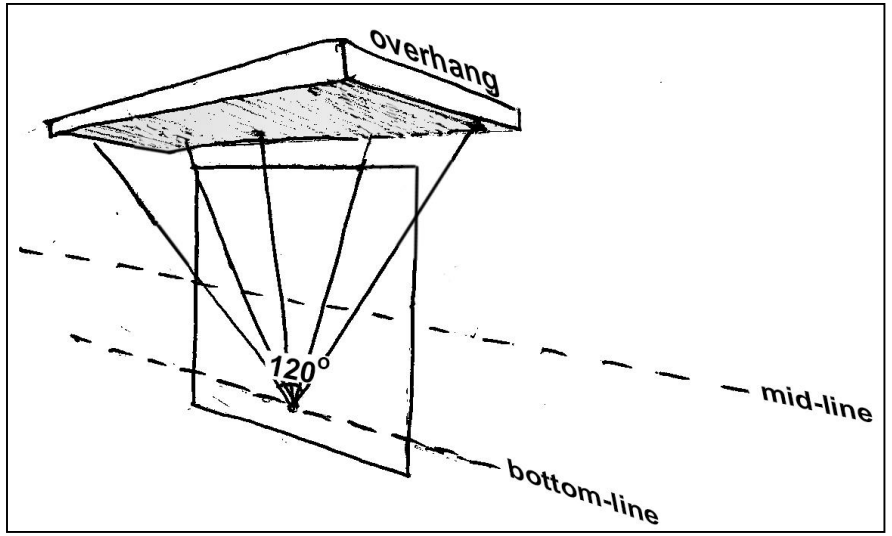
Angle α range



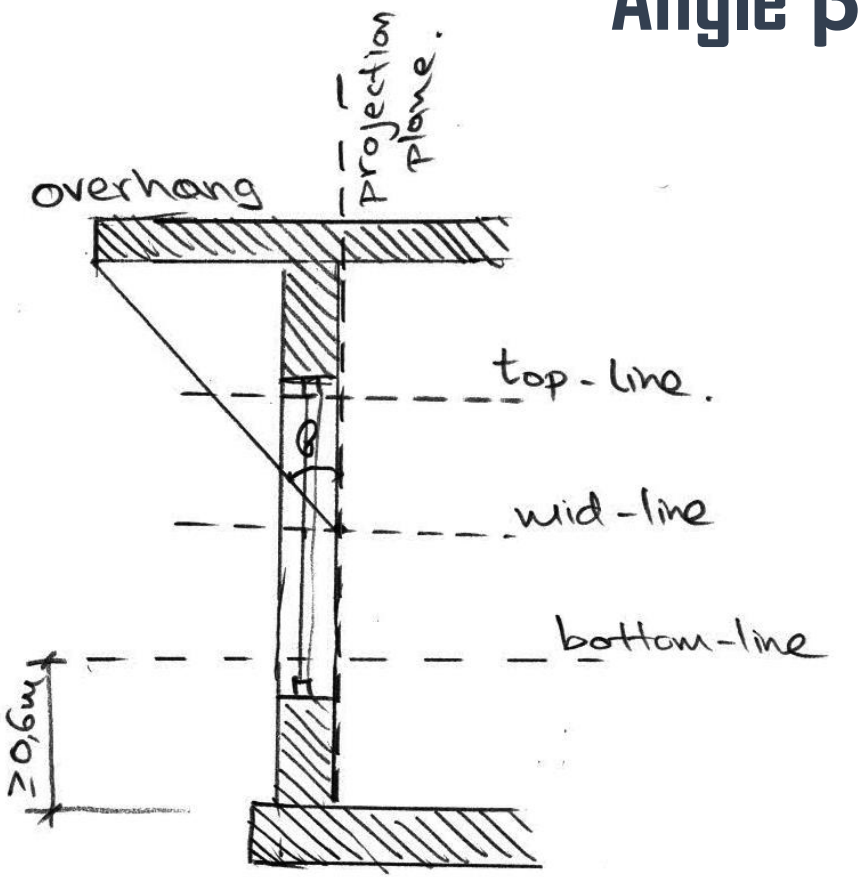
DESCRIPTION

OBSTRUCTION FACTOR ($C_{b,i}$)

Angle β range



Angle β



DAYLIGHT REGULATIONS

ADVANTAGES

LOW THRESHOLD

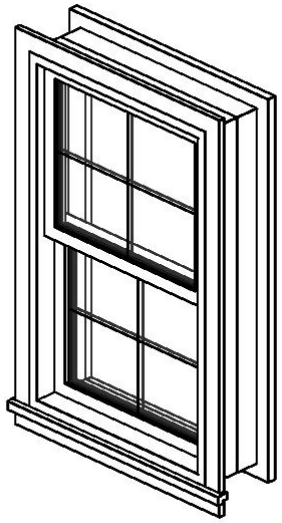
GEOMETRIC RELATIONS

REASONING BEHIND PERFORMANCE

QUANTIFIABLE OBJECT INTERRELATIONS

DAYLIGHT REGULATIONS

ADVANTAGES



Daylight

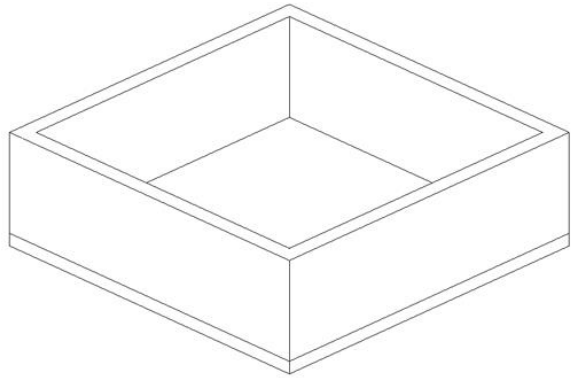
.....

.....

Daylight

.....

.....



COMPUTATIONAL DESIGN

SOFTWARE SELECTION

Parametric add-in

Visual programming Language

"Code" connected to Revit UI

COMPUTATIONAL DESIGN

INPUT → DATA EXTRACTION

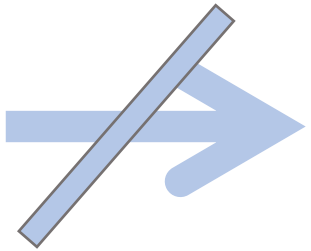
PROCESSING → FUNCTION RECOGNITION

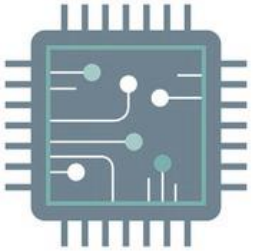
PROCESSING → DAYLIGHT EVALUATION

PROCESSING → 2D MAPPING

INTERACTION → USER INTERFACE INTEGRATION

DEVELOPMENT LIMITATIONS



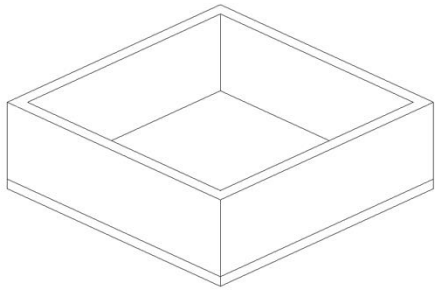


INPUT

DATA EXTRACTION

Closed Space

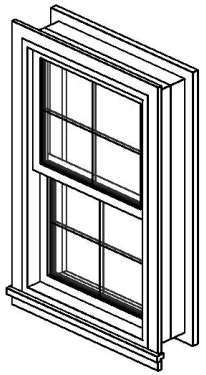
Room specification



Room Parameters

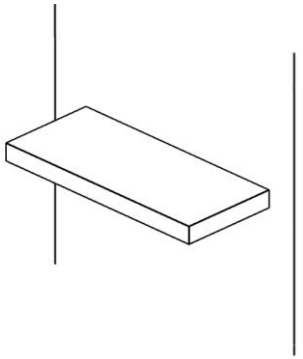
Wall Parameters

Typical Revit Window family



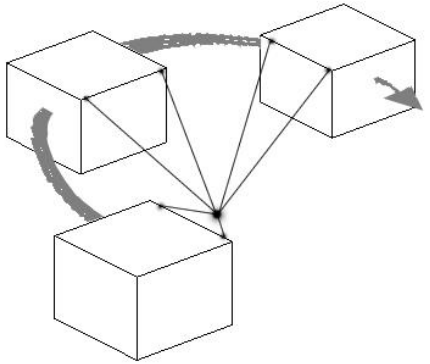
Parameters

Wall-hosted Overhangs



Geometry

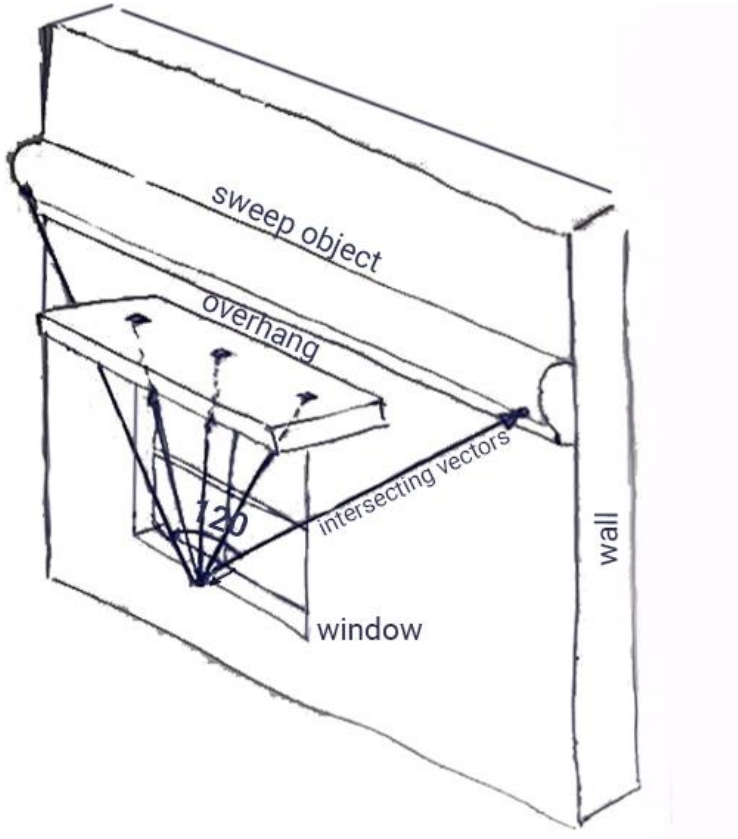
Surroundings



Geometry

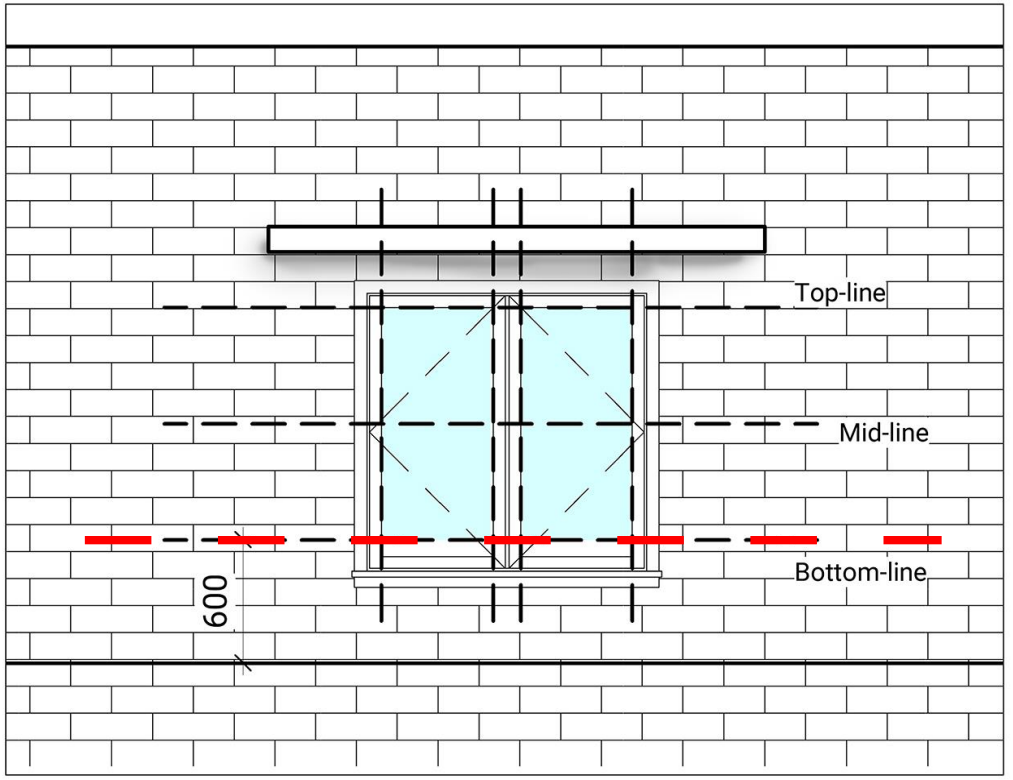
OVERHANG RECOGNITION

Overhangs



DAYLIGHT EVALUATION

Equivalent Daylight Opening area (Ad)

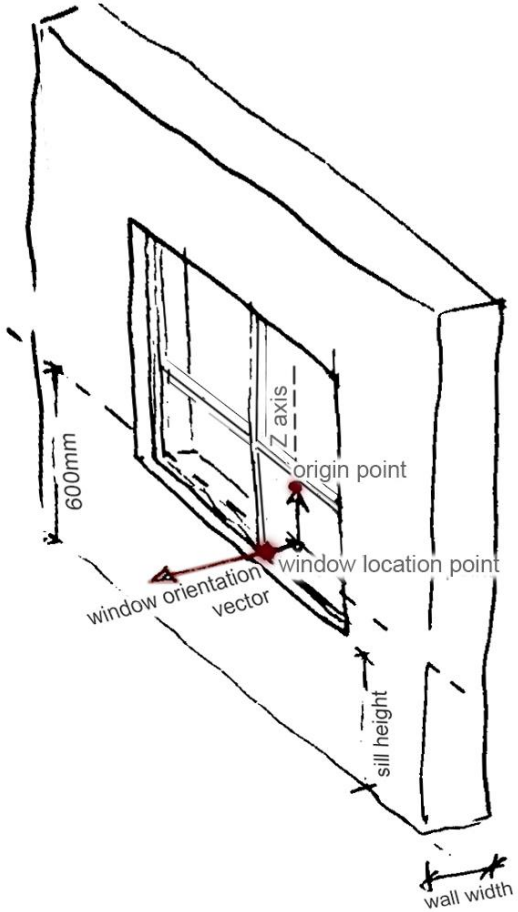


DAYLIGHT EVALUATION

Angle α

1

Specify Origin Point

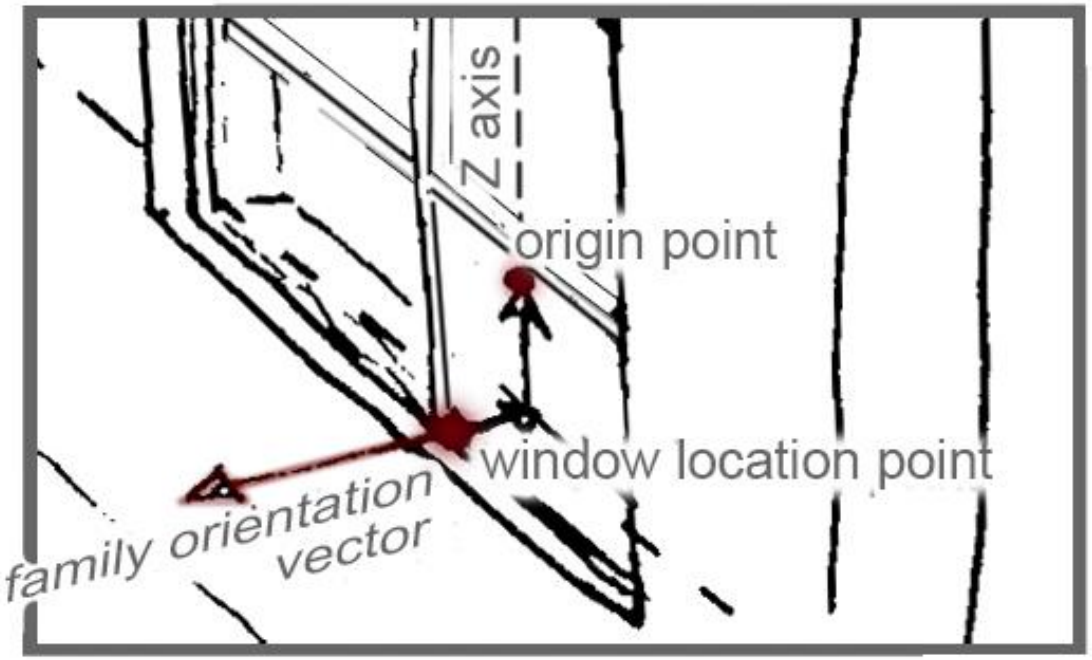


DAYLIGHT EVALUATION

Angle α

1

Specify Origin Point

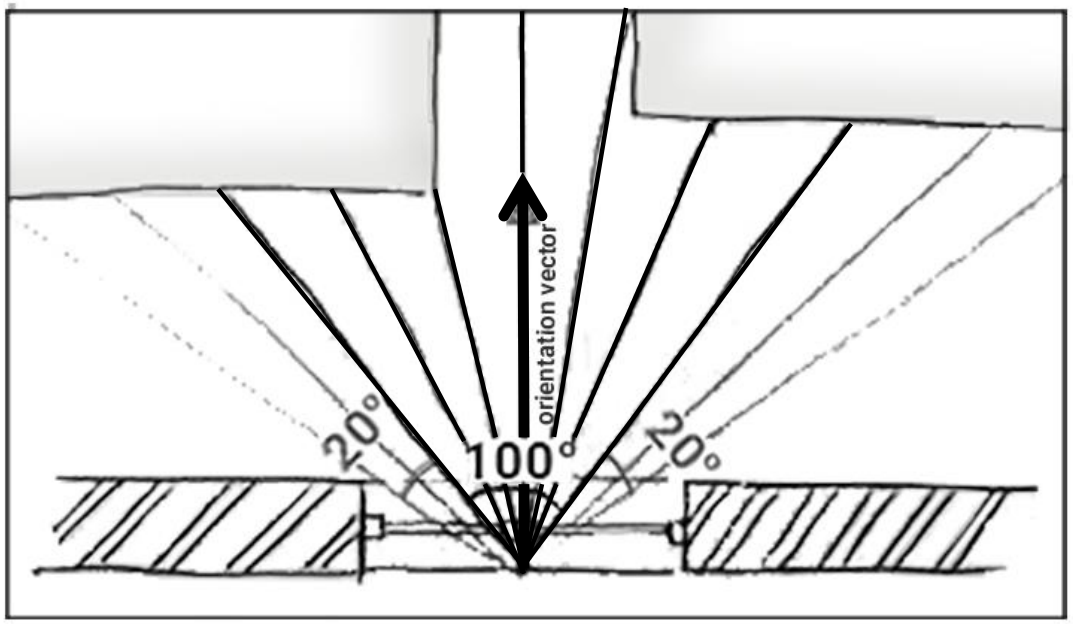


DAYLIGHT EVALUATION

Angle α - Raycasting

2

Array α by Z axis

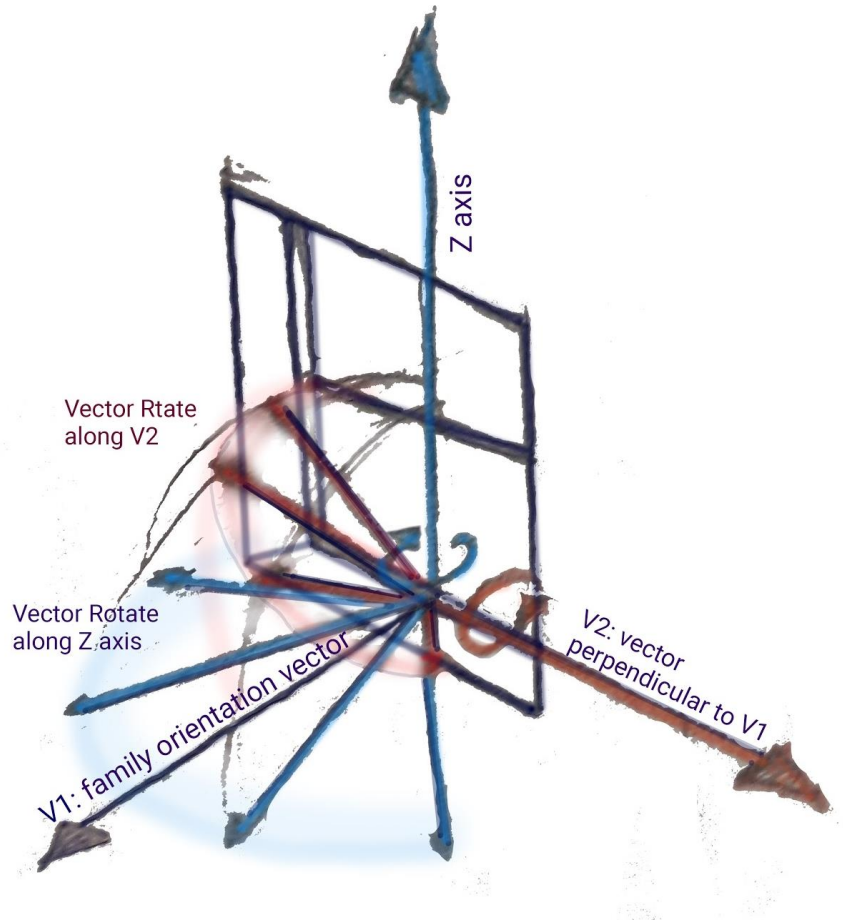


DAYLIGHT EVALUATION

3

Array by (X) axis

Angle α - Raycasting

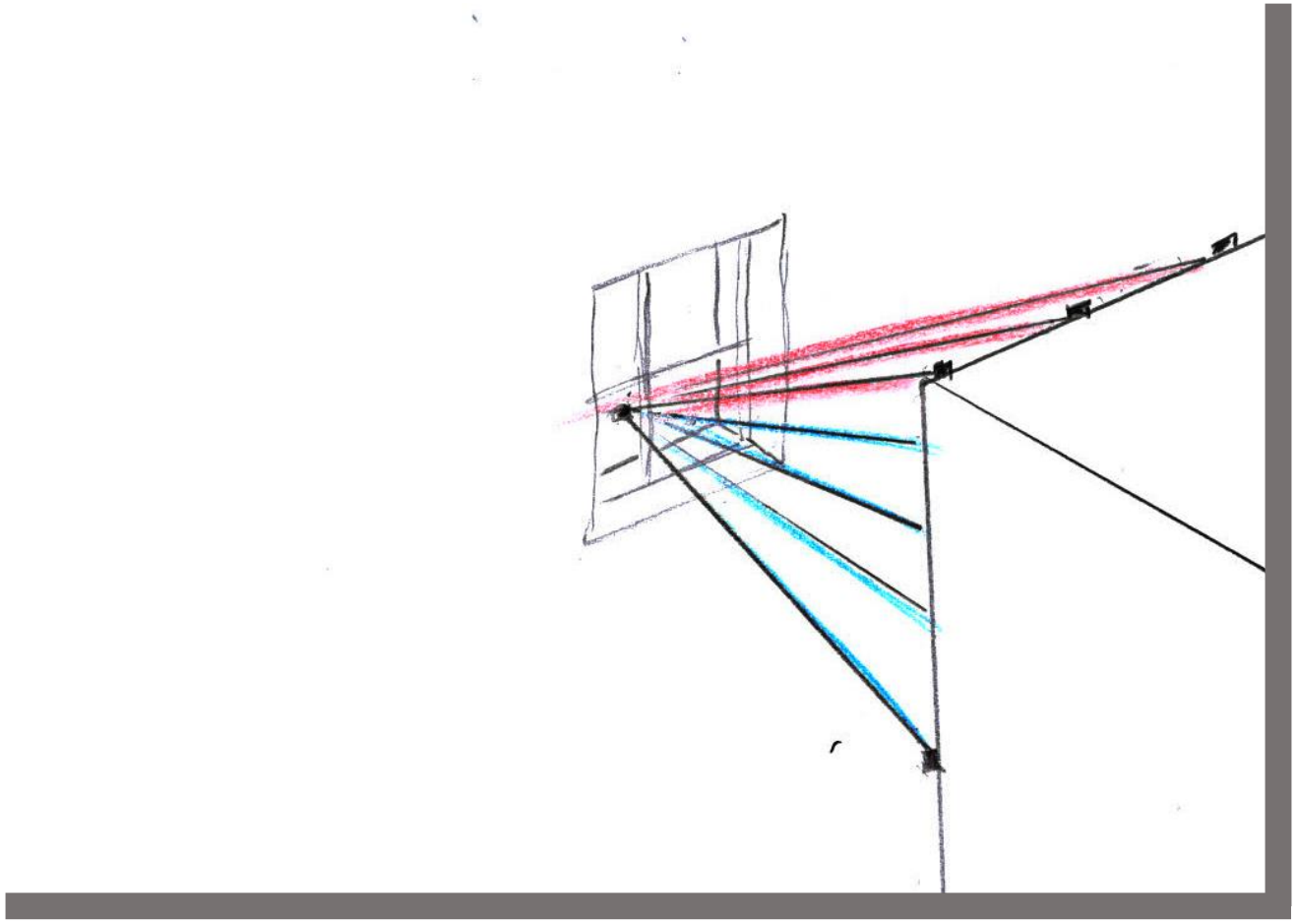


DAYLIGHT EVALUATION

Angle α – Raycasting & Raybounce

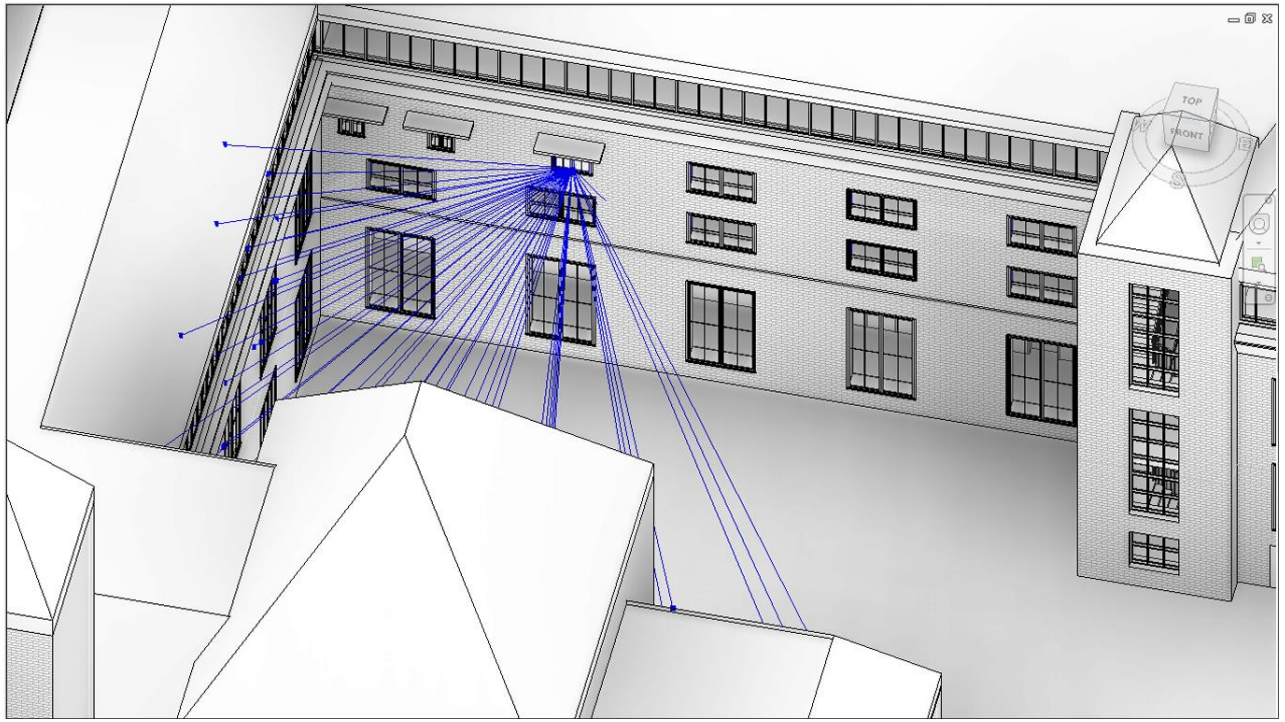
4

Raybounce

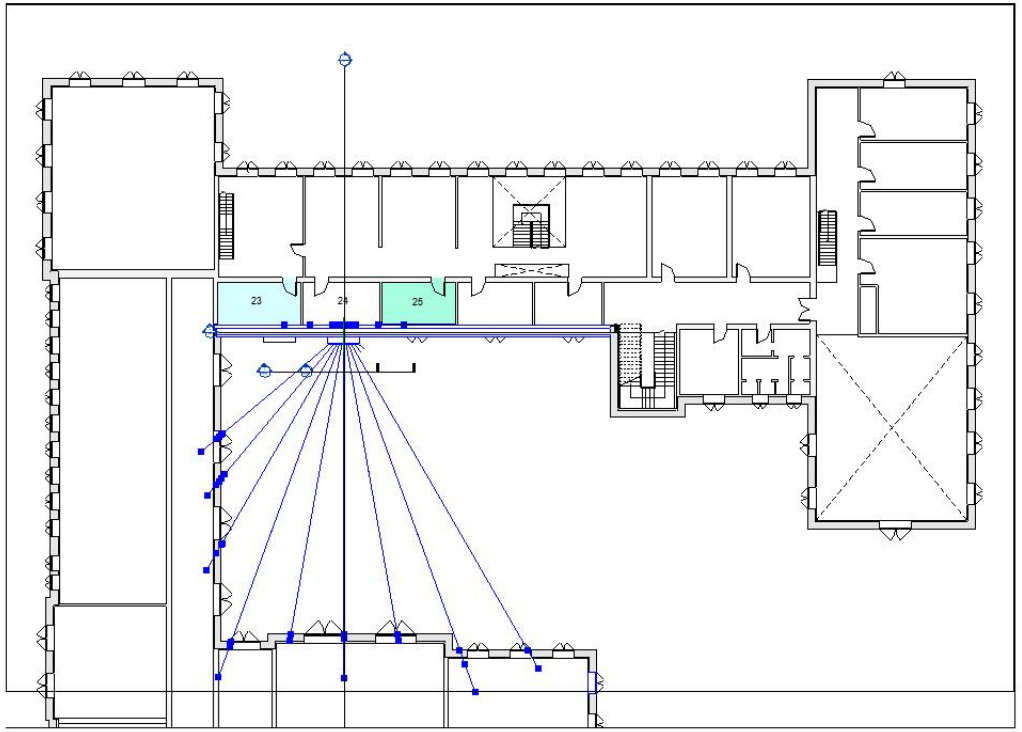


DAYLIGHT EVALUATION

Angle α – Raycasting & Raybounce



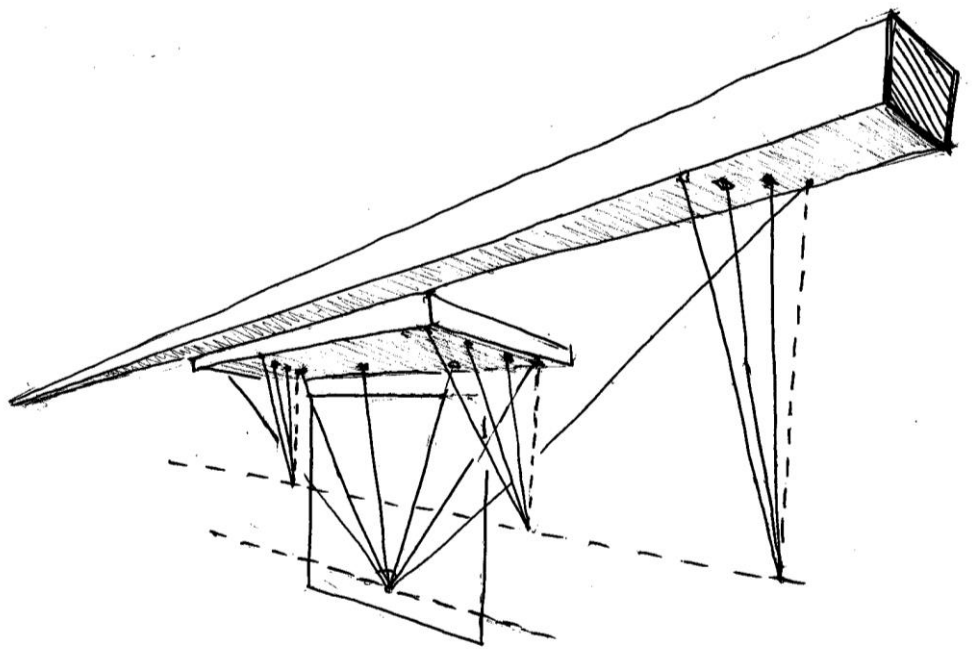
Revit preview of Dynamo algorithm



DAYLIGHT EVALUATION

Angle β – Raycasting & Raybounce

4



DAYLIGHT EVALUATION

Angle β – Raycasting & Raybounce

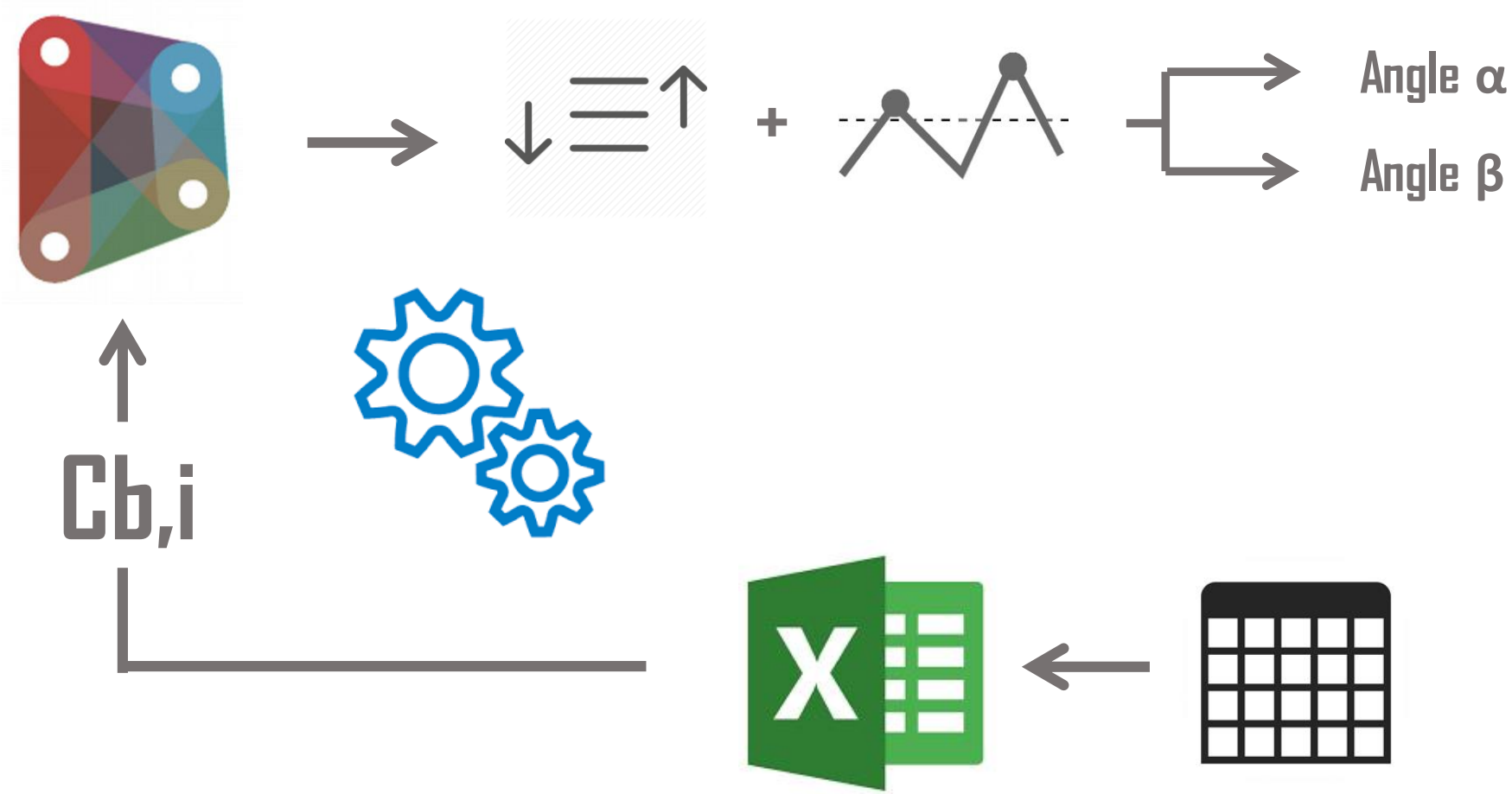
4

Revit preview of Dynamo algorithm

DAYLIGHT EVALUATION

Calculate factor Cb,i

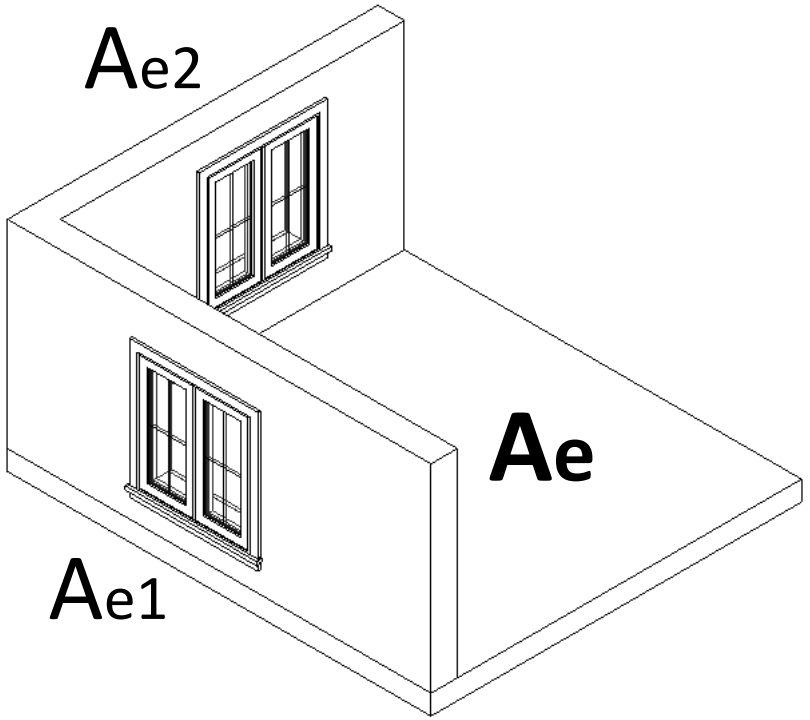
5



DAYLIGHT EVALUATION

Calculate Ae,i

6



$$A_{e,i} = A_{d,i} \times C_{b,i}$$

$$A_e = \sum A_{e,i}$$

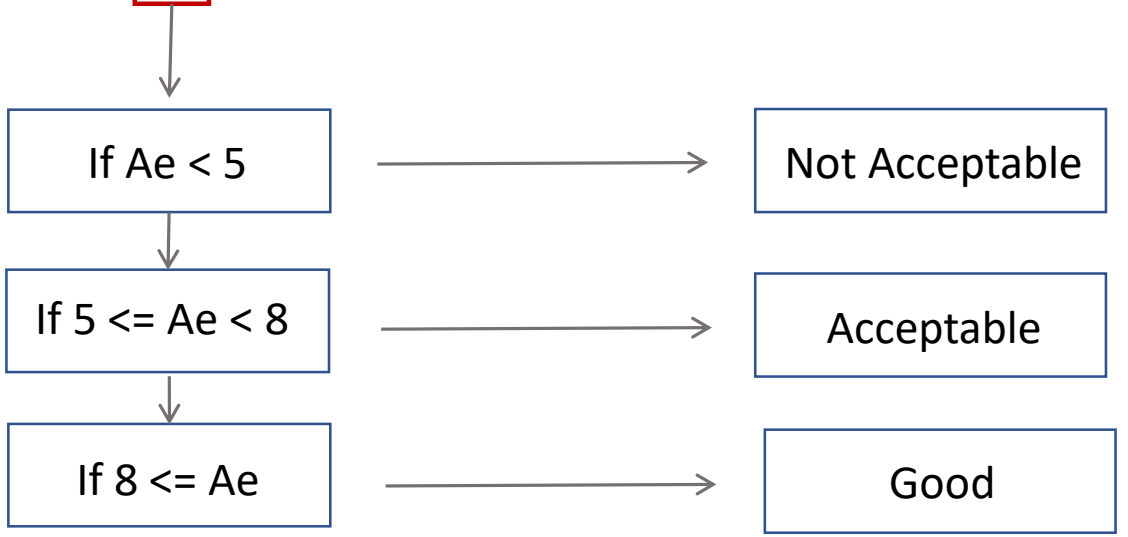
DAYLIGHT EVALUATION

Daylight Assessment

7

	Relative equivalent daylight area [%}	Absolute equivalent daylight area [m²]
Living	10	0,5
Childcare	5	0,5
Cell	3	0,15
Office	2.5	0.5
Education	5	0.5

Table of permitted Equivale Daylight Area (Ae,i) values



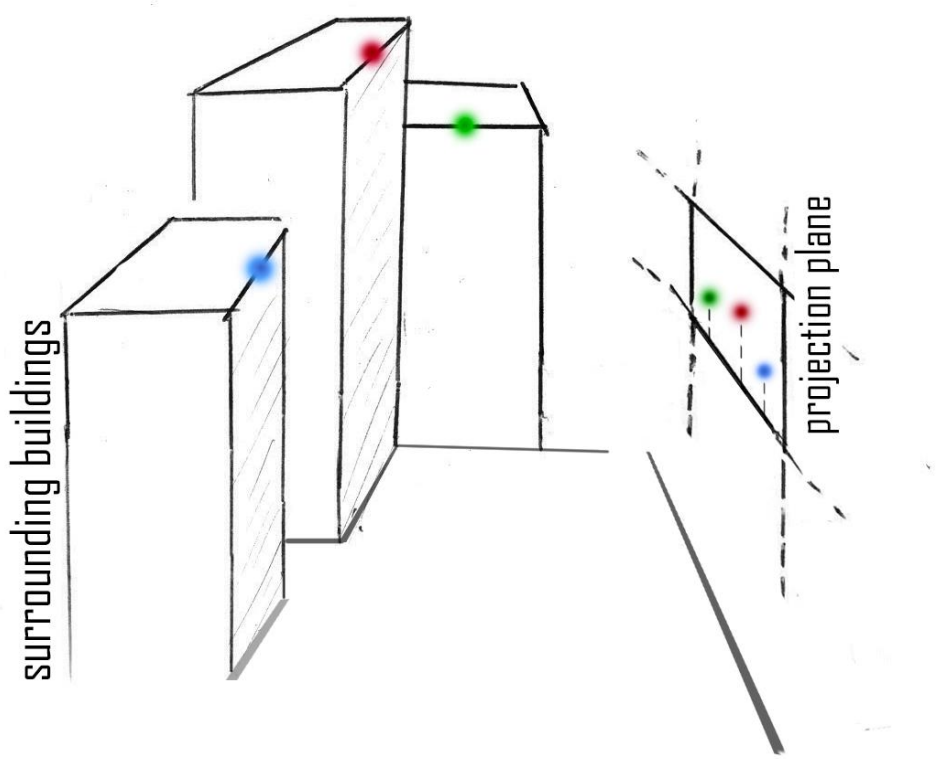
PROCESSING

DAYLIGHT EVALUATION

If Assessment is "Not Acceptable"	→	Proceed to 2D Mapping
If Assessment is "Acceptable"	→	Proceed to 2D Mapping
If Assessment is "Good"	→	No further action needed/ delete previous representations

2D MAPPING

Maximum-angle points

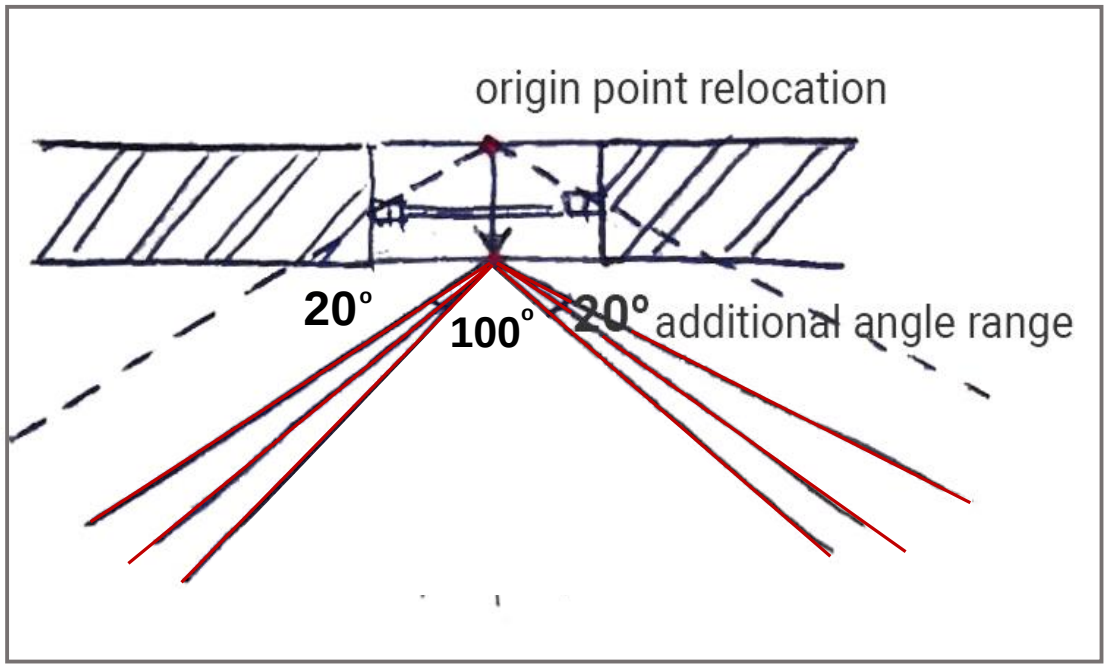


2D MAPPING

Angle α – Additional Ray casting

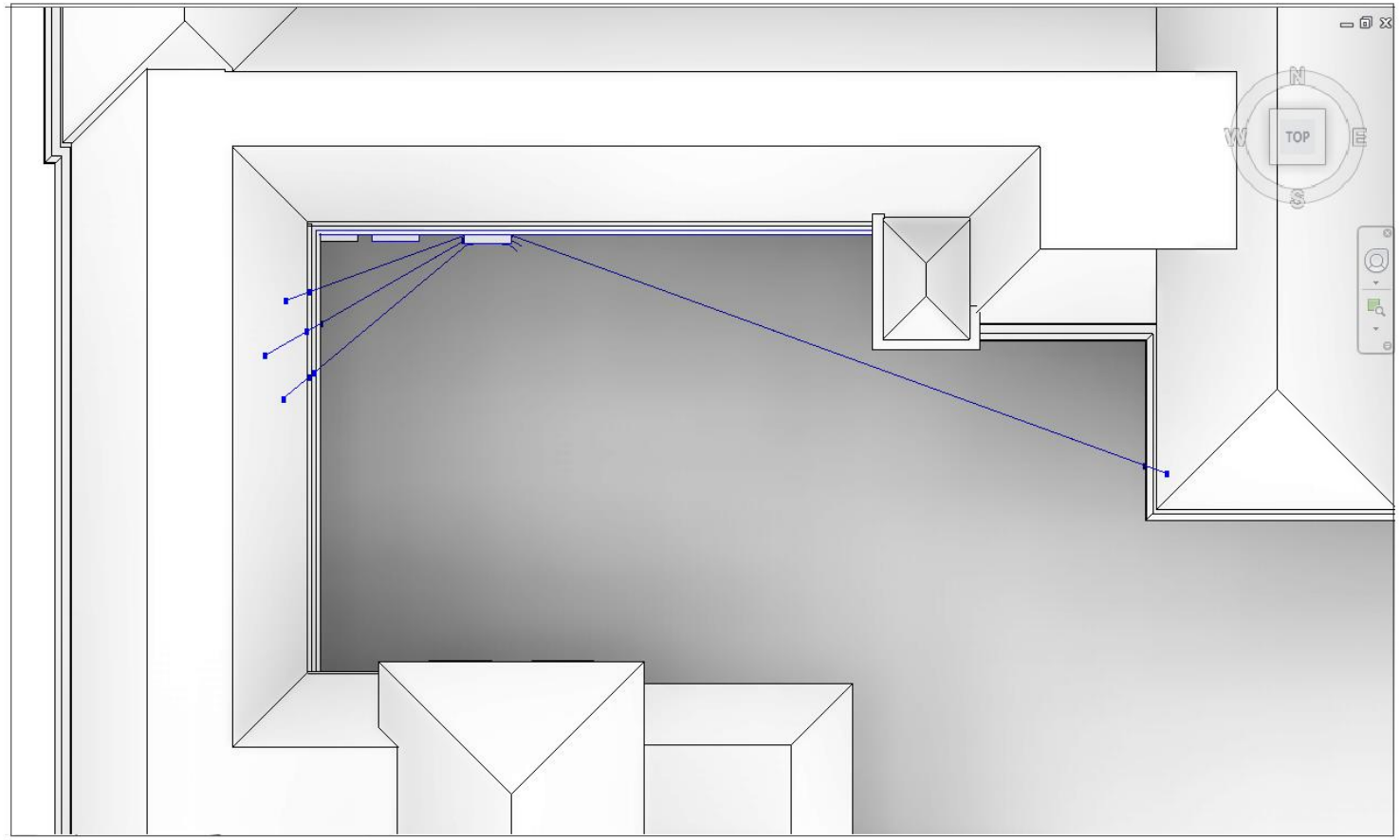
1

Angle Range Extension



2D MAPPING

Angle α – Additional Raycasting

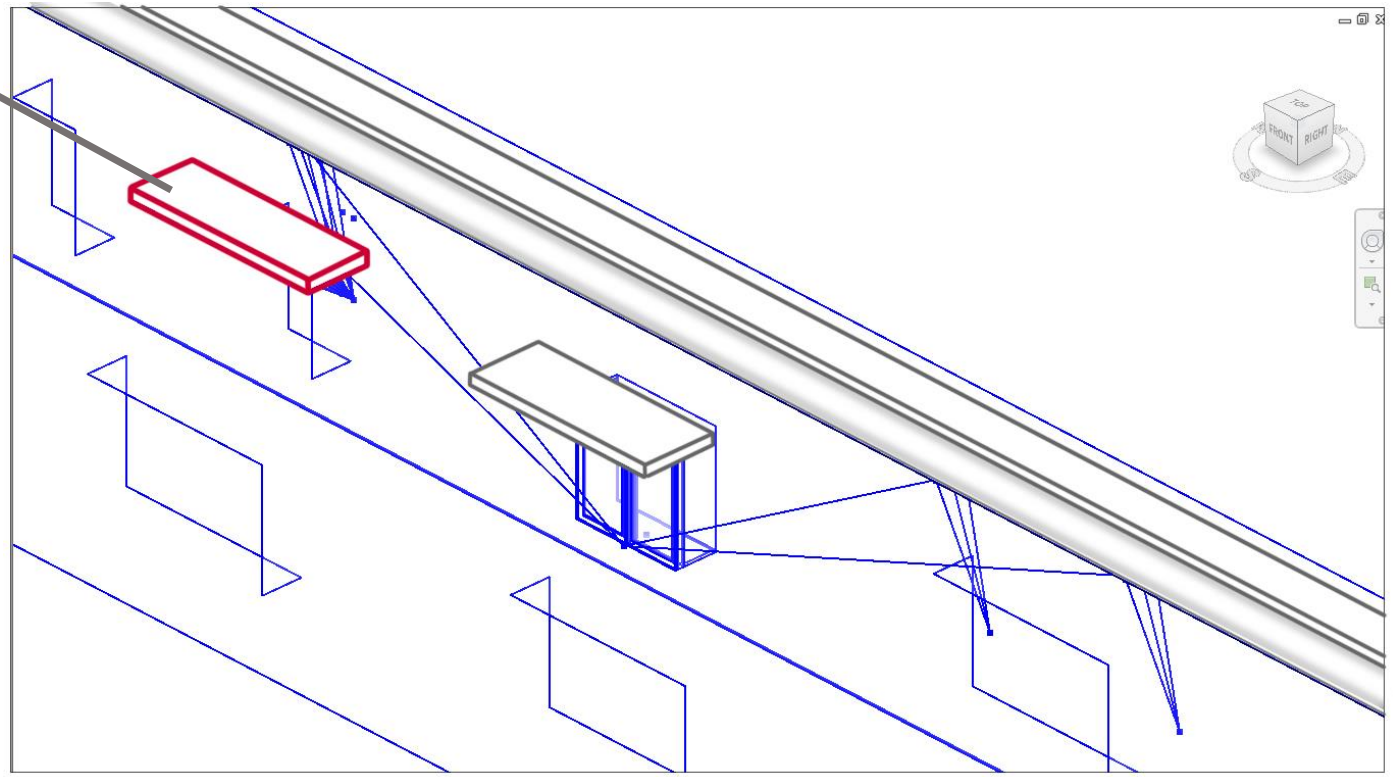


Revit preview of
Dynamo algorithm

2D MAPPING

Angle β – Additional Ray casting

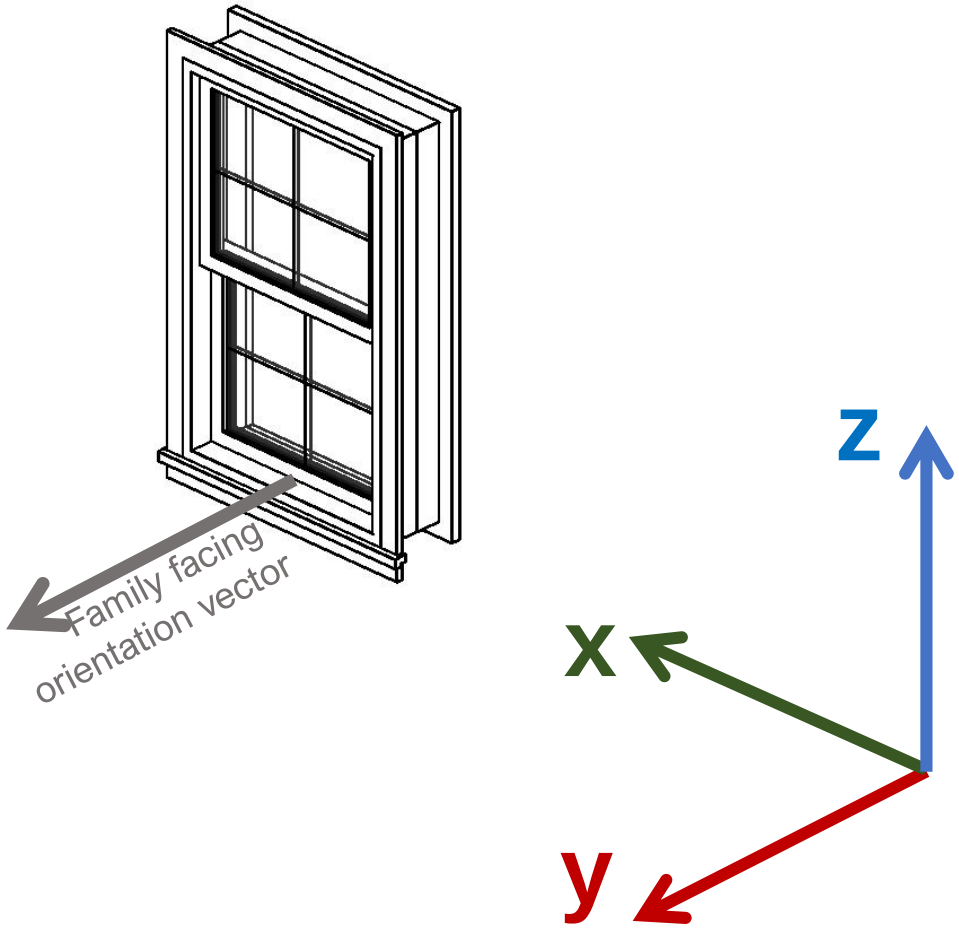
Additional Overhang due to Extended Angle Range



Revit preview of Dynamo algorithm

2D MAPPING

Local Coordinate System



2D MAPPING

Mapping on the x axis

$\theta_1 = \theta_2 = \ldots = \theta_n \Rightarrow$

$x_1 = x_2 = \ldots = x_n \Rightarrow$

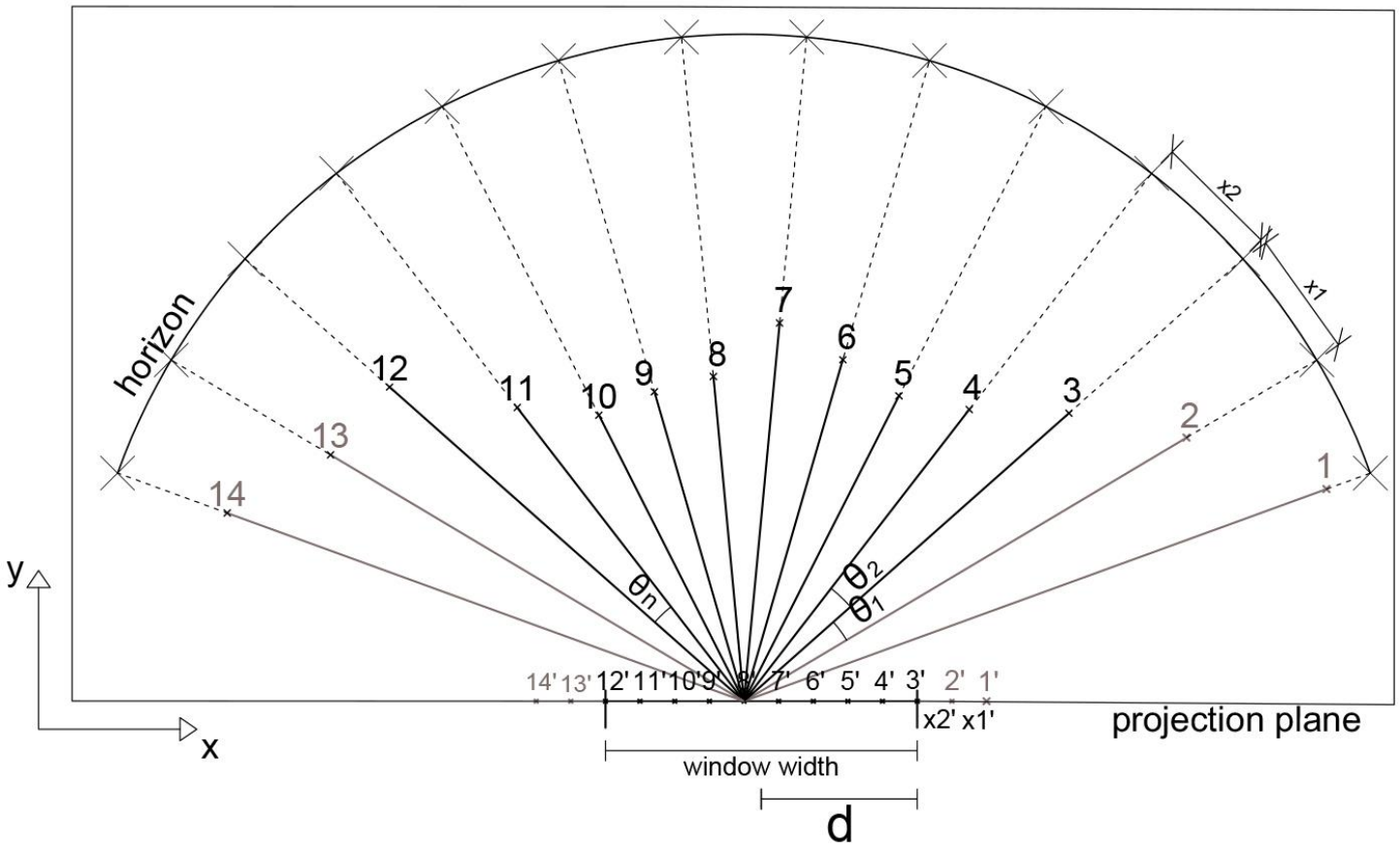
$x_{1'} = x_{2'} = \ldots = x_{n'}$

Sequence number only is enough:

$Xi = (1- (2*(ni - Round.(0.3*n)) / (n-1))) * d$

Number of additional vectors

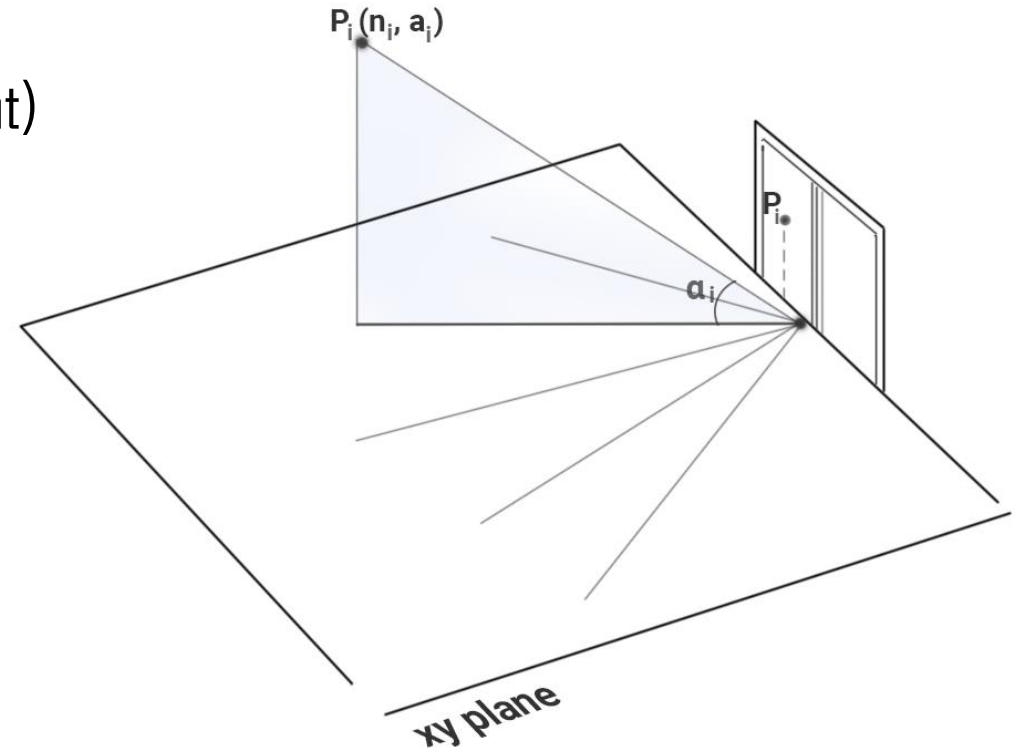
Number of initial vectors



2D MAPPING

Mapping on the z axis

$Z_i = (\alpha_i / 90) * \text{Window Height} + (600 - \text{Sill\_Height})$



INTERACTION

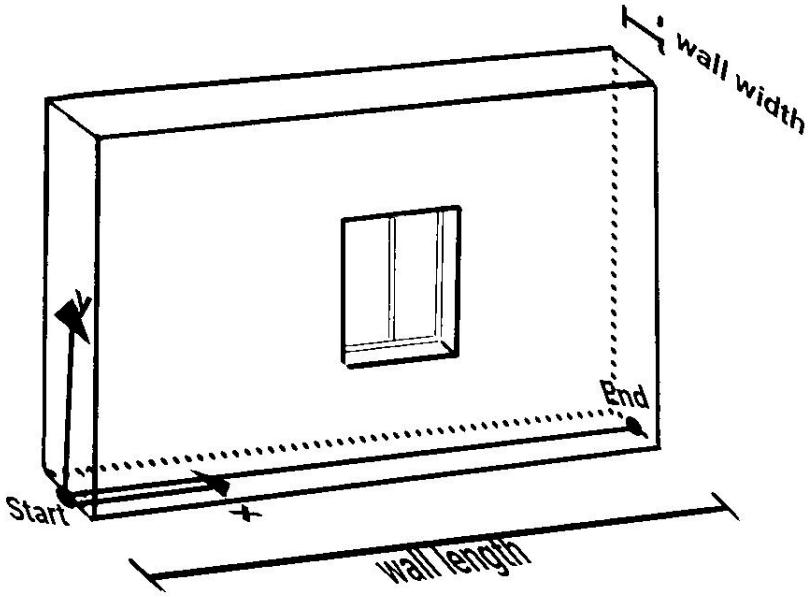
USER INTERFACE INTEGRATION

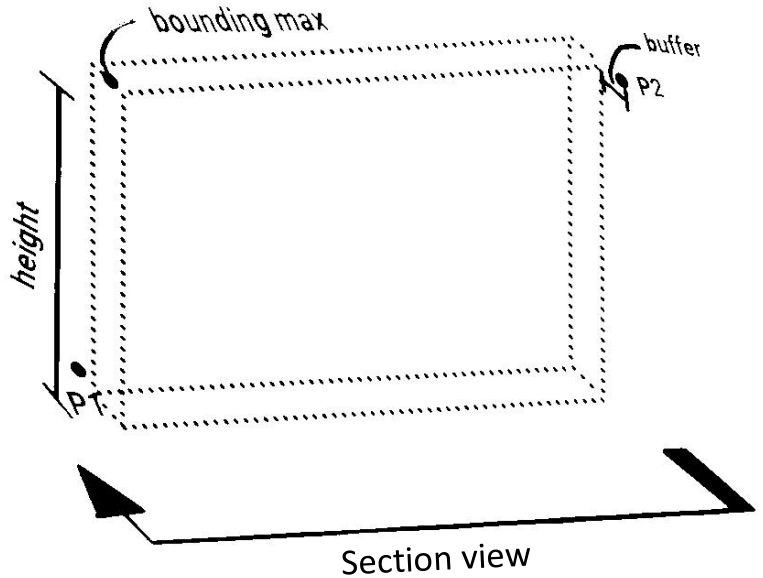
NOT INTERRUPT DESIGN PROCESS → **Representation in a Revit View**

NOT HAVE PERMANENT PRESENCE → **Delete View when Assessment fulfils**

USER INTERFACE INTEGRATION

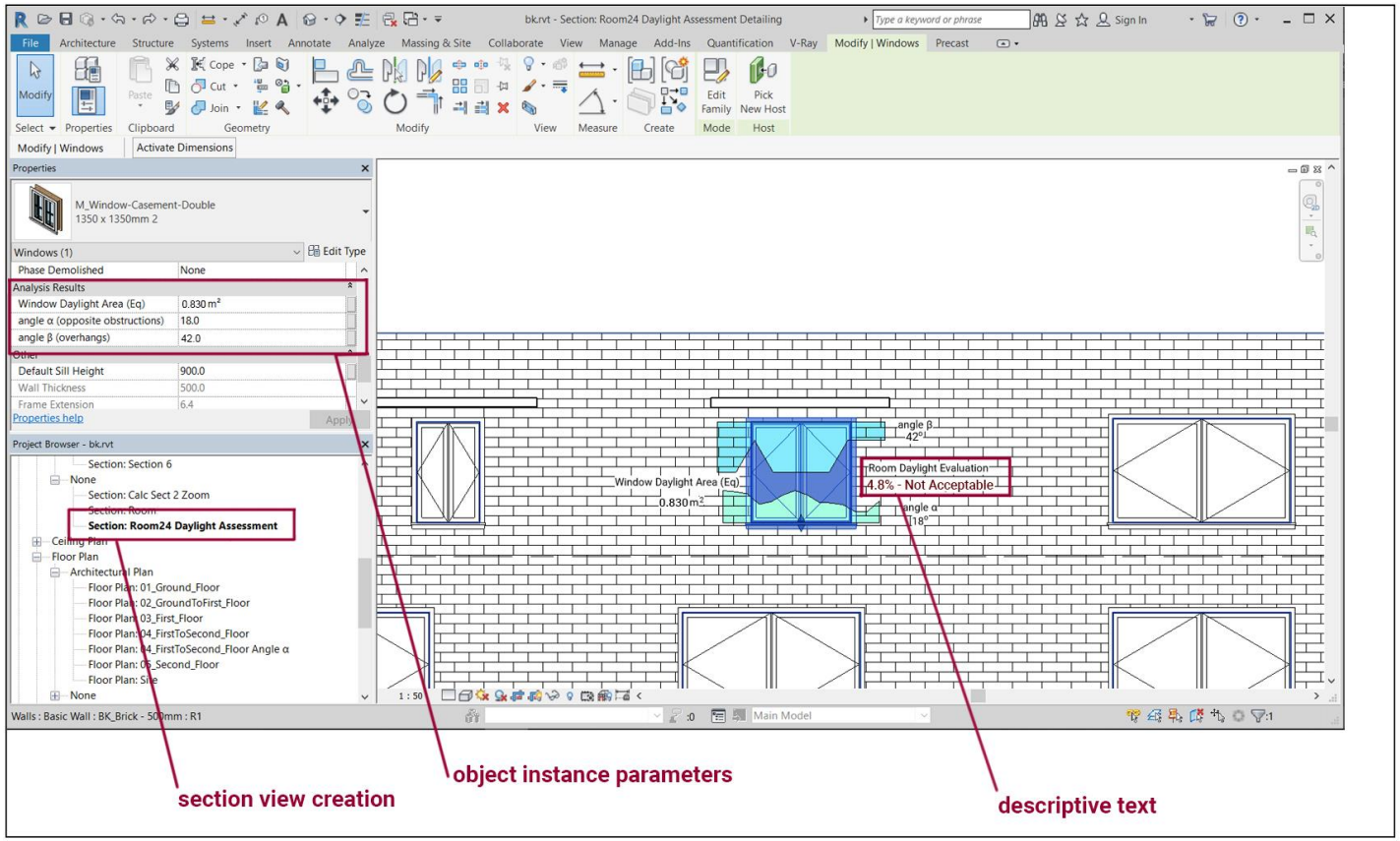
Daylight View Creation





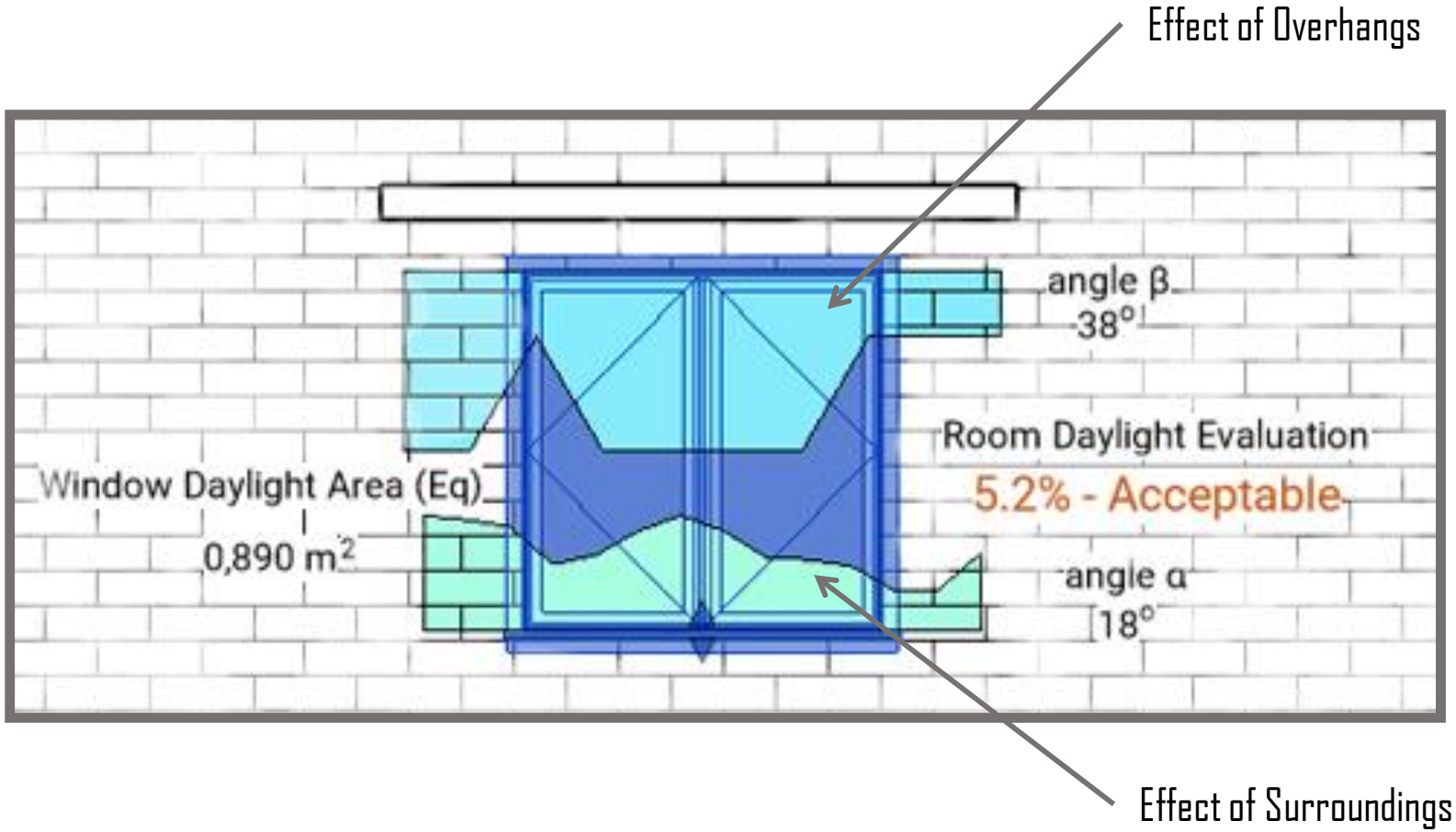
USER INTERFACE INTEGRATION

User Interface Representation



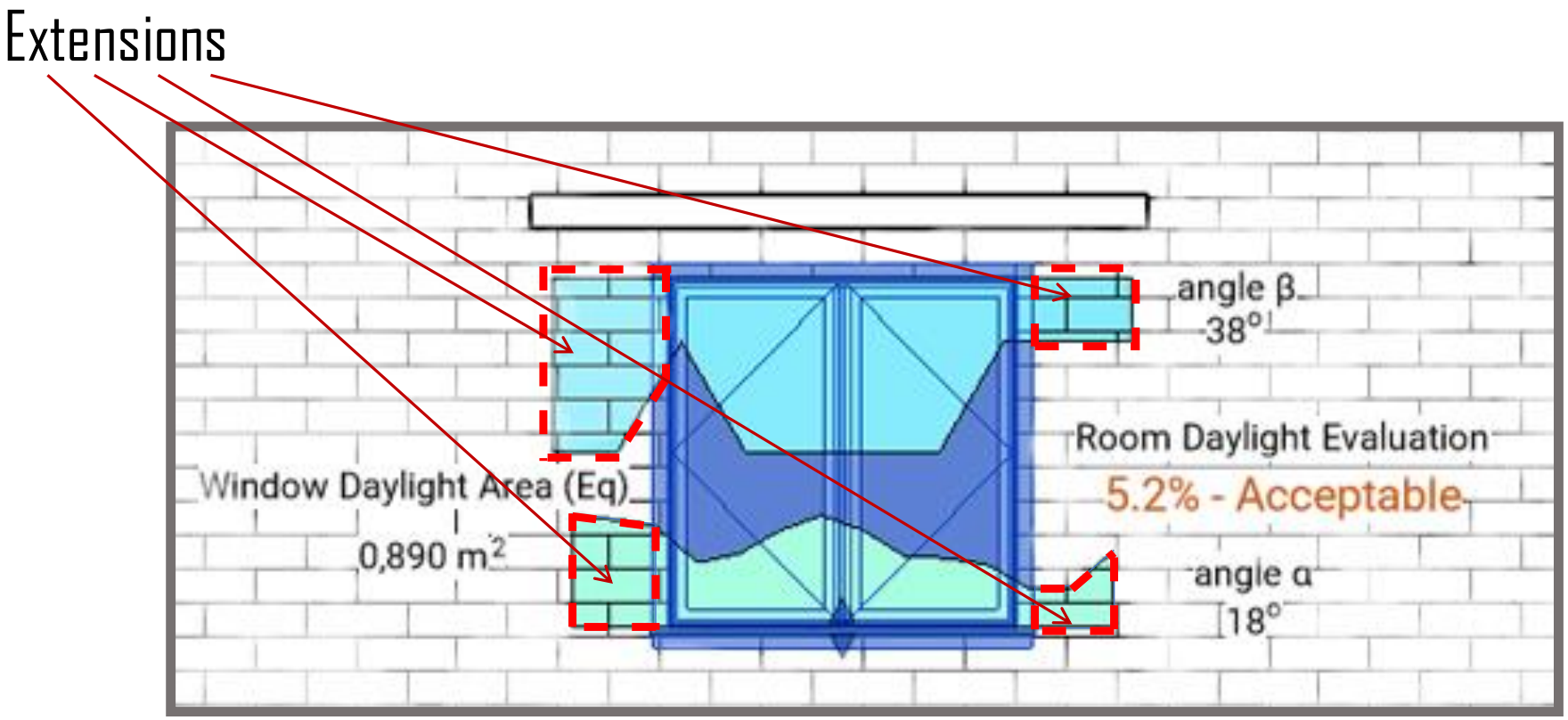
USER INTERFACE INTEGRATION

User Interface Representation



USER INTERFACE INTEGRATION

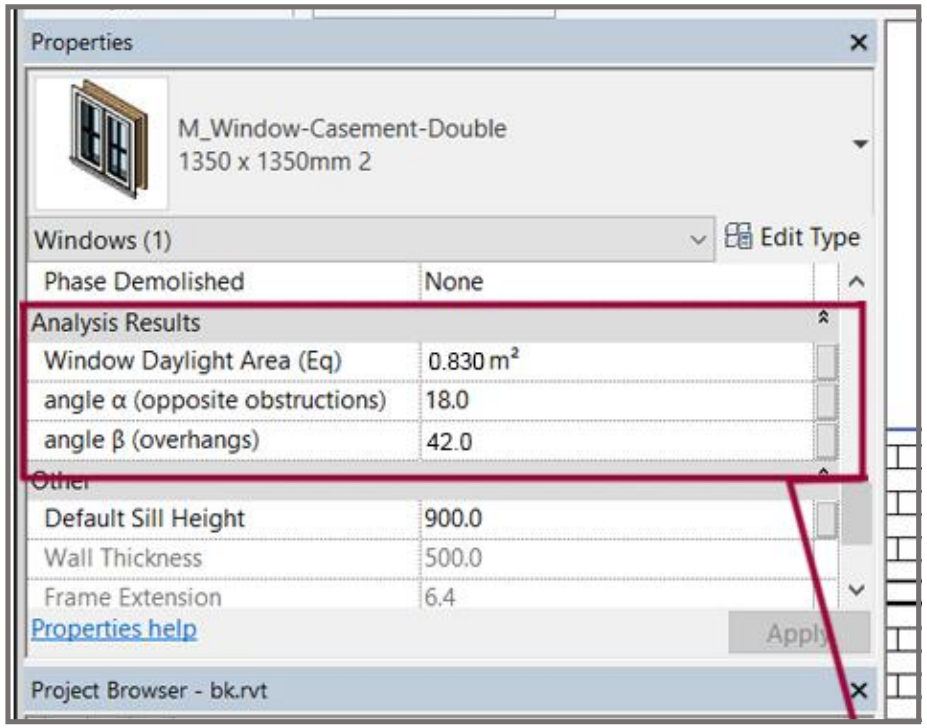
User Interface Representation

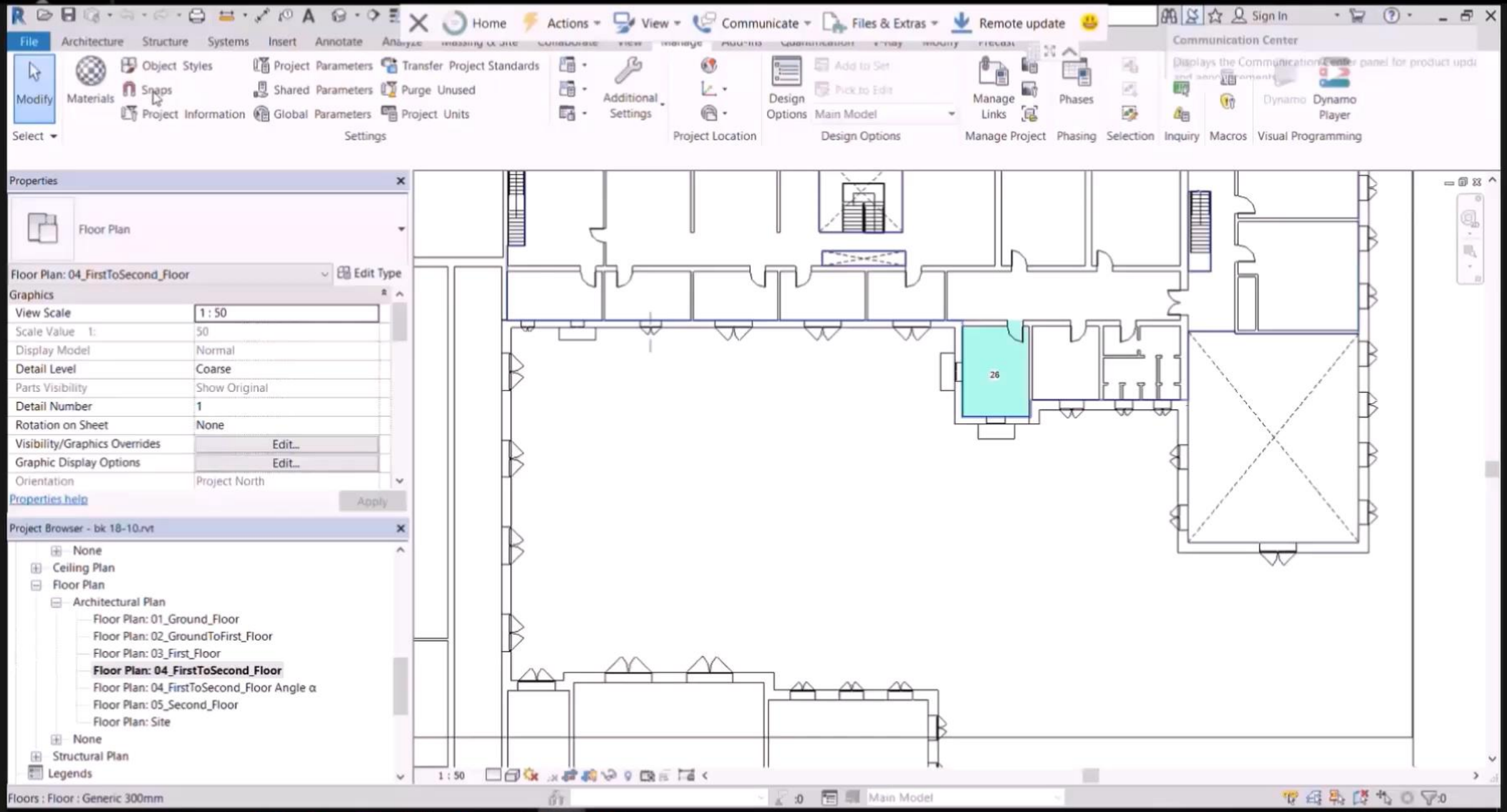


USER INTERFACE INTEGRATION

User Interface Representation

Window Instance parameters




Home
Actions
View
Communicate
Files & Extras
Remote update
Sign In
File
Architecture
Structure
Systems
Insert
Annotate
Modify
Materials
Object Styles
Snaps
Project Information
Project Parameters
Shared Parameters
Global Parameters
Transfer Project Standards
Purge Unused
Project Units
Additional Settings
Settings
Project Location
Design Options
Main Model
Manage Links
Manage Project
Phases
Phasing
Selection
Inquiry
Macros
Dynamo
Dynamo Player
Visual Programming
Communication Center
Properties
Floor Plan
Floor Plan: 04_FirstToSecond_Floor
Edit Type
Graphics
View Scale 1 : 50
Scale Value 1: 50
Display Model Normal
Detail Level Coarse
Parts Visibility Show Original
Detail Number 1
Rotation on Sheet None
Visibility/Graphics Overrides Edit...
Graphic Display Options Edit...
Orientation Project North
Properties help
Apply
Project Browser - bk 18-10.rvt
None
Ceiling Plan
Floor Plan
Architectural Plan
Floor Plan: 01_Ground_Floor
Floor Plan: 02_GroundToFirst_Floor
Floor Plan: 03_First_Floor
Floor Plan: 04_FirstToSecond_Floor
Floor Plan: 04_FirstToSecond_Floor Angle α
Floor Plan: 05_Second_Floor
Floor Plan: Site
None
Structural Plan
Legends
26
1 : 50
Floors : Floor : Generic 300mm
Main Model
ENG
19:04
22-Oct-19