

 AUTODESK® UNIVERSITY

AS468807

# Generative Design in Revit and Beyond

**Lilli Smith**

Sr. Product Manager AEC Generative Design | @LilliMSmith



## About the speaker

### Lilli Smith, AIA

Lilli is an architect with a passion for re-envisioning the way that buildings are designed. After working for several years as an architect, she joined Revit Technology as a fledgling start up and helped grow it to where it is today in almost every architect's tool box. She has gone on to work on many Autodesk tools including Vasari, FormIt, Dynamo, Project Fractal and Project Refinery which recently graduated to a suite of tools for generative design studies in Revit.

# Safe Harbor

During the course of this presentation, we may make statements regarding future events and/or statements regarding planned or future development efforts for our existing or new products and services. We wish to caution you that such statements reflect our current expectations, estimates and assumptions based on factors currently known to us and that actual events or results could differ materially. Also, these statements are not intended to be a promise or guarantee of future delivery of products, services or features but merely reflect our current plans, which may change. Purchasing decisions should not be made based upon reliance on these statements. The statements made in this presentation are being made as of the time and date of its live presentation. We do not assume any obligation to update any statements we make to reflect events that occur or circumstances that exist after the date of this presentation.

Autodesk, the Autodesk logo, 3ds Max, BIM 360, Forge, Revit, and other solutions mentioned by name are registered trademarks or trademarks of Autodesk, Inc., and/or its subsidiaries and/or affiliates in the USA and/or other countries. All other brand names, product names, or trademarks belong to their respective holders.

Autodesk reserves the right to alter product and services offerings, and specifications and pricing at any time without notice, and is not responsible for typographical or graphical errors that may appear in this document.

© 2020 Autodesk, Inc. All rights reserved.



**No promises made  
Like water all things may change  
No purchase decide**





40%



25%



30%

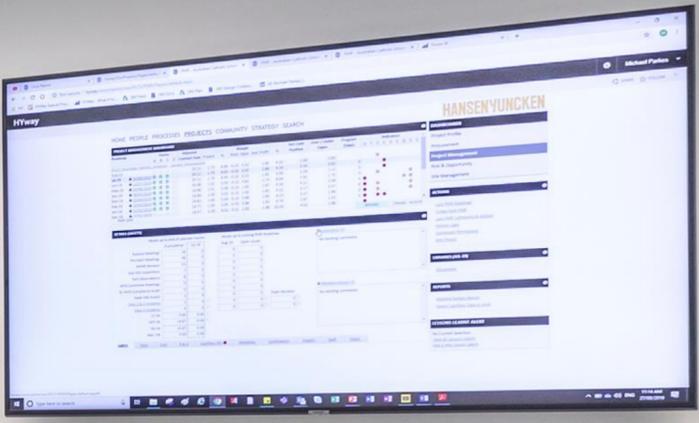
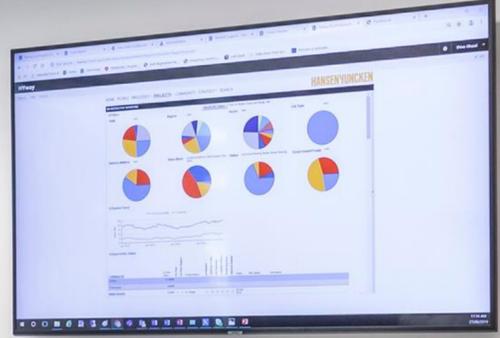
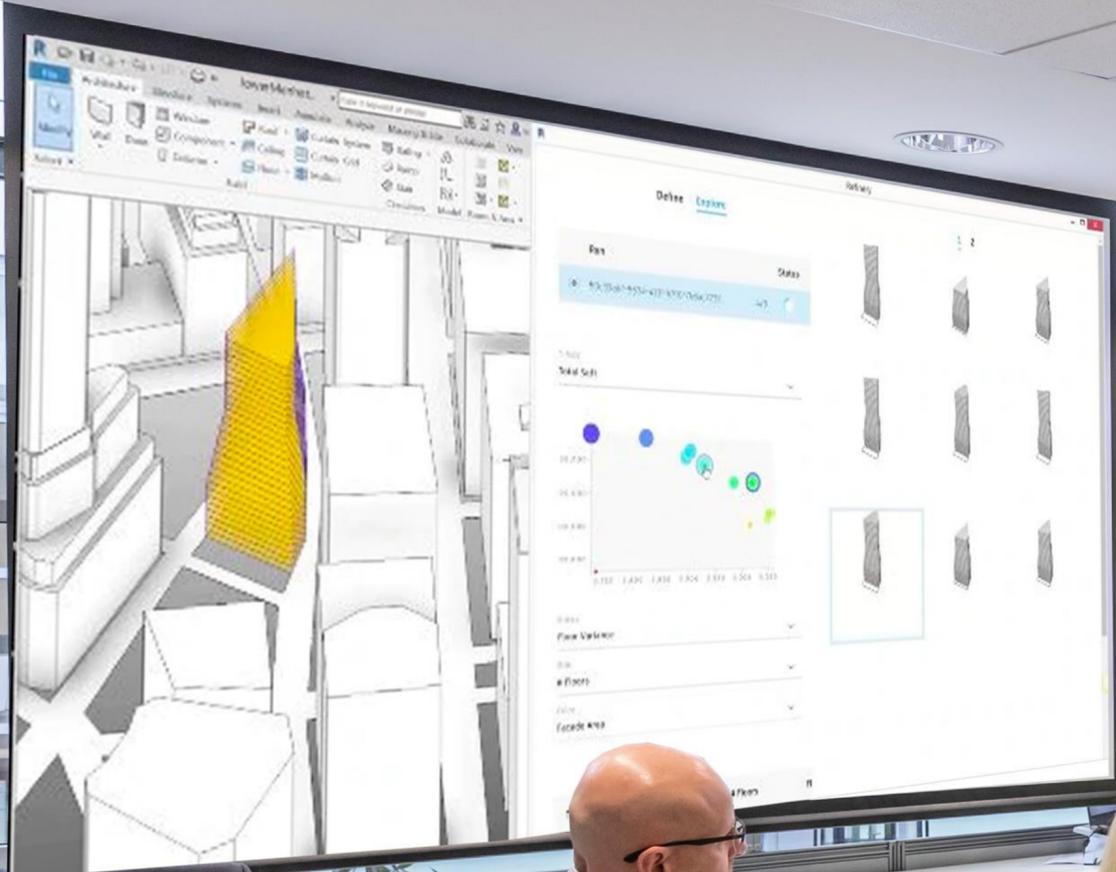


General Motors Technical Center in Warren Michigan.



**AutoCAD Release 1 - A major impact on CAD industry**





A man with glasses and a light blue shirt is seated on a grey stool, looking towards the large curved wall-mounted screen.

A woman with long blonde hair, wearing a black jacket, is seated on a grey stool, looking towards the large curved wall-mounted screen.

A man with glasses and a beard, wearing a maroon blazer, is seated at a white desk with a laptop, looking towards the large curved wall-mounted screen.

A man with glasses and a light blue shirt is standing, gesturing with his hands towards the large curved wall-mounted screen.



# GENERATIVE DESIGN FOR ARCHITECTURE, ENGINEERING & CONSTRUCTION

Generative design is a definitive shift in conceptualizing, designing, and building. Discover how design automation and design optimization deliver a new freedom and possibilities.

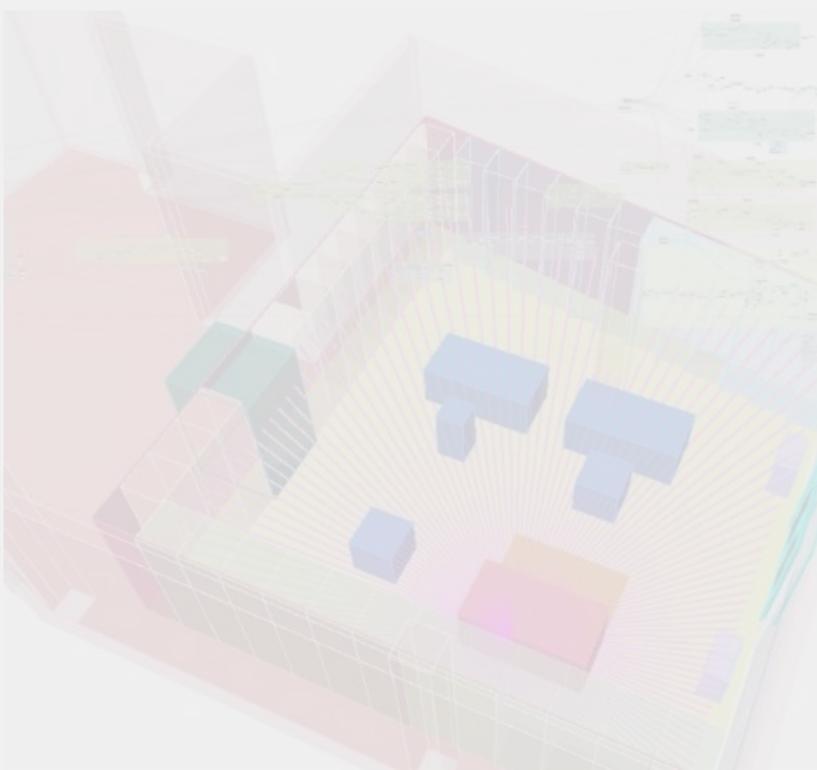
[GENERATIVE DESIGN IN REVIT](#)



# Use cases

# What's new?

# What's next?



Create Study

Select a study type

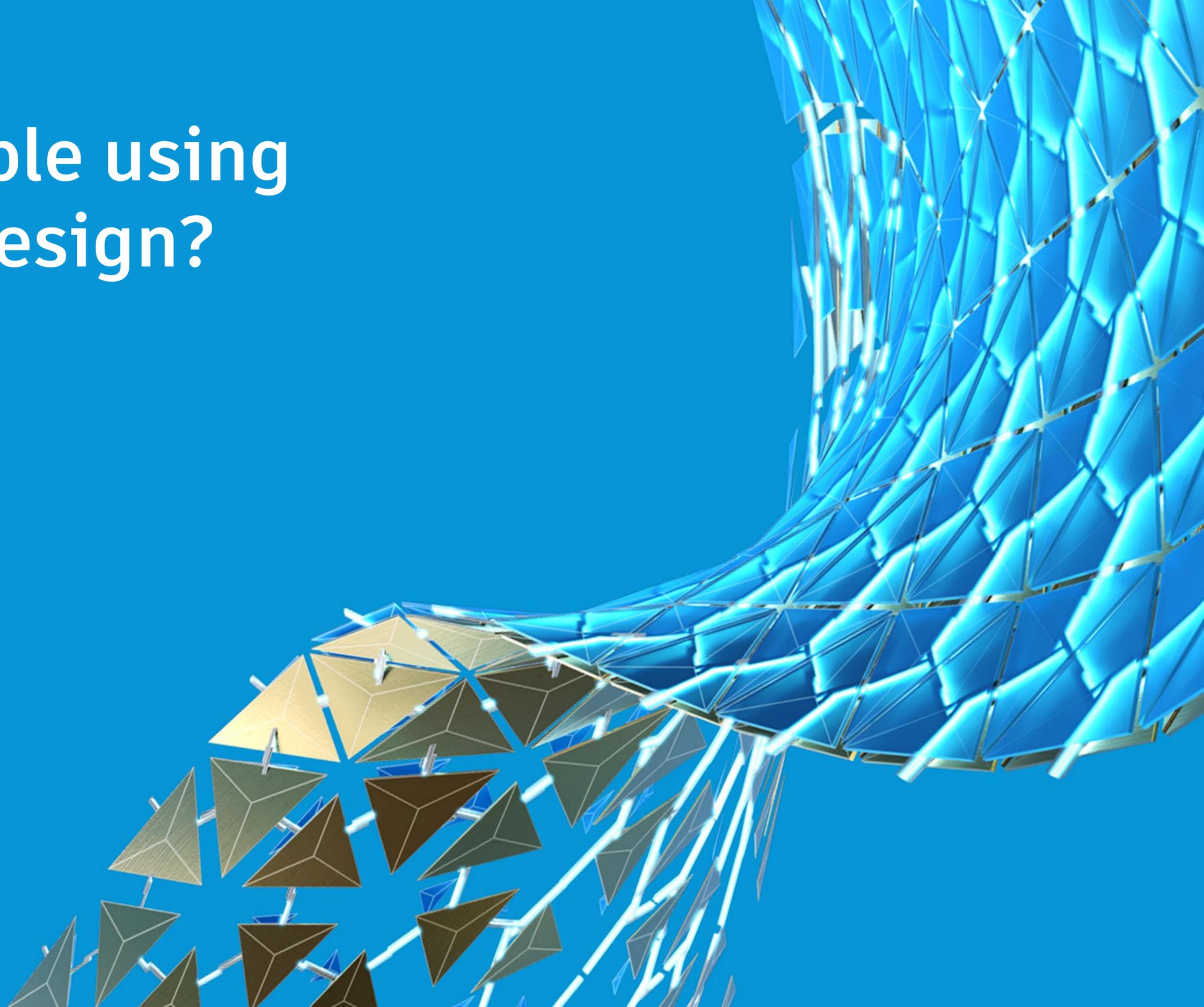
- Grid Object Placement**  
Places elements in a regular grid pattern inside a room.
- Maximize Window Views**  
Generates various viewpoints. Calculates sizes that present the greatest view to the outside in those points.
- Randomize Object Placement**  
Creates clusters of elements inside a selected room.
- Stepped Grid Object Placement**  
Places elements in a stepped grid pattern inside a room.
- Three Box Massing**  
Generates simple massing models by varying the heights and relative positions of three boxes. Calculates facade area and floor area.
- Workspace Layout**  
Generates rows of desks in a room, considering doors, windows, and columns. Calculates distance to exits, views to outside, and more.

How do I add study types? Cancel

How do I define a study? Cancel Generate

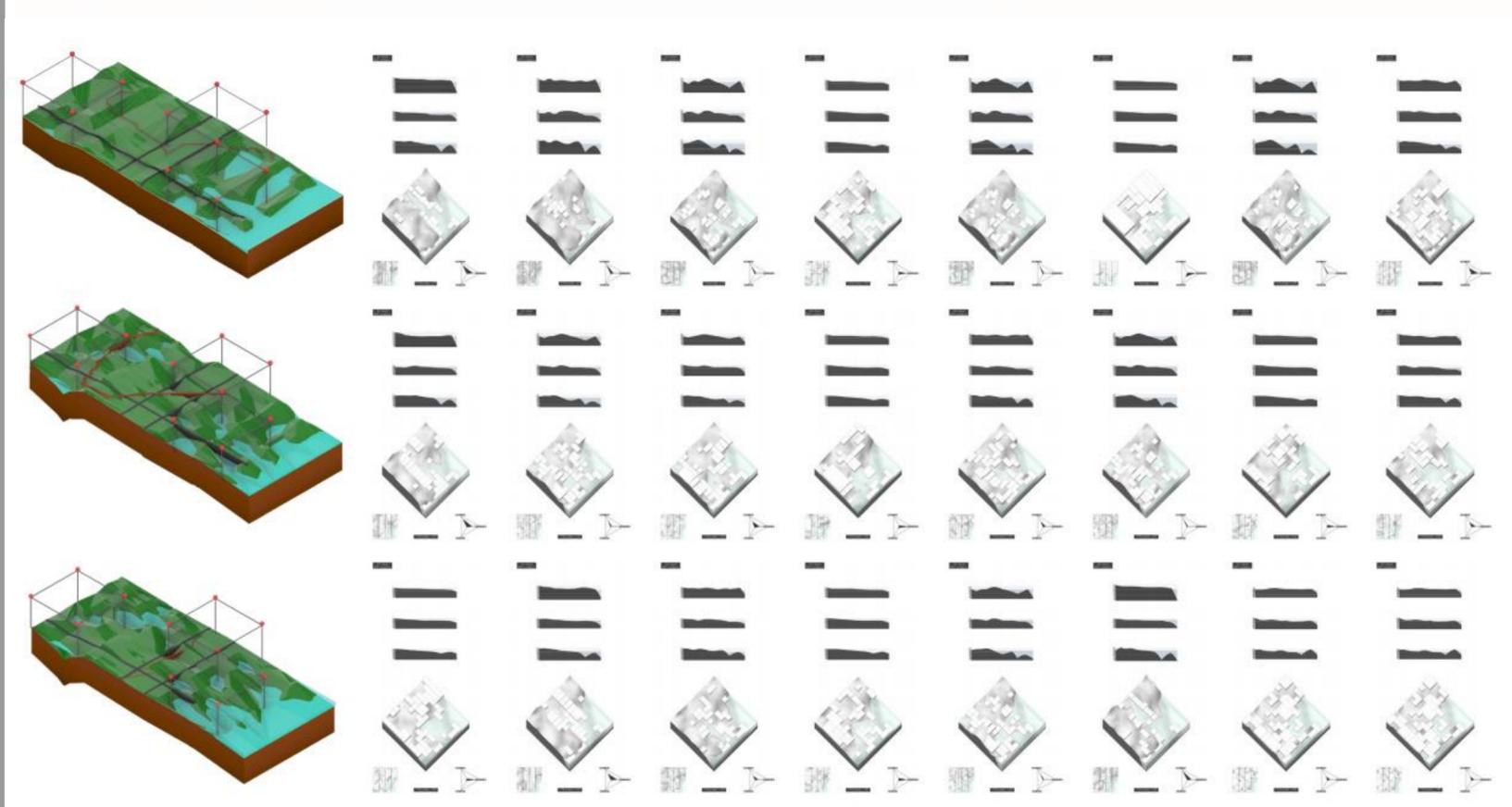


# How are people using Generative Design?



# University of Toronto Coastal Resilience

How can we plan for growing coastal communities in the face of rising coastal flooding incidents?



## Land Value

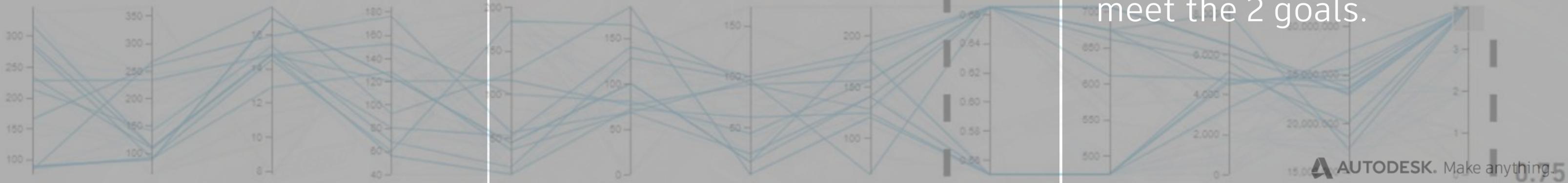
How can we get the most value out of the available land?

## Flood Risk

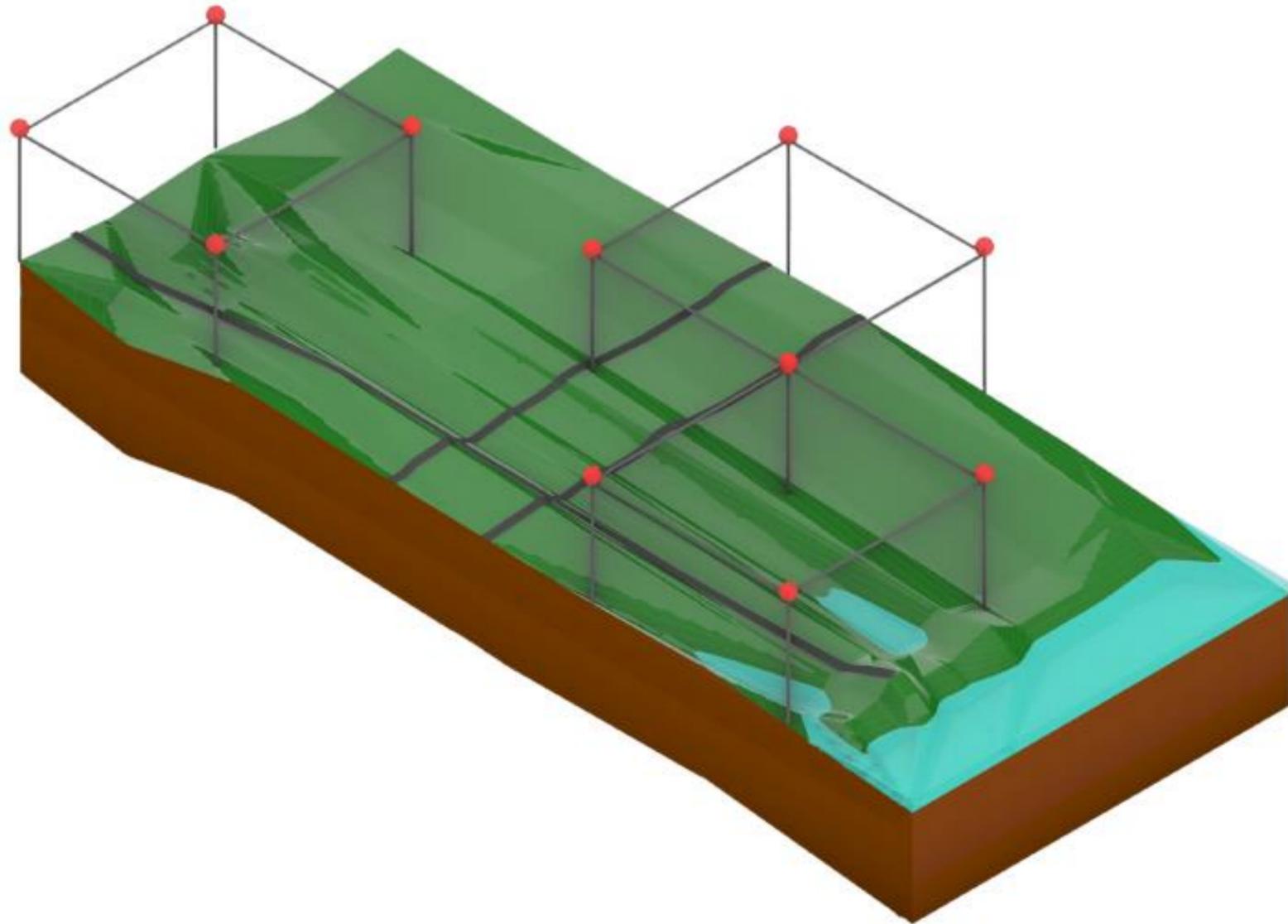
As floods become more common, how can we minimize flood risk?

## 7 Metrics

Defined to perform automated design exploration on how to best meet the 2 goals.



# University of Toronto: Coastal Resilience



How should the urban and physical landscape evolve in response to rising sea levels?

How can we leverage big data to generate resilient architectural typologies?

# Phase 1: Defining Design Goals

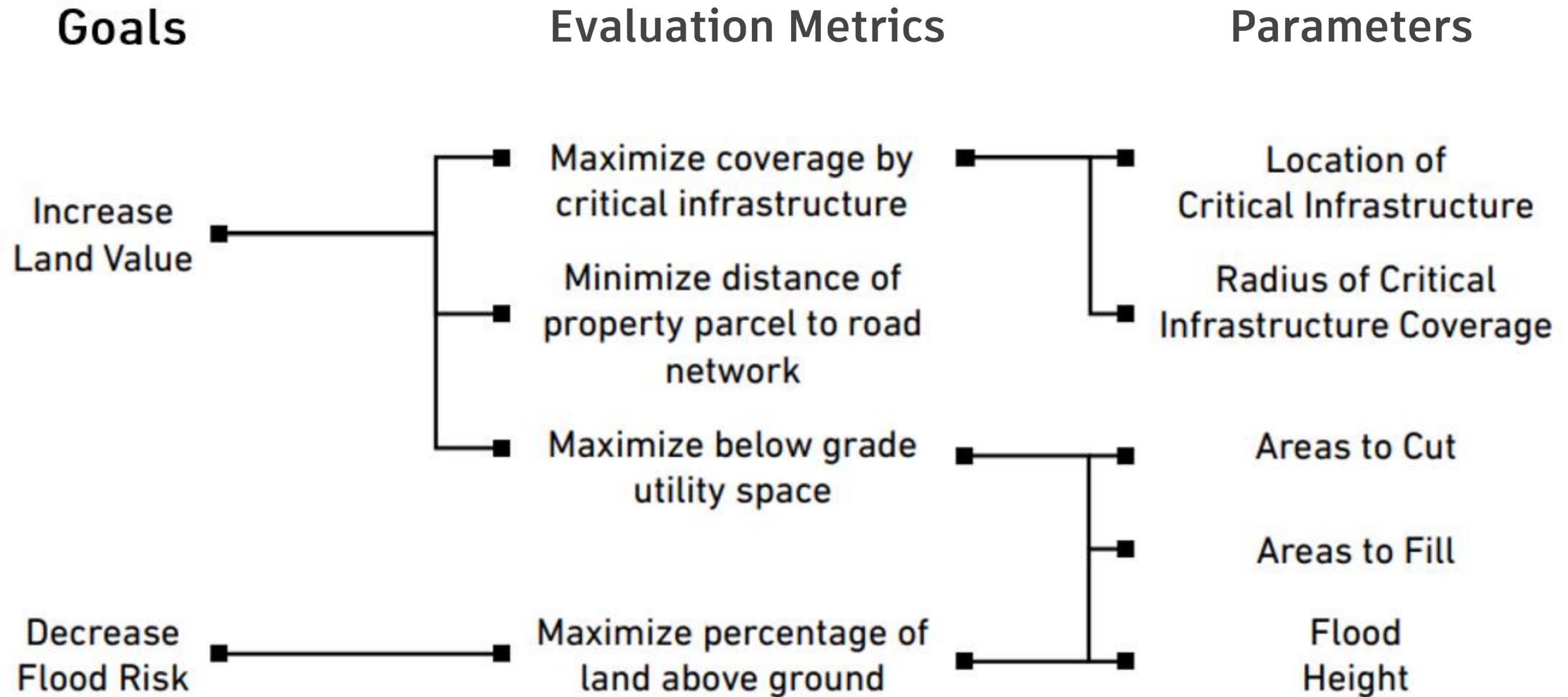
## Flood Risk ↓

As floods become more common, how can we minimize flood risk?

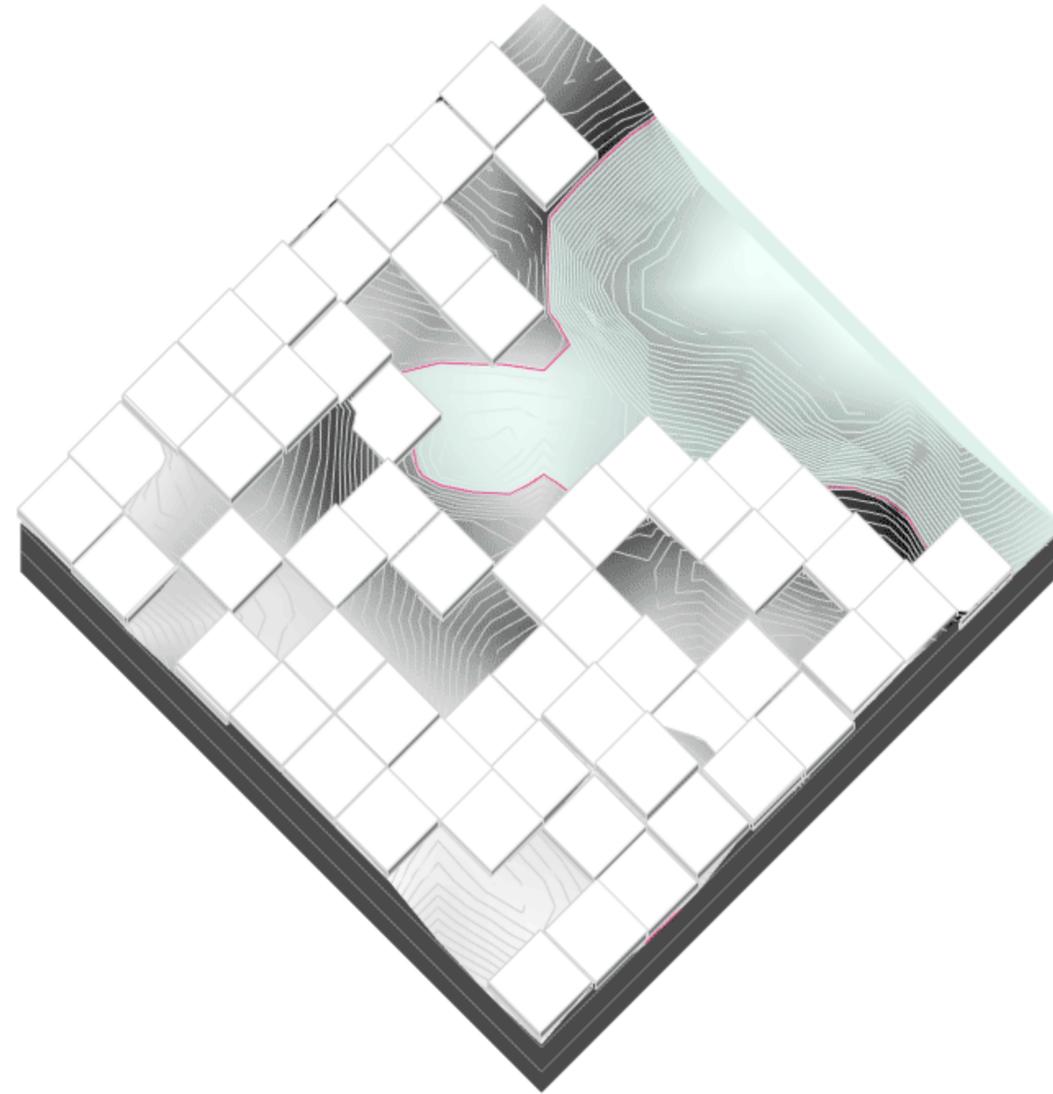
## Land Value ↑

How can we get the most value out of the available land?

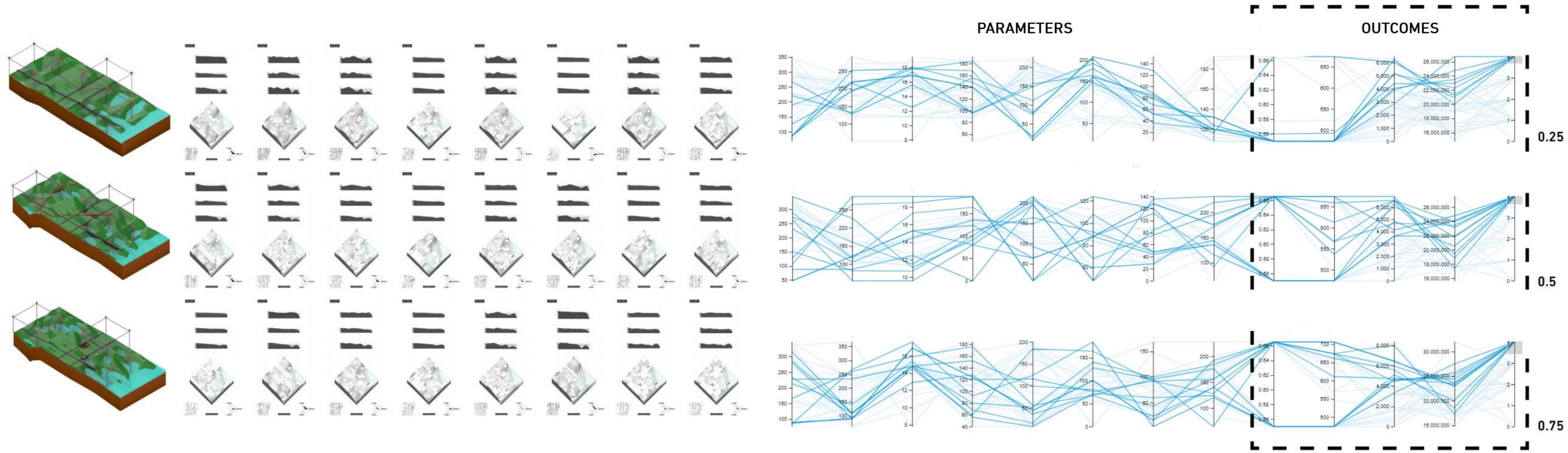
# Phase 2: Defining Evaluation Metrics



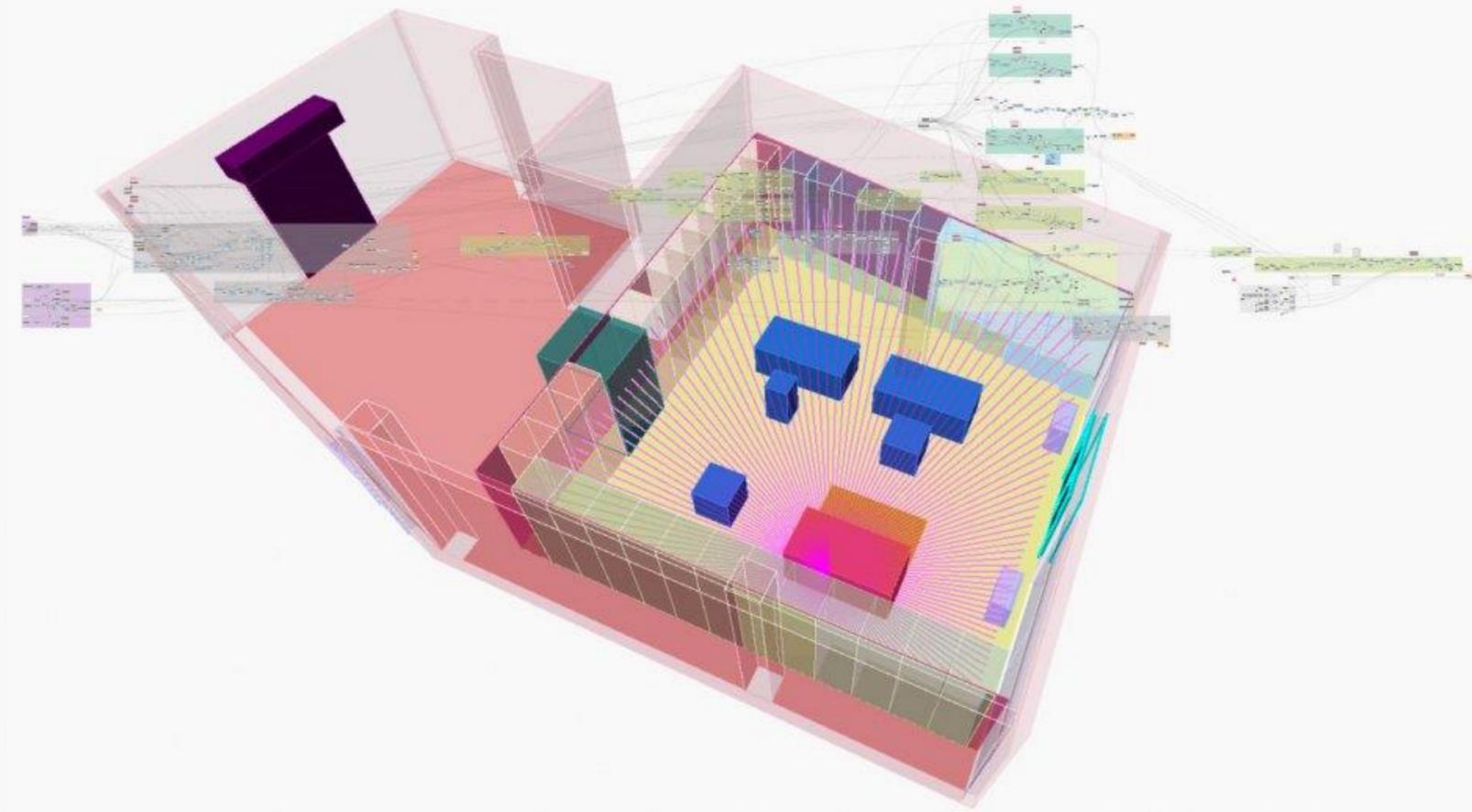
# Phase 3: Optioneering, Optimization and Curation



# Phase 3: Optioneering, Optimization and Curation



# Stamhuis Designs Entire Store in Minutes



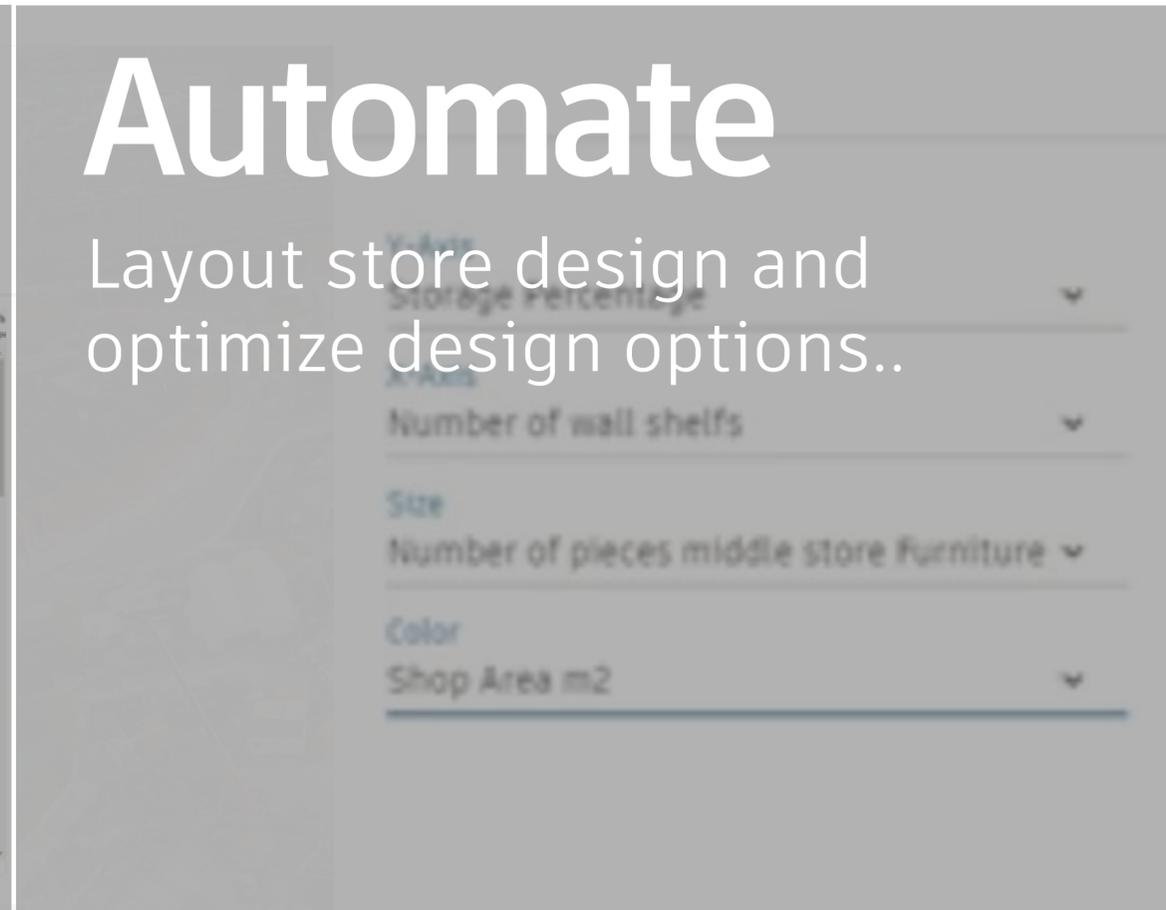
## 4 hours

The traditional design process took 4 hours for a typical design of one standard layout.

Shop Area m2	Storage Area m2	Total Area m2	Storage Percentage	Number of wall shelves	Number of pieces middle store furniture	Shop depth	Shop width	Storage width	Number of shelves
90.0	19.0	109.0	18%	37.0	14.0	10200.0	8800.533	5125.451	
85.0	22.0	107.0	21%	35.0	10.0	9702.280	8798.683	5091.061	
83.0	25.0	108.0	23%	35.0	6.0	10086.360	7251.801	5951.307	
81.0	18.0	99.0	19%	34.0	13.0	9512.401	8720.160	5486.651	
85.0	22.0	107.0	21%	35.0	13.0	8773.587	8679.479	5362.339	
78.0	18.0	97.0	19%	34.0	14.0	10013.848	7807.858	4875.541	
82.0	18.0	100.0	18%	34.0	14.0	10069.901	8187.075	4759.616	
79.0	20.0	100.0	20%	34.0	14.0	10053.586	7892.965	5125.918	
77.0	18.0	96.0	19%	33.0	10.0	10063.204	7576.346	4722.135	
79.0	21.0	100.0	21%	33.0	14.0	10041.460	7904.304	5296.406	
71.0	18.0	89.0	20%	33.0	7.0	9999.292	7105.492	4433.299	

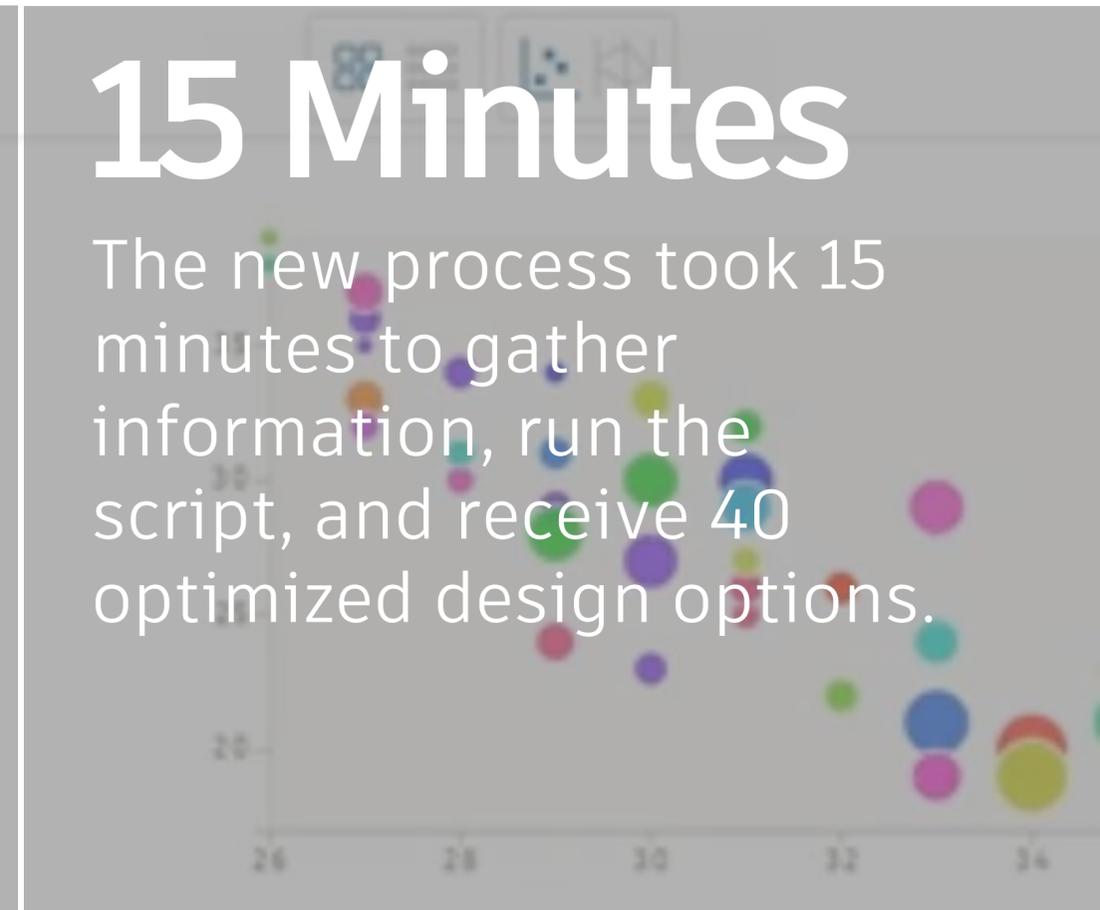
## Automate

Layout store design and optimize design options..

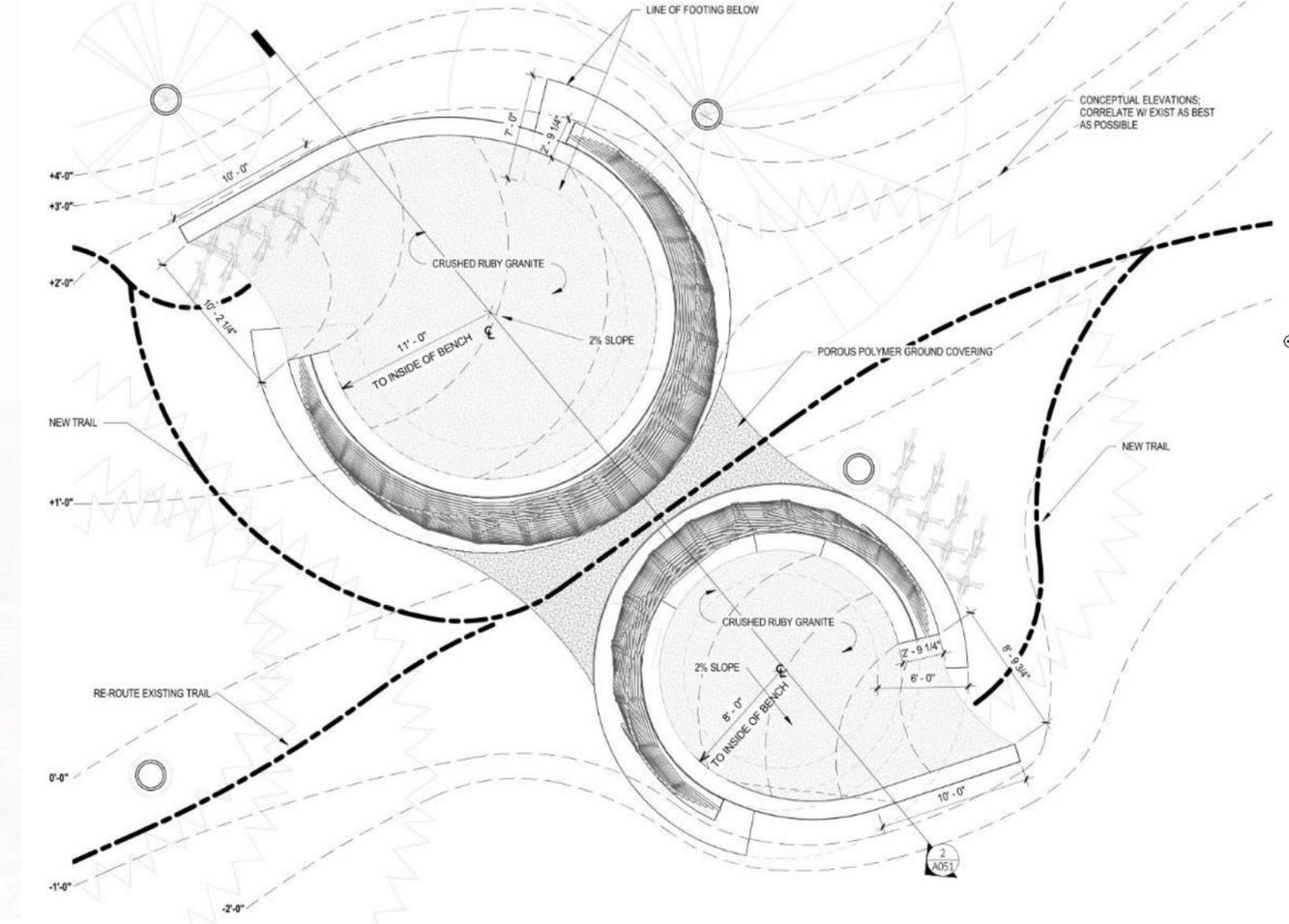


## 15 Minutes

The new process took 15 minutes to gather information, run the script, and receive 40 optimized design options.



# Hufft Hobbs Trail Structure



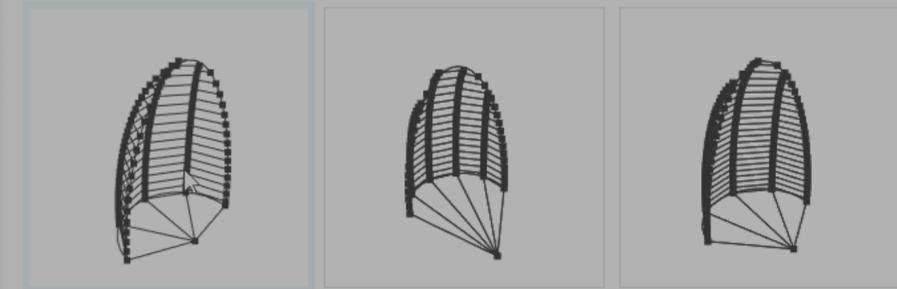
## 5 Metrics

Including efficiency of components, reduction of waste, and cost guided the design.



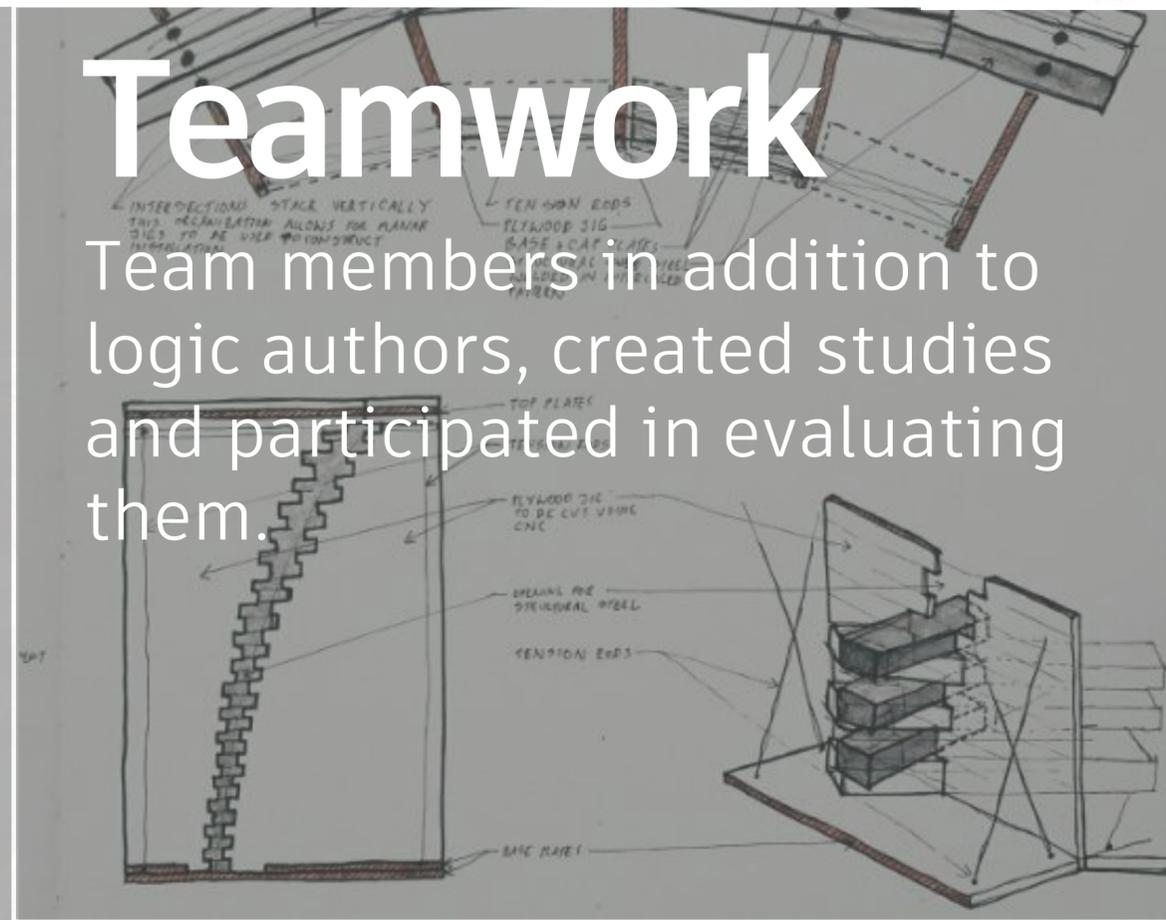
Sort by member count

1 | 2



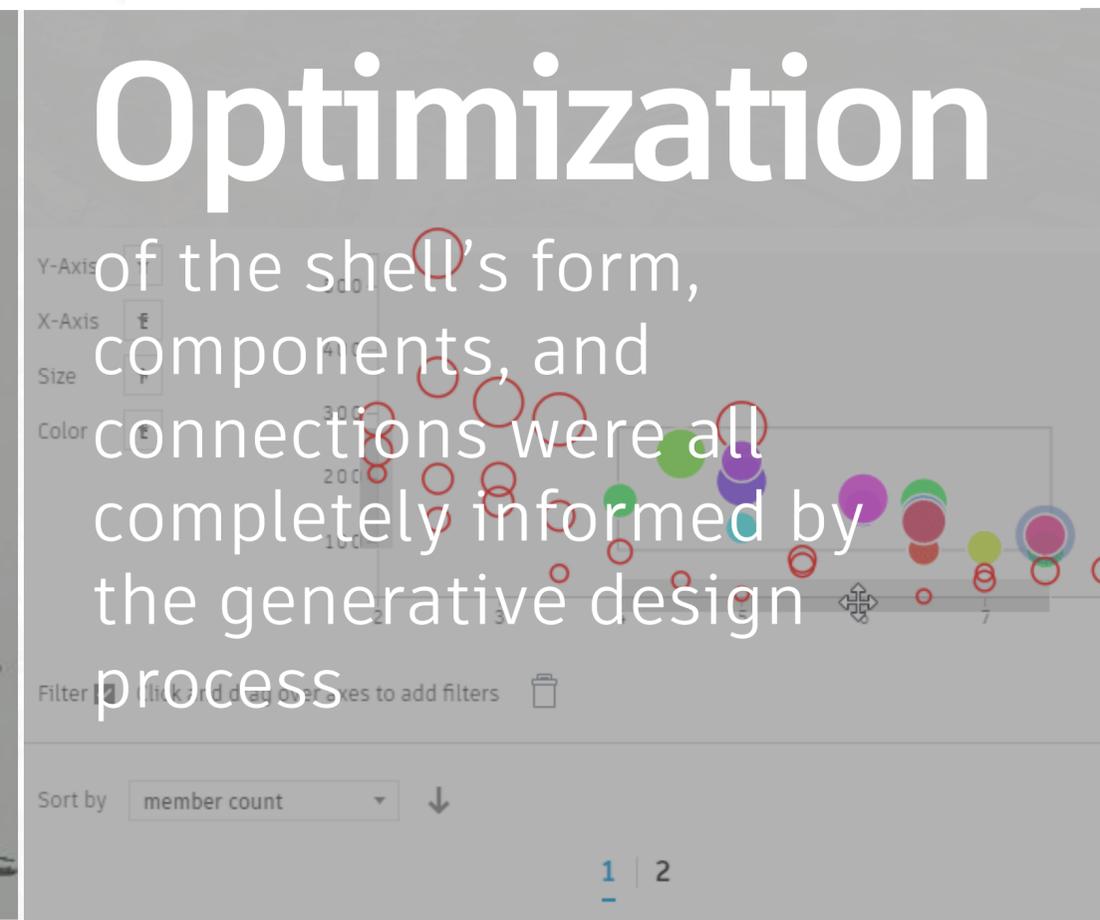
## Teamwork

Team members in addition to logic authors, created studies and participated in evaluating them.



## Optimization

of the shell's form, components, and connections were all completely informed by the generative design process



Sort by member count

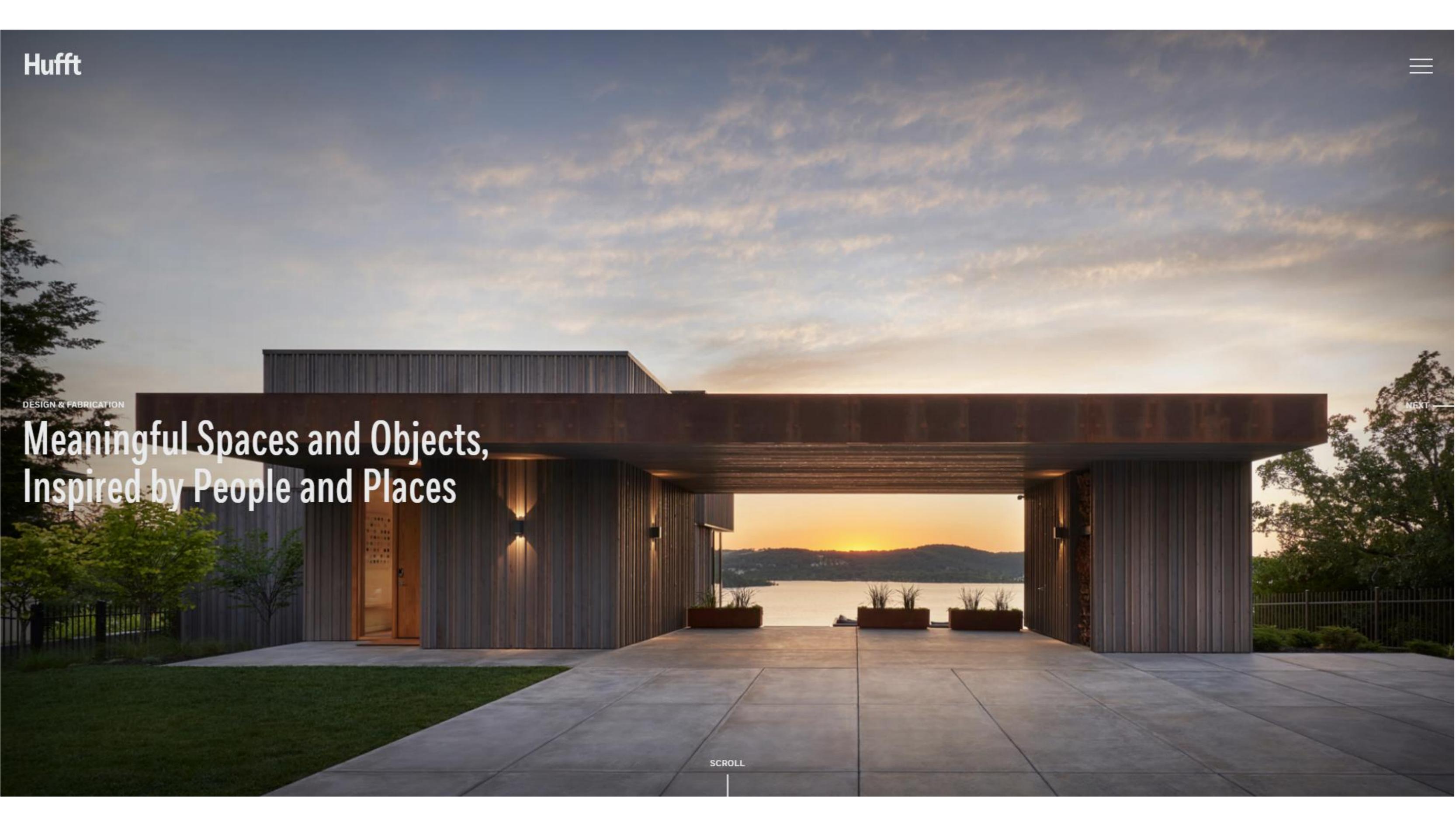
1 | 2

DESIGN & FABRICATION

NEXT

# Meaningful Spaces and Objects, Inspired by People and Places

SCROLL





# HOBBS STATE PARK-CONSERVATION AREA



Mountain biking at Hobbs State Park-Conservation Area...



## What to know

Hobbs is Arkansas's largest state park, spanning a 12,054-acre tract of Ozark landscape along the southern shore of Beaver Lake. It's an asset to the ecosystem and water with minimum human impact.

Highlights of this day-use park include a diverse, 52-mile trail system with hiking, ADA, mountain biking, and horseback riding trails, and 5 primitive campsites. It's the only state park in Arkansas to allow regulated hunting. The visitor center includes exhibits about the park's natural resources, limestone landscape, and history. Interpretive programs and workshops are offered

20201 East H  
Rogers, AR 72

GET DIRE

CALL THE PA  
479-789-500

EMAIL >

HOURS +

DIGITAL DISC

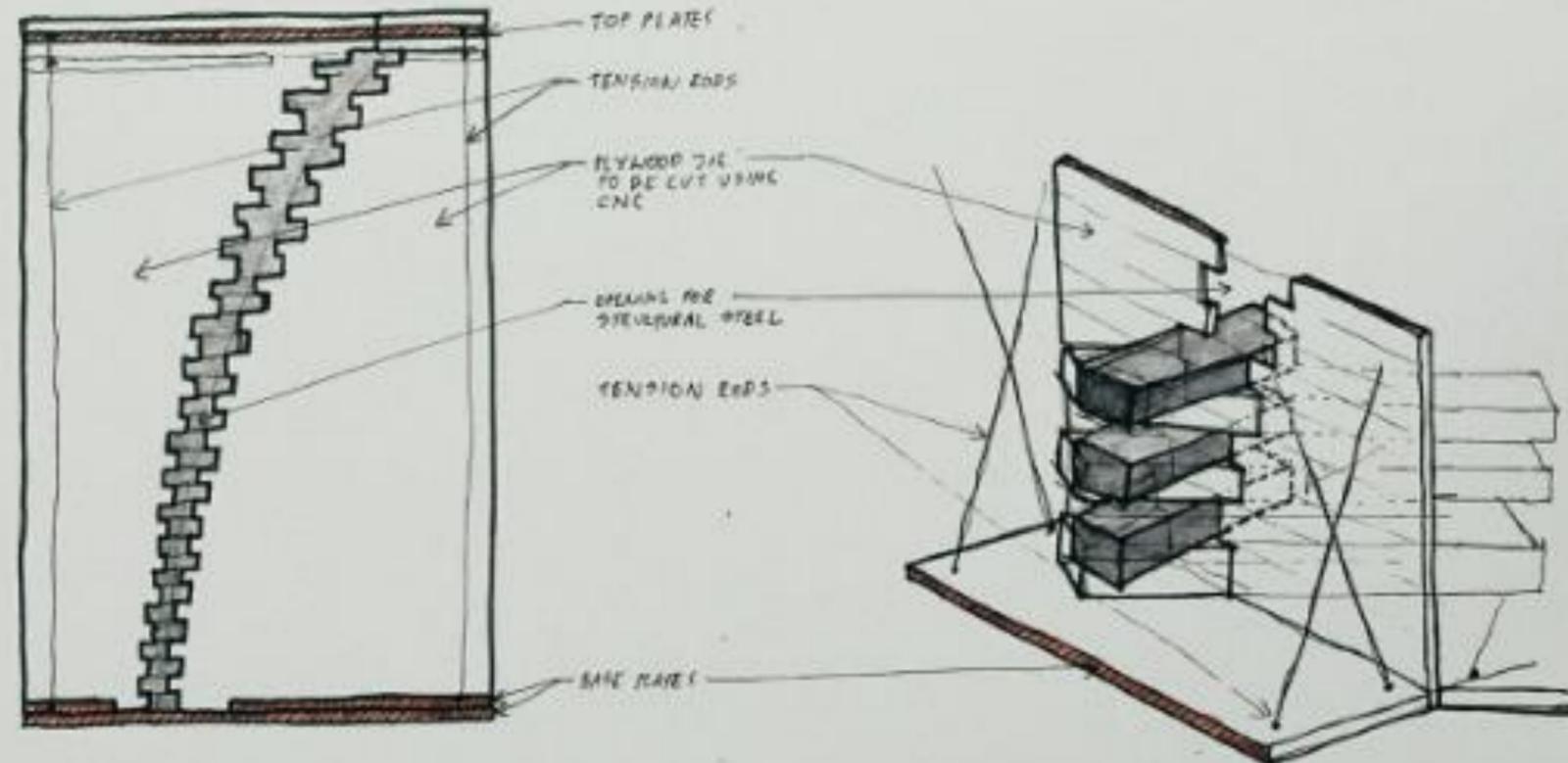
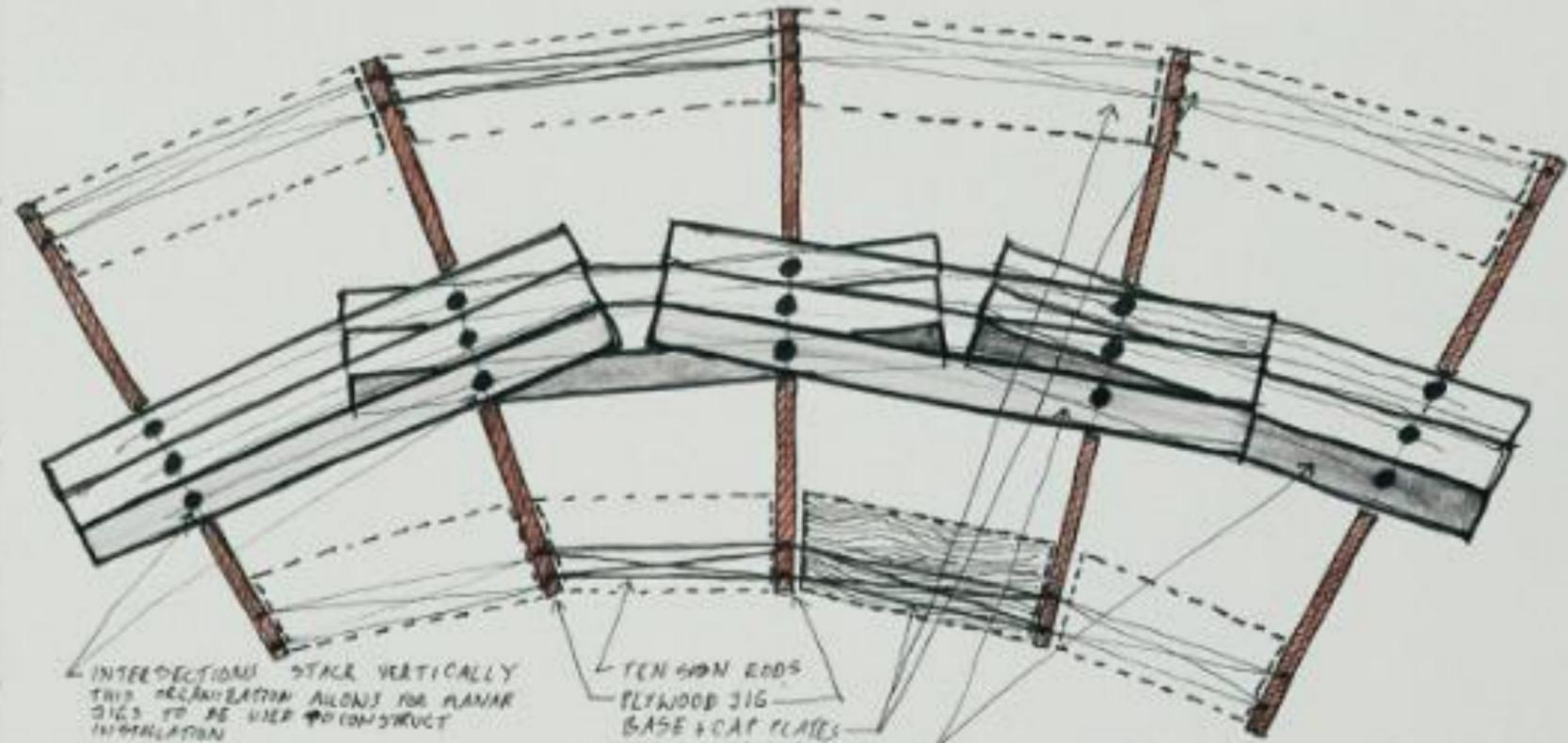
EVENTS +

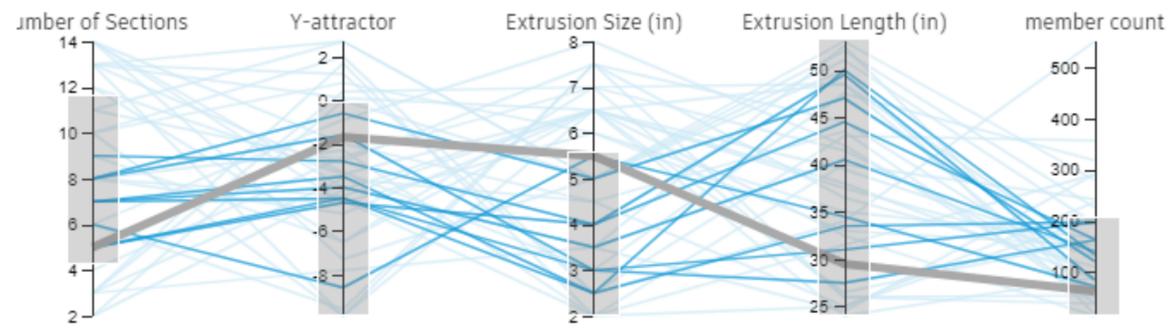
TRAILS +

BROCHURES

NEARBY ACC

NEARBY ATT

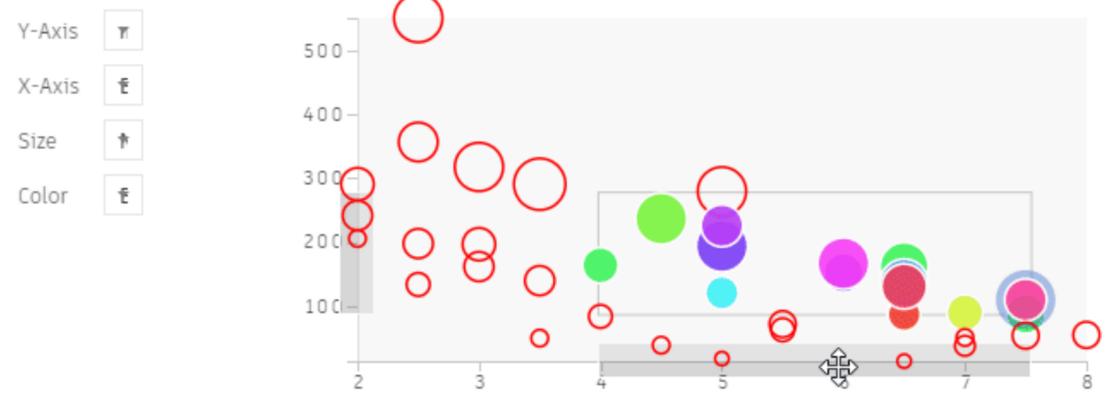
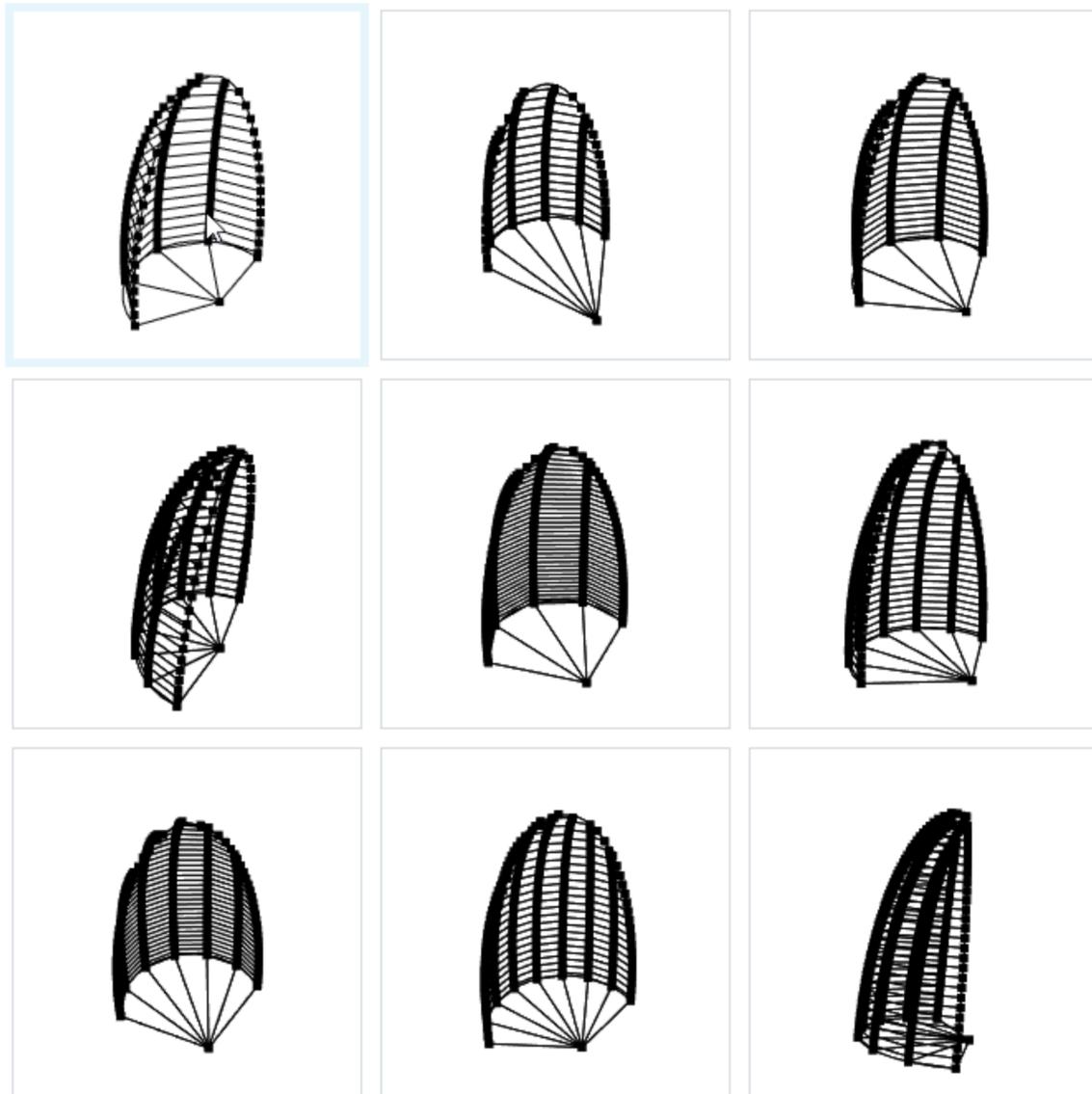




Filter  Click and drag over axes to add filters

Sort by member count  ↓

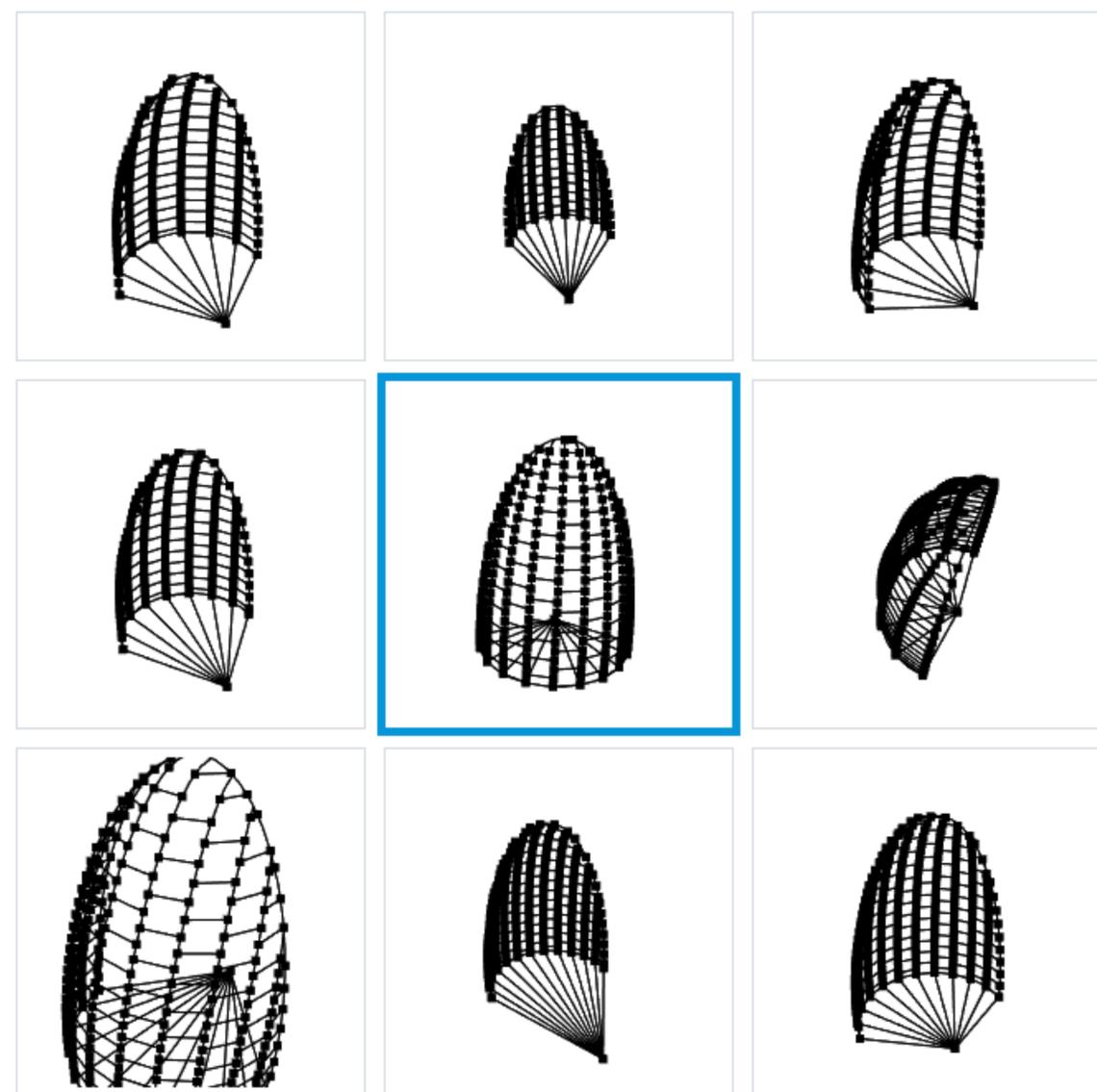
1 | 2

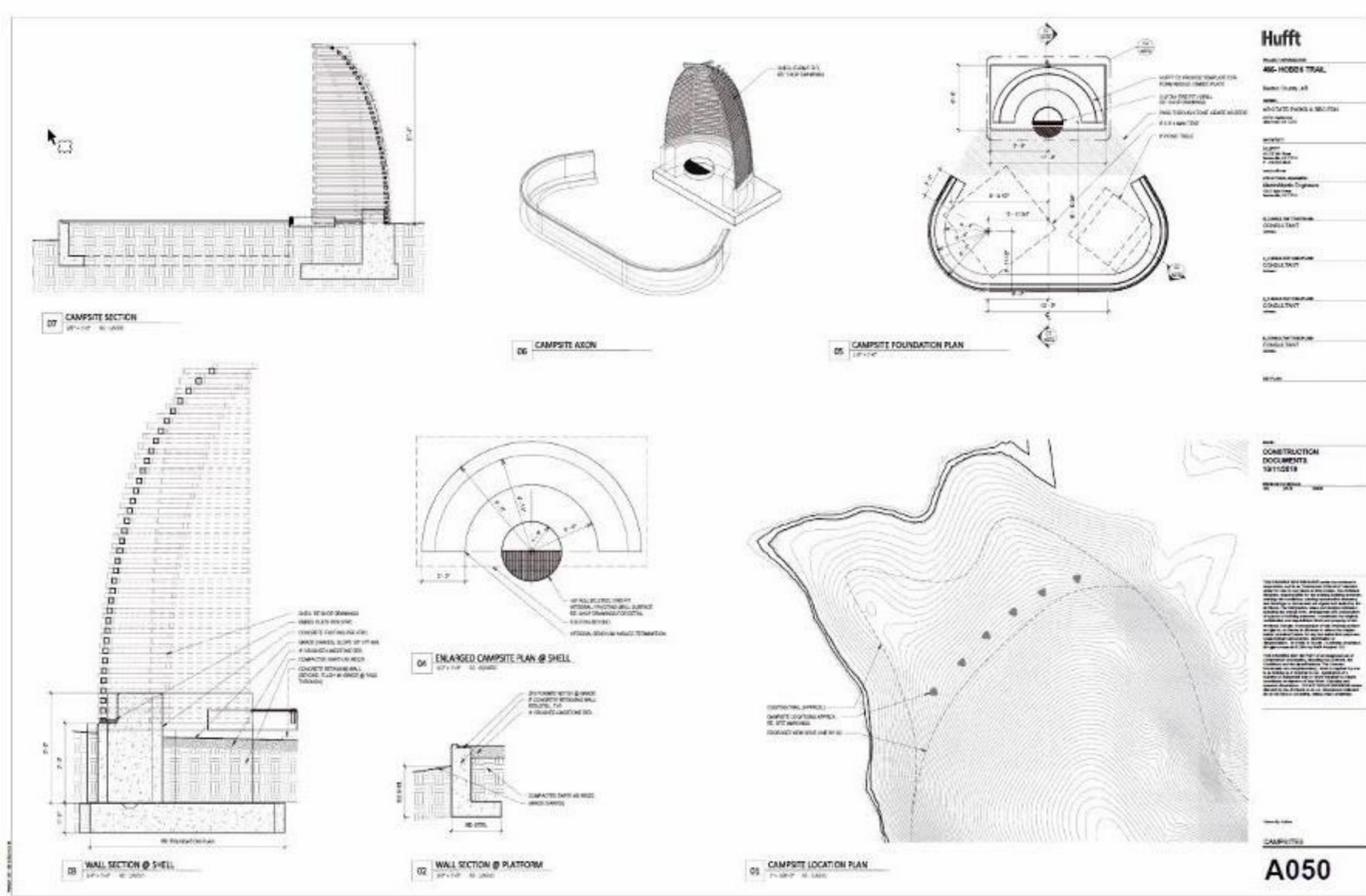


Filter  Click and drag over axes to add filters

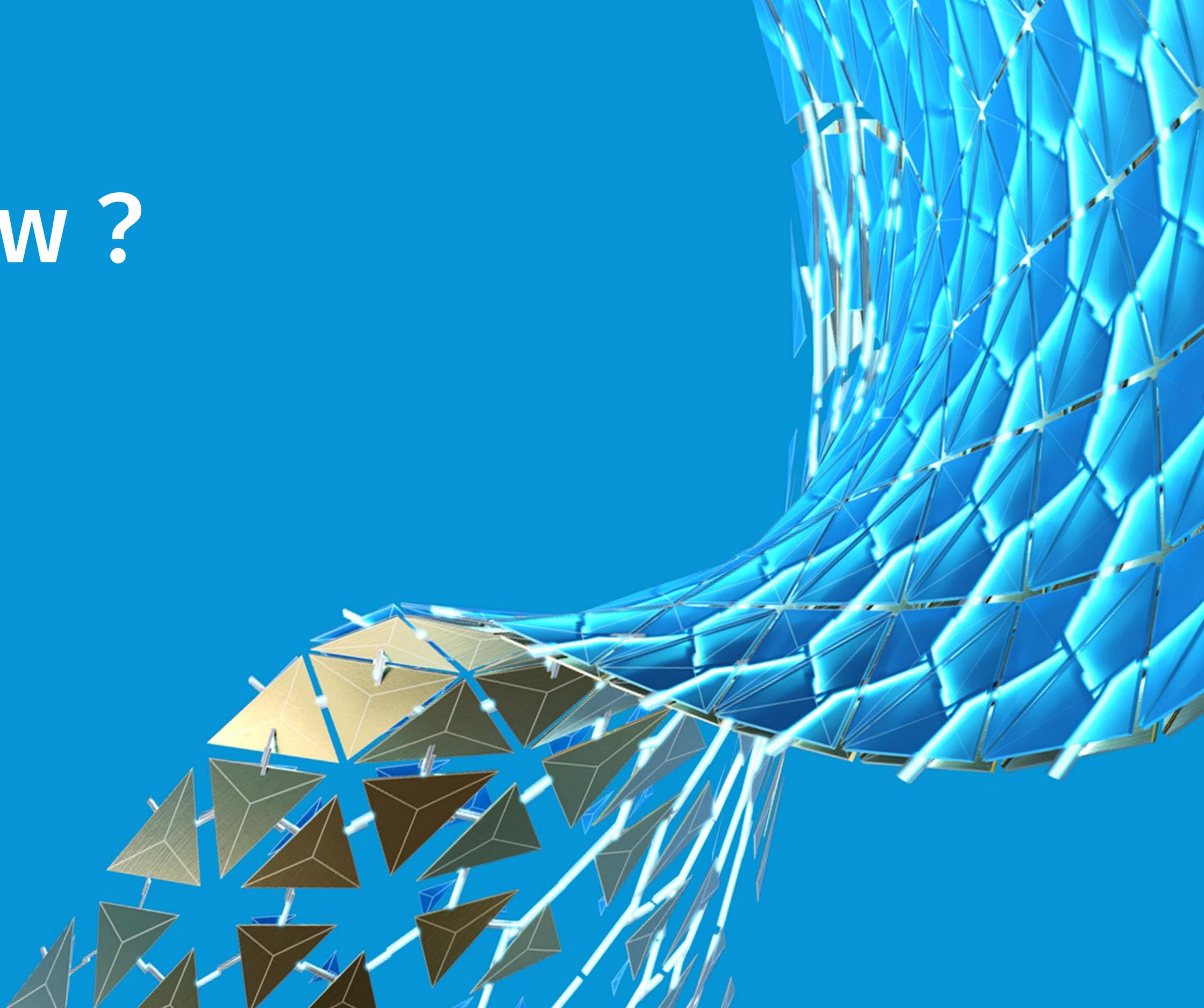
Sort by member count  ↓

1 | 2





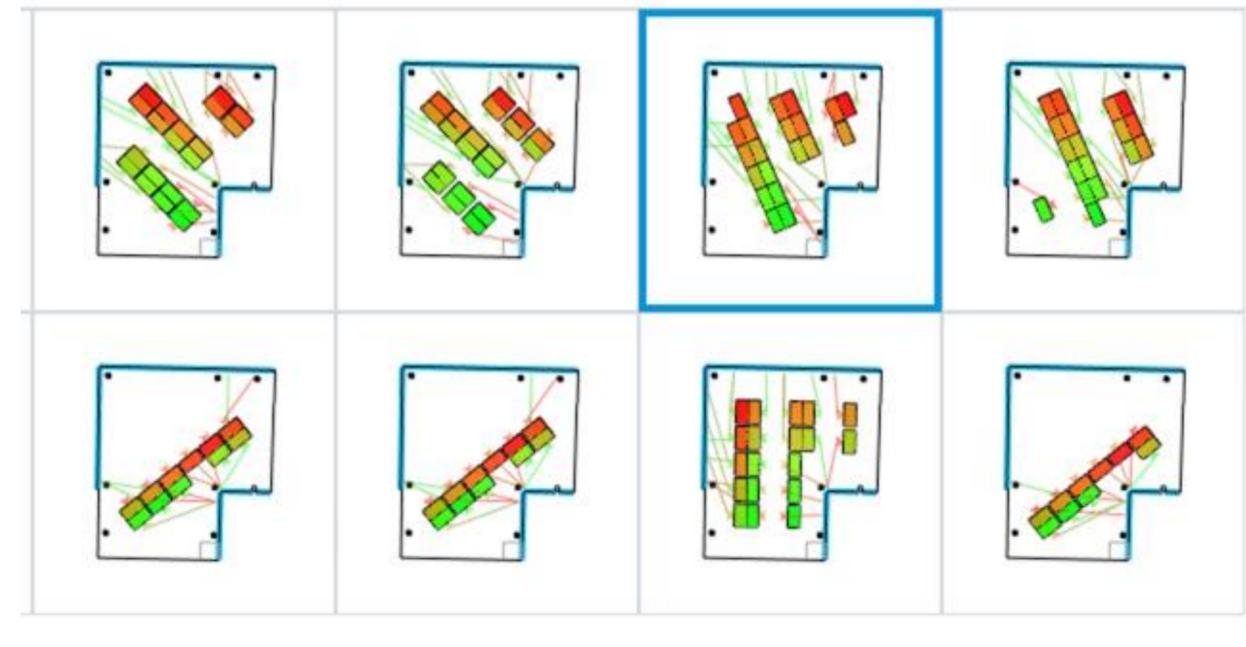
What's new ?



New!

# Generative Design in Revit 2021

“As an Architect who uses Revit, but is not a skilled computational designer, I want to perform generative studies so that I can evaluate better performing design options.”



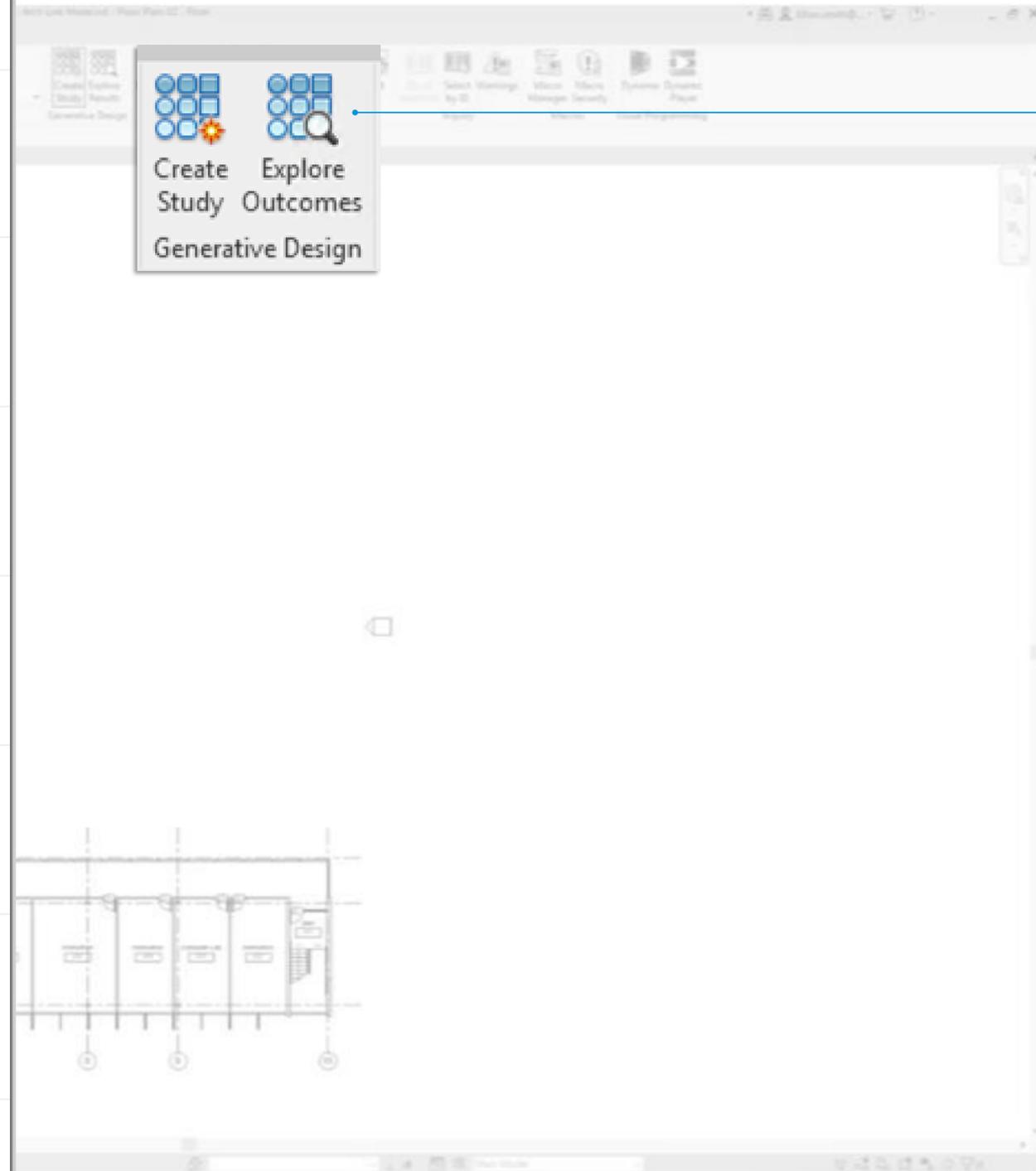
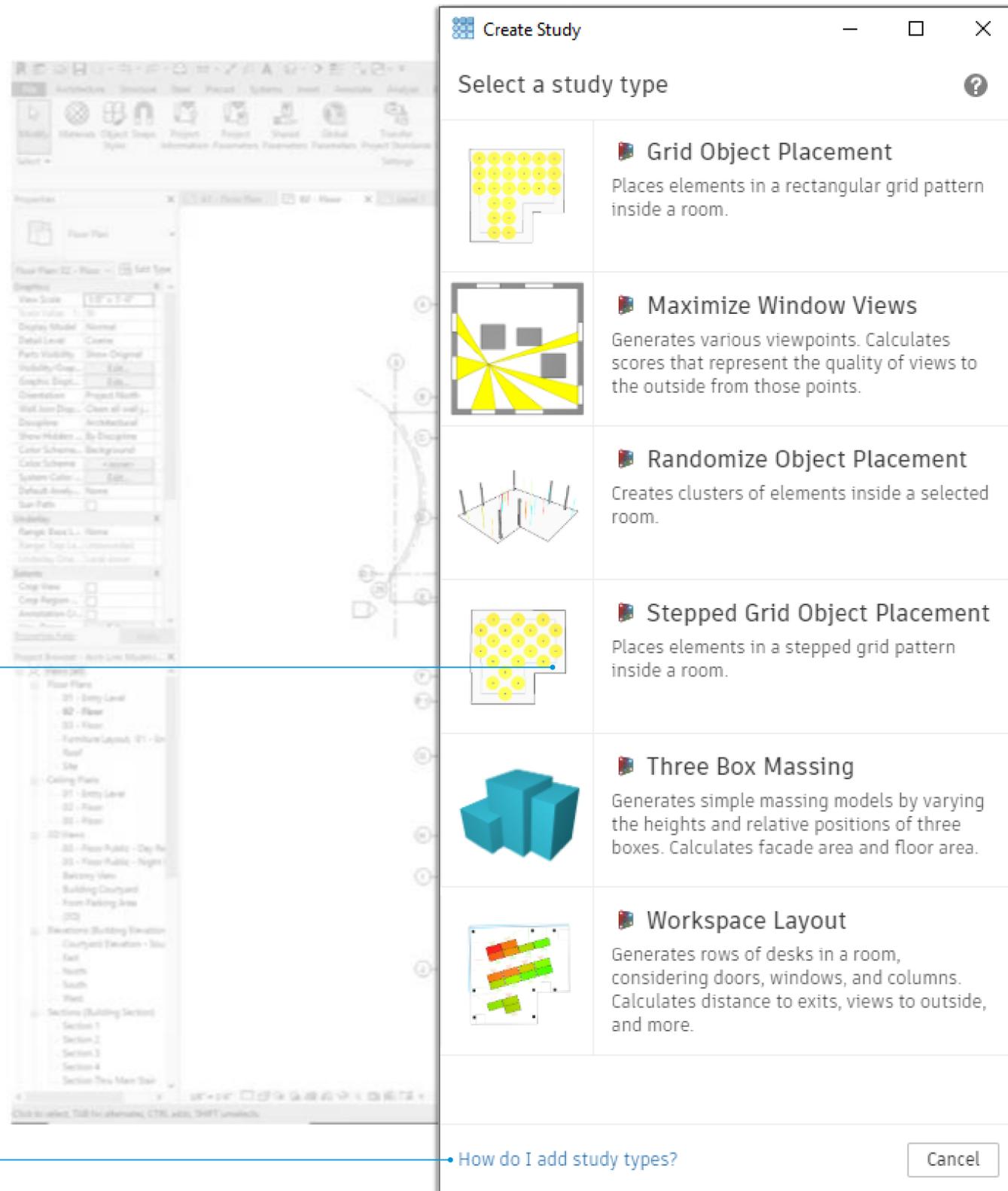
“It will be a huge time saver to generate and evaluate options so quickly”

AU Idea Exchange Participant

“This will automate repetitive work and create better designs”

AU Idea Exchange Participant

# Generative Design for Revit – Create Study



Create and explore generative studies directly from Revit

Learn from included sample content

Create custom studies

# Generative Design for Revit – Define Study

Save Default Values

Create and Explore generative studies directly from Revit

Generate design options

Select Revit elements to use in study

Set design goals

Define Study

Workspace Layout

Study Name: Works Save Default Settings

Method: Optimize

Select in model

Select a room (Element : 281513)  Select

Select desk family instance (Element : 281519)  Select

Choose variables

Desk row rotation -90 to 90

Spacing between rows (ft.) 10 to 16

Set goals

Average distance to exits  Minimize  Maximize

Views to outside  Minimize  Maximize

Number of desks  Minimize  Maximize

Set constraints

Average distance to exits Min  Max

Views to outside Min  Max

Number of desks Min  Max

Generation Settings

How do I define a study? Cancel Generate

# Generative Design for Revit - Explore Outcomes

**Workspace Layout 003**

Sort by: Number of desks

Details

Outputs	
Average distance to exits	16.545
Views to outside	0.547
Number of desks	22.0

Inputs	
Desk row rotation	0
Spacing between rows (ft.)	12

10 of 10

Create Revit Elements

Explore outcomes

Evaluate goals

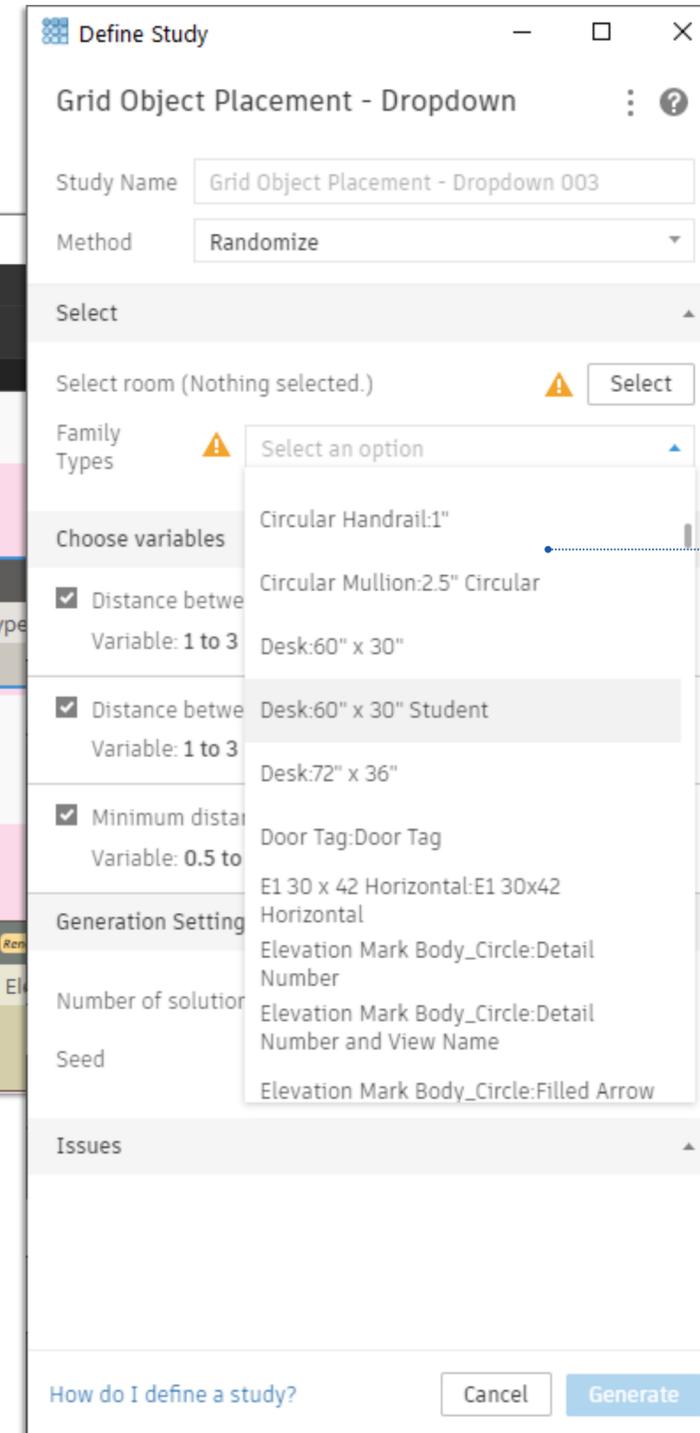
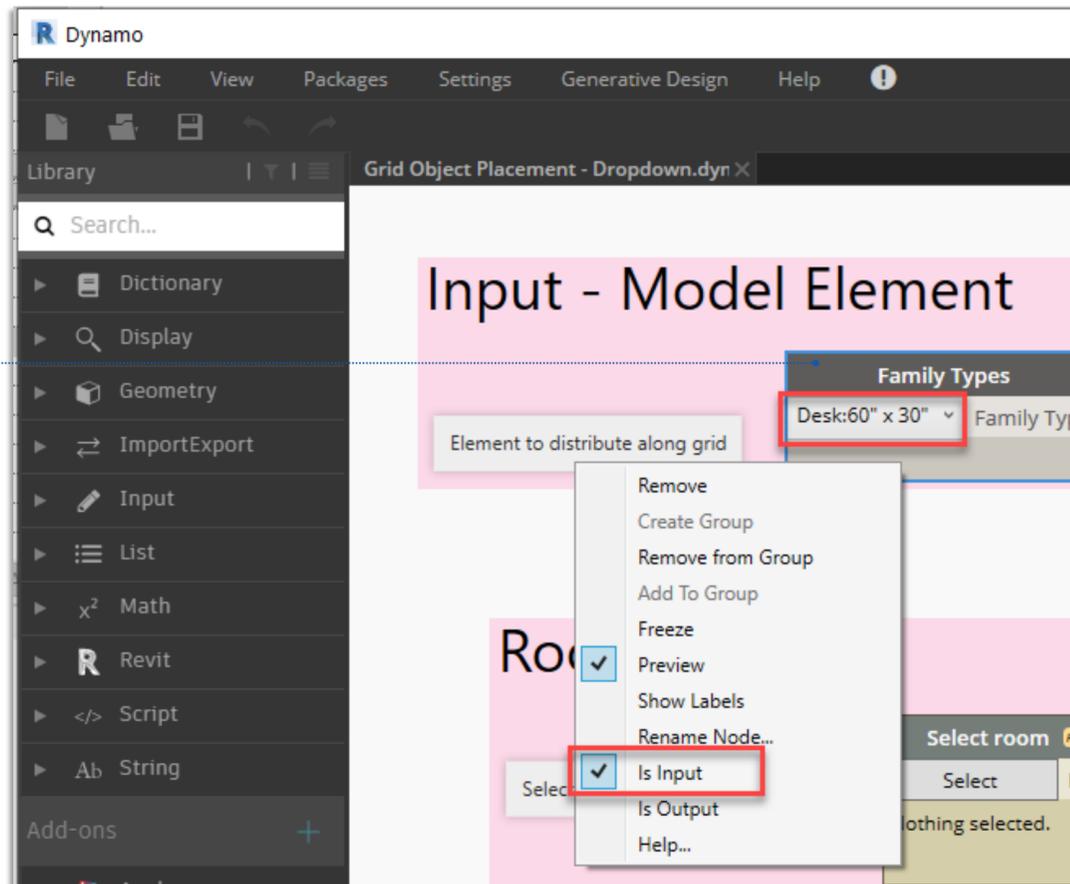
Create Revit elements

Track studies

Filter and rank results

# Drop-down inputs

Drop-down nodes can be set as “Is Input”



Drop-down input list for selection similar to Dynamo Player

# Clear settings for constant and variable inputs

Variables  
labelled

Unchecking box  
changes label to  
“constant”

Define Study

Three Box Massing (Boolean)

Study Name: Three Box Massing (Boolean) 001

Method: Optimize

Choose variables

- Box 3 height  
Variable: 20 to 200
- Box 3 position Y  
Variable: 20 to 70
- Box 3 position X  
Variable: 20 to 70
- Box 2 height  
Variable: 20 to 200
- Box 2 position Y  
Variable: 0 to 50
- Box 2 position X  
Variable: 0 to 50
- Box 1 height  
Constant: 160
- Color Switch  
Constant: False
- Constant Boolean  
Variable: True or False

Set goals

- Floor area     Minimize  Maximize
- Surface area     Minimize  Maximize

Set constraints

- Floor area    Min  Max
- Surface area    Min  Max

How do I define a study?    Cancel    Generate

Constant value can be  
set with a slider

Boolean Value can be  
set with a toggle  
instead of a slider

# Collections and Enterprise Customer Licensing

The screenshot shows the Autodesk License Manager window. It is titled "License Manager" and has a close button in the top right corner. Below the title bar, there is a section titled "Licenses currently in use in this application". This section contains one entry: "Revit" with a blue 'R' icon, a right-pointing chevron, and the text "User License : Commercial Change license type". Below this is another section titled "Autodesk Plugins, Add-ons and Extensions". This section contains one entry: "Autodesk Revit 2021 - Generative Design" with a blue 'R' icon, a right-pointing chevron, and the text "Network License : Not For Resale Version Change license type". To the right of this entry is a button labeled "Borrow".

New Revit Generative Design license for collections and enterprise customers enables direct access from Revit

# Student Licensing Now Available

The screenshot displays the Autodesk Education website. At the top, the Autodesk logo is on the left, and navigation links for 'FREE TRIALS', 'PRODUCTS', 'SEARCH', 'SIGN IN', 'UNITED STATES', and 'MENU' are on the right. Below this is a secondary navigation bar with 'EDUCATION' and sub-links: 'Get Products', 'Learn & teach', 'Competitions & events', 'Prepare & excel', 'Support', and 'About Autodesk Education'.

The main content area features a large heading: 'Unlock educational access to Autodesk products'. Below this, a paragraph states: 'Students and educators can get free one-year educational access to Autodesk products and services, renewable as long as you remain eligible. Confirm your eligibility now.' There are two buttons: a blue 'GET STARTED' button and a video icon with the text 'How it works (3:08 min.)'. A link 'Already have educational access? Sign in' is also present.

A secondary link 'Not a student or educator? Explore our free trials' is located below the main text.

The lower section shows a search interface. On the left, there are category filters: 'All products', 'Architecture, Engineering, & Construction', 'Product Design & Manufacturing', and 'Media & Entertainment'. The search bar contains the text 'generative'. To the right of the search bar are filters for 'Installation type' (Individual, Class/Lab), 'Platform' (Windows, Apple, Linux, Android, iOS), and 'Sort by' (Featured).

The search results show a card for 'REVIT' with the title 'Revit Generative Design'. The description reads: 'Quickly generate design alternatives based on your goals, constraints, and inputs to give you higher-performing options for data-driven decision making. Note: this product requires Autodesk Revit.' A 'Get started' button is visible at the bottom of the card.

<https://www.autodesk.com/education/edu-software>

# OR all users can access Generative Design via Dynamo for Revit

The image displays the Autodesk Revit 2021 interface with the Dynamo software integrated. The Revit ribbon is visible at the top, showing various toolsets including 'Add-Ins' and 'Modify'. The Dynamo window is open, showing a complex logic graph with numerous nodes and connections. A context menu is open over the 'Generate' button, listing options: 'Export for Generative Design...', 'Create Study...', and 'Explore Outcomes...'. A small 3D model of a building floor plan is visible at the bottom of the Dynamo window.

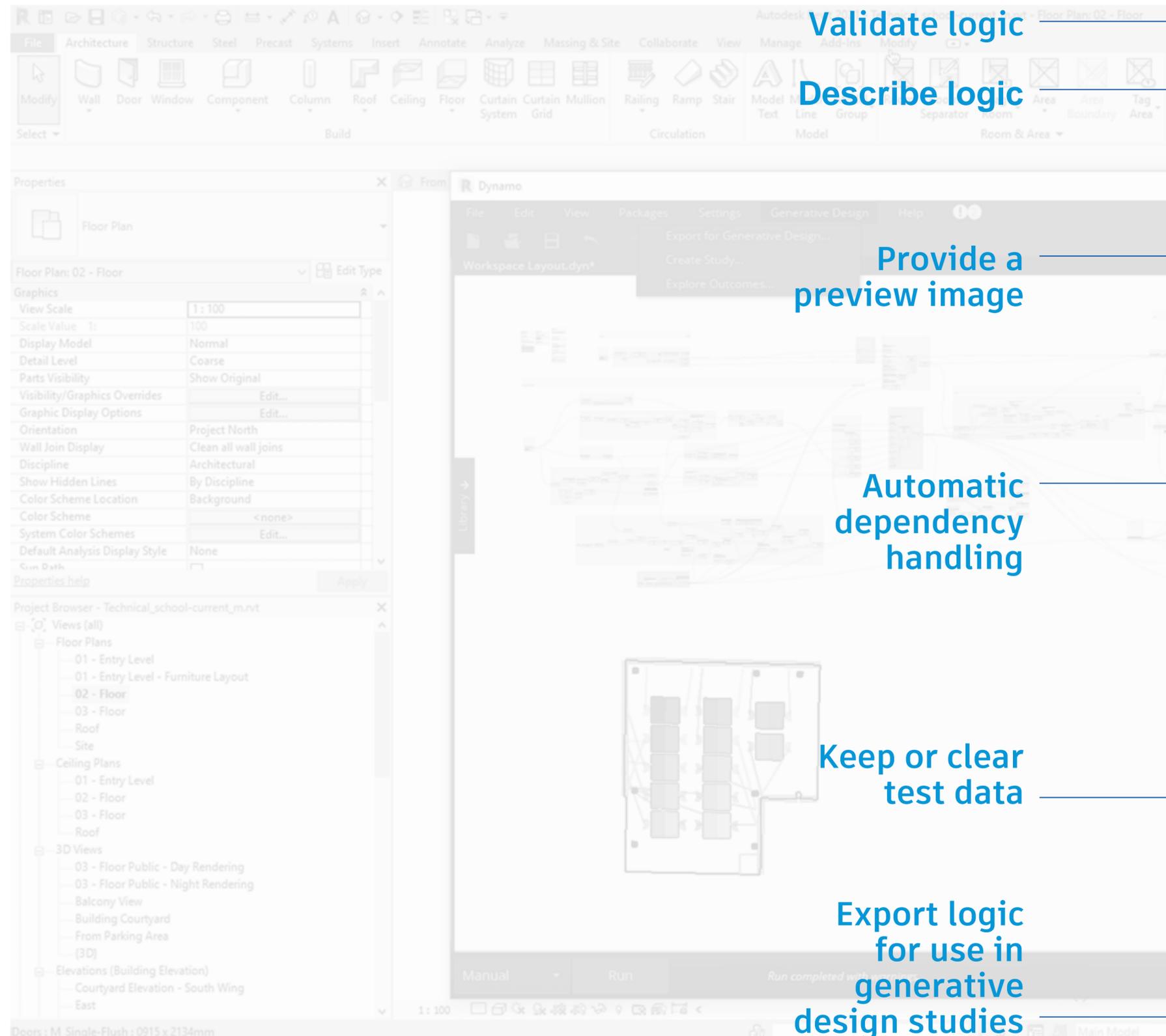
**Export scripts for use in GD for Revit**

**Create Study**

**Explore outcomes**

**Tweak samples or create new logic**

# Dynamo Export of Generative Design studies



Validate logic

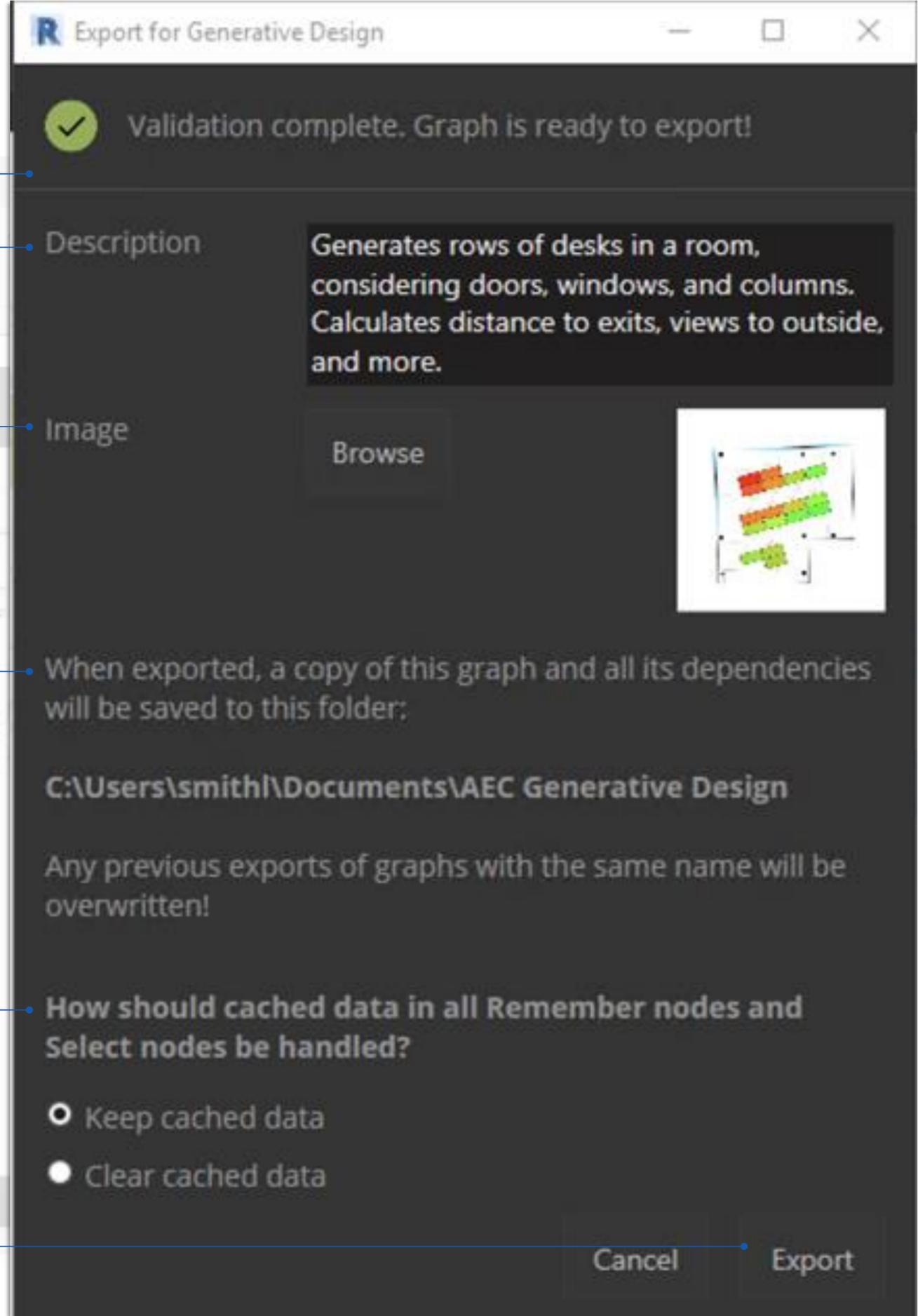
Describe logic

Provide a preview image

Automatic dependency handling

Keep or clear test data

Export logic for use in generative design studies



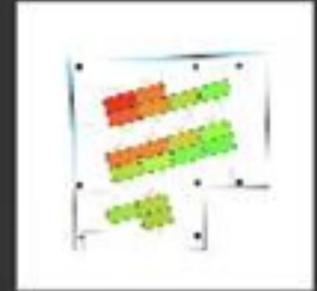
Validation complete. Graph is ready to export!

Description

Generates rows of desks in a room, considering doors, windows, and columns. Calculates distance to exits, views to outside, and more.

Image

Browse



When exported, a copy of this graph and all its dependencies will be saved to this folder:

C:\Users\smith\Documents\AEC Generative Design

Any previous exports of graphs with the same name will be overwritten!

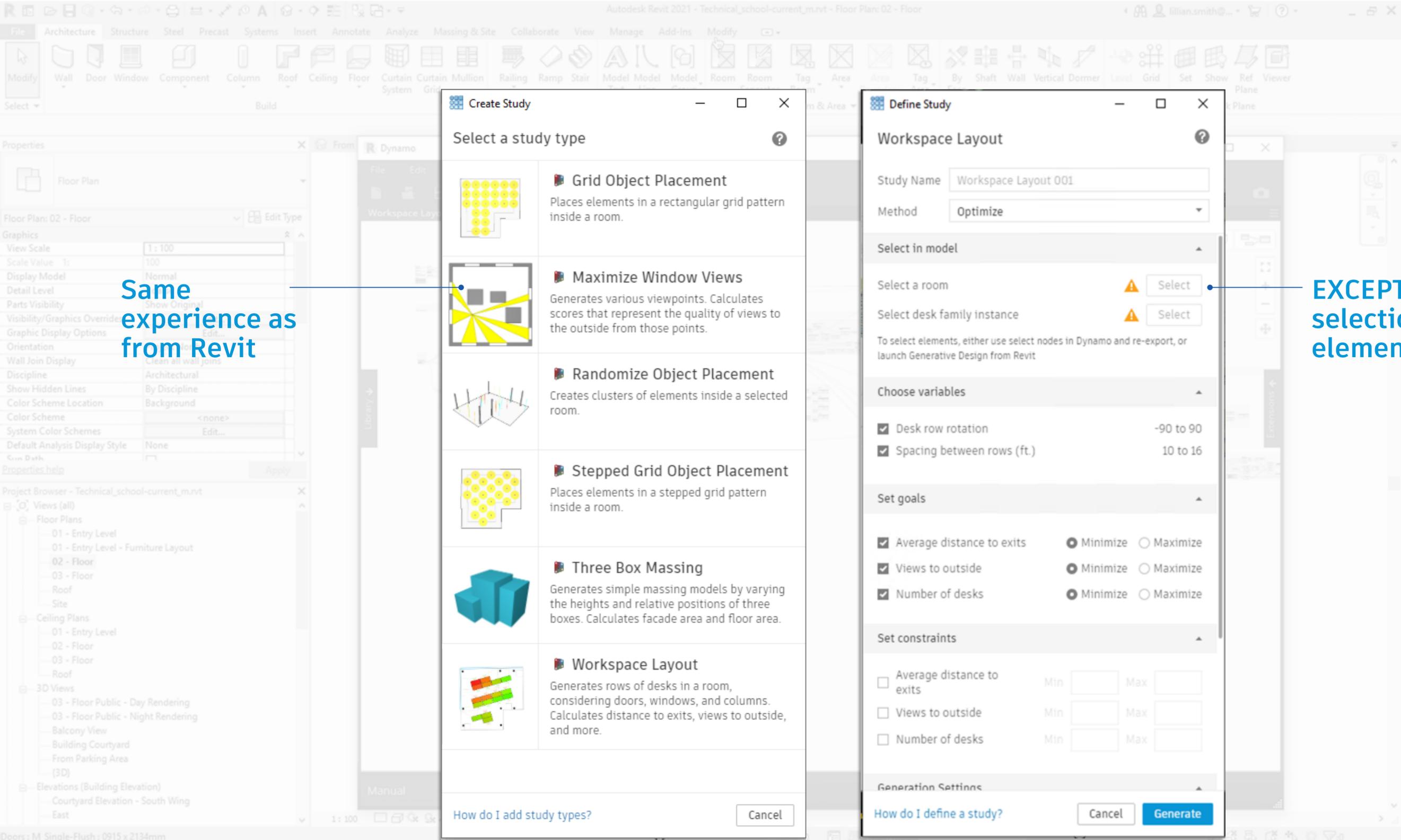
How should cached data in all Remember nodes and Select nodes be handled?

- Keep cached data
- Clear cached data

Cancel

Export

# Dynamo access to Create and Define Studies



Same experience as from Revit

EXCEPT No direct selection of Revit elements from UI

# Dynamo access to Explore Outcomes

Same Explore experience as from Revit

EXCEPT No creation of Revit elements from UI - Open in Dynamo instead

Outputs	Value
Average distance to exits	13.250
Views to outside	0.599
Number of desks	20.0

Inputs	Value
Desk row rotation	25
Spacing between rows (ft.)	11

# Available in the 14 languages supported by Revit

The image displays the Autodesk Revit software interface in Chinese. The main window shows a floor plan titled 'Arch Link Model v2021 Preview with desks.rvt - Plan d'étage: 02 - Floor'. A '创建分析' (Create Analysis) dialog box is open, prompting the user to 'Select a study type'. The dialog shows a preview of three rectangular volumes and a list of analysis types. The '三个长方体体量' (Three Rectangular Volumes) study type is selected. The dialog also displays a table of analysis results and a '创建分析' (Create Analysis) button.

**三个长方体体量 001**

楼层面积	体积	曲面面积
32183.0	297690.0	32346.0

**输入**

参数	值
长方体 1 高度	22
长方体 2 高度	56
长方体 3 高度	79
长方体 2 位置 X	49
长方体 2 位置 Y	39
长方体 3 位置 X	37
长方体 3 位置 Y	...

**输出**

参数	值
楼层面积	32183.0
体积	297690.0
曲面面积	32346.0

# Autodesk Desktop App Updates

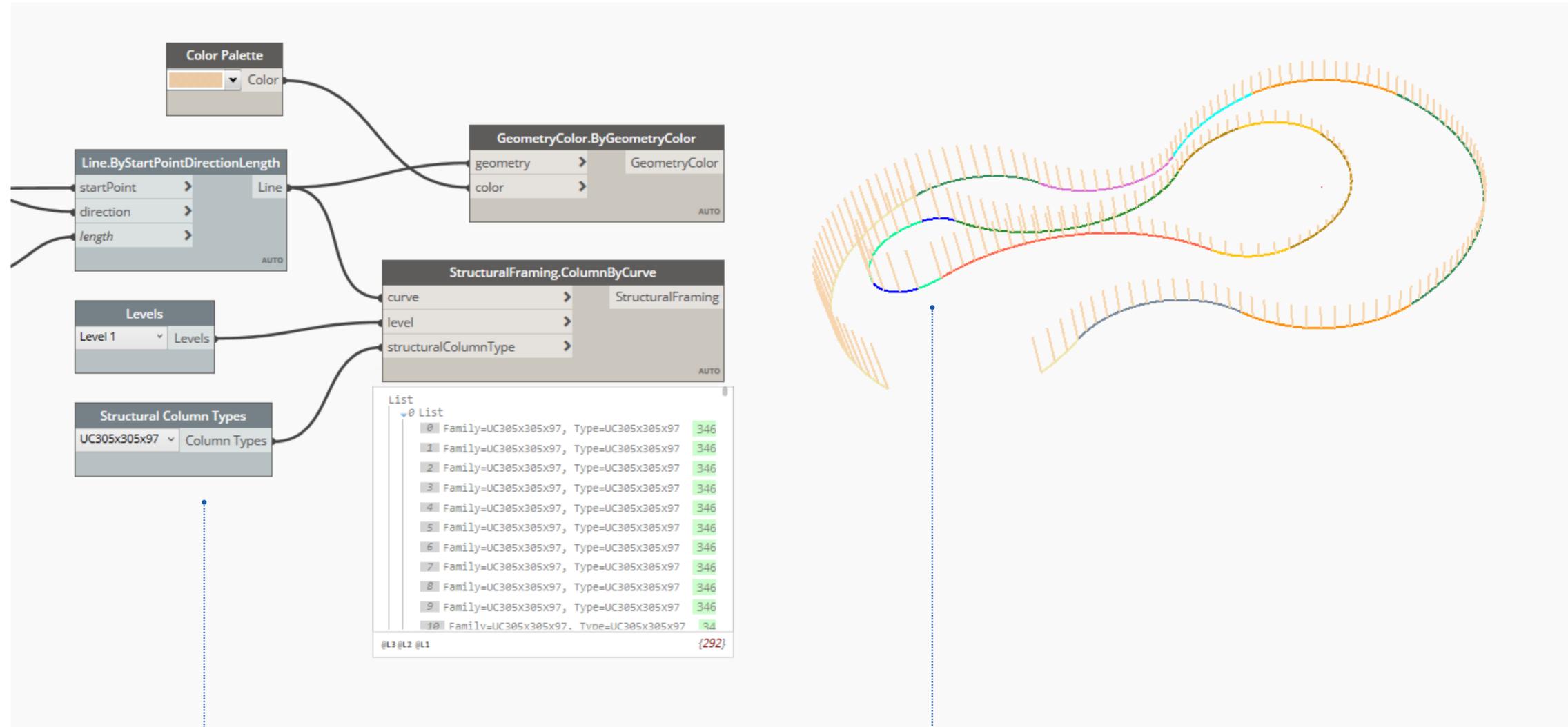
The screenshot shows the Autodesk Desktop App interface. At the top, the Autodesk logo and the name 'Lilli Smith' are visible. A sidebar on the left contains navigation icons for 'My updates' (highlighted in orange), 'F 360', and 'R'. The main content area displays a list of updates:

- Advance Steel Extension for Revit**: 3 weeks ago | 55.6 MB. Description: Advance Steel Extension for Revit allows you to exchange BIM data from your models between Revit and Autodesk Advance Steel. You can export, import and synchronize BIM data between Revit models for structural analysis and detailing in Autodesk Advance Steel. [Update](#)
- Revit 2020.2.3 Hotfix**: 1 month ago | 389.9 MB. Description: This hotfix includes new functionality, addresses customer reported issues and crashes, and contains the fixes included in previous Revit 2020 updates and hotfixes. With this install the following will be updated: Revit 2020, Collaboration for Revit 2020, Personal Accelerator for Revit, and Revit Architecture 2020. [Update](#)
- Generative Design v21.9.4 for Revit 2021**: 1 month ago | 124.0 MB. Description: With Generative Design in Revit you can leverage computing power to quickly generate and explore alternatives to a design problem. This release improves the ability to choose variable or constant values when creating a study. This release also resolves Customer reported issues... [Update](#)
- Autodesk Licensing Service - 10.2.0.4231 - Win - Update**: 2 months ago | 73.7 MB. Description: The 10.2 release update focuses on licensing installer enhancements to fix defects, improve logging, gather install related data for troubleshooting and analytics purposes. In addition, this update includes changes to the License Manager to display correct licensing attributes for... [Update](#)

What's new in Dynamo ?



# Dynamo Performance Improvements

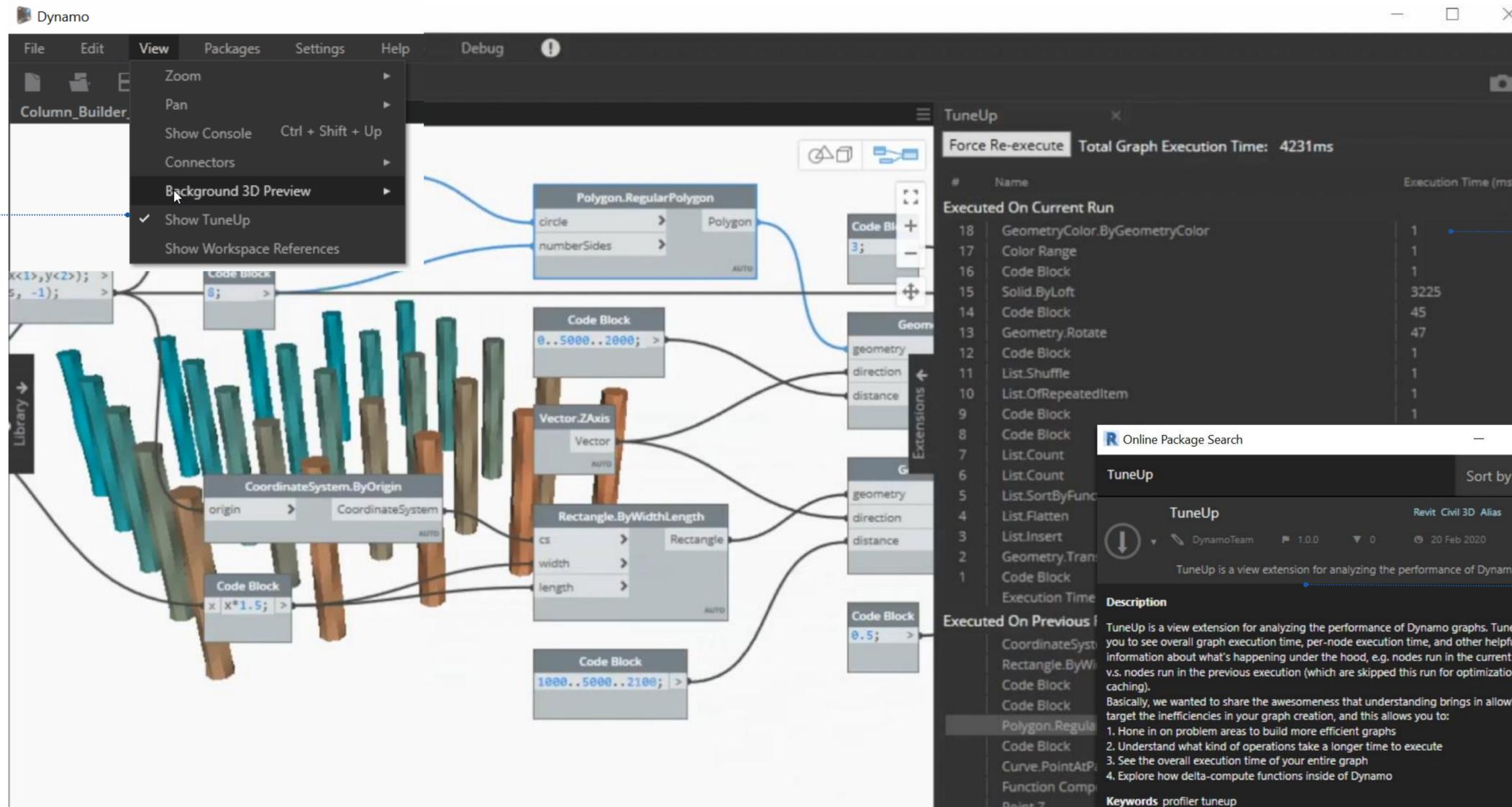


Large node count graphs that create Revit Elements 23 seconds reduced to 23 MILLiseconds

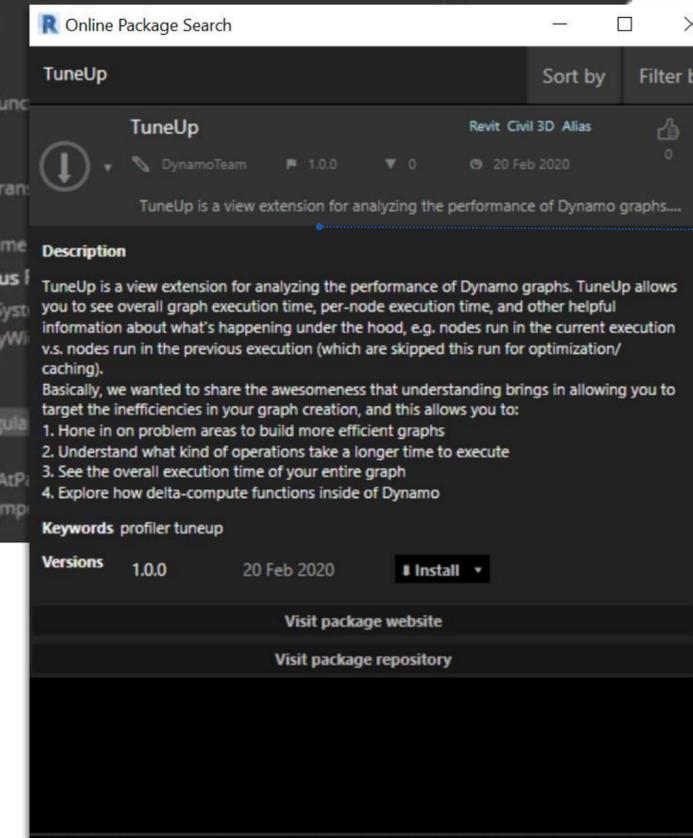
General and intersection specific PolyCurve improvements now up to 100x faster

# Dynamo Usability: Graph Performance monitoring

Accessible from View Menu with other team extensions.



Shows total execution time at a glance.



“TuneUp” available on Dynamo Package Manager

# Dynamo Usability: Understanding Warnings and Errors

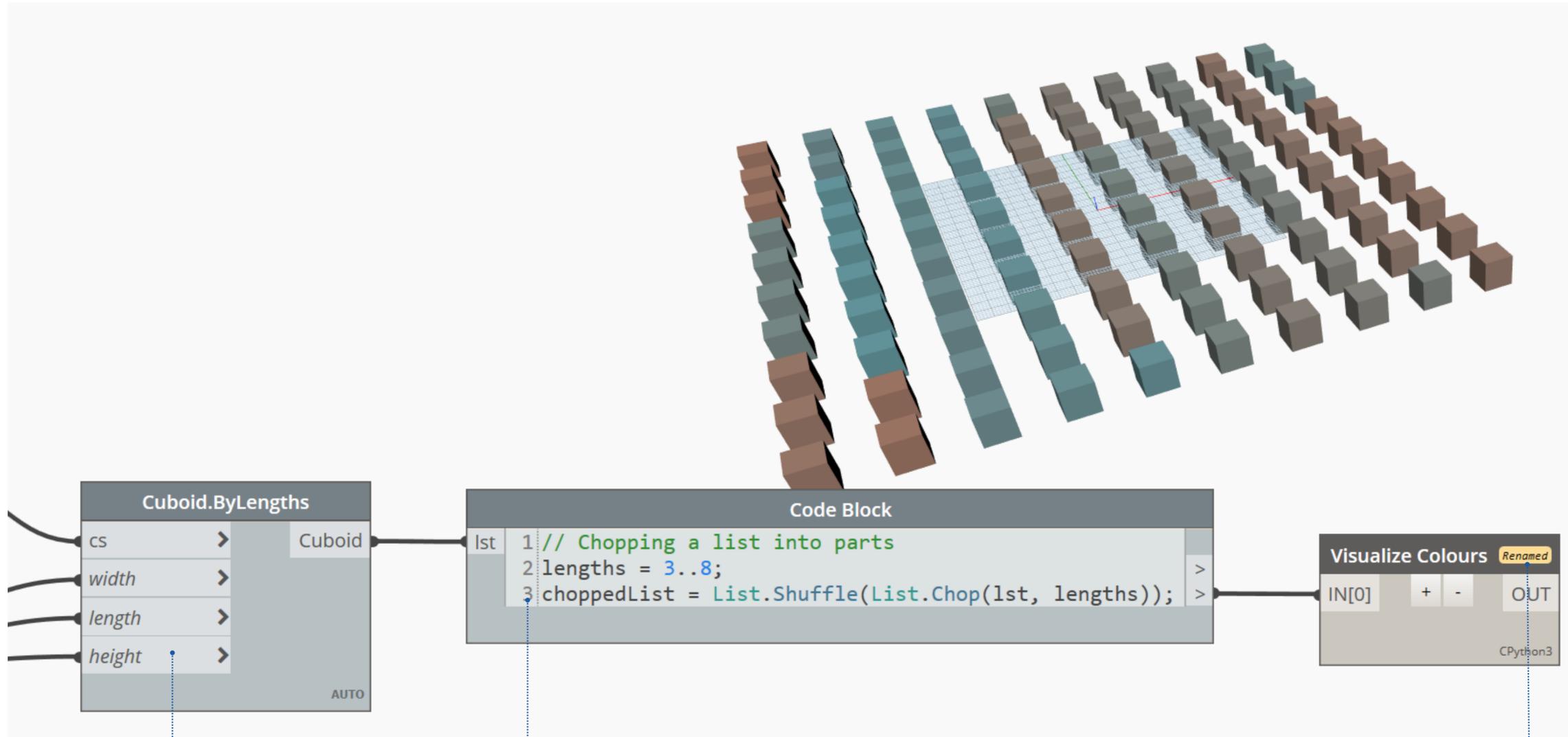
Accessible directly from node UI.

The screenshot displays the Dynamo software interface with a grid background. At the top, a window titled "All errors.dyn" is visible. Four distinct error scenarios are highlighted in light blue boxes:

- Local documentation HTML file:** A code block containing `string_enum["hello"] = 1; |>` is connected to an exception message: "Exception : List indices must be numeric".
- Missing documentation file:** A code block containing `extra=2.7; |>` and `extra=c; |>` is connected to the same exception message: "Exception : List indices must be numeric".
- Remote documentation webpage:** A code block containing `"skdjfna"; |>` is connected to the `Math.Random` node. The node's `seed` input is highlighted, and the exception message reads: "Exception : Expects argument type(s) (int), but was called with (string)".
- No content in docs:** A code block containing `error="Friendly error message"; |>` and `withUrl=error+"href=Empty.html"; |>` is connected to the `Throw.WithText` node. The node's `text` input is highlighted, and the exception message reads: "This throws an exception with the specified message. If a URL is provided, it adds the required 'href=uri' to the message so the InfoBubble parses the link."

Extensible for third party package authors.

# Dynamo Usability: Enhancing the graph authoring experience



Node ports that do not require an input are now shown in italics

Codeblock Nodes now have line numbers

Renamed nodes now have a tag to show users which nodes are customized

# Dynamo for Revit: New nodes

This image displays a comprehensive set of new Dynamo nodes for Revit, organized into 15 columns and 4 rows. Each node is represented by a small icon with a title and a list of inputs and outputs. The nodes are color-coded by category:

- Area:** Area.Boundaries (area → Curve[])
- Dimension:** Dimension.SetAboveValue (dimension → Element, value → double); Dimension.SetBelowValue (dimension → Element, value → double); Dimension.BelowValue (dimension → string[]); Dimension.AboveValue (dimension → string[])
- Document:** Document.WorksharingPath (document → string); Document.IsCloudPath (document → bool); Document.PurgeUnused (document → int[]); Document.SaveFamilyToFolder (document → string, family → Element, directoryPath → string)
- Element:** Element.GetJoinedElements (element → Element[]); Element.AreJoined (element → bool, otherElement → Element); Element.UnjoinAllGeometry (elements → Element[]); Element.UnjoinGeometry (element → Element[]); Element.JoinGeometry (element → Element[]); Element.GetParentElement (element → Element); Element.GetChildElements (element → Element[]); Element.SetPinnedStatus (element → Element, pinned → bool); Element.IsPinned (element → bool); Element.GetHostedElements (element → Element, includeOpenings → bool, includeHostedElementsOfJoinedHosts → bool, includeEmbeddedWalls → bool, includeSharedEmbeddedInsets → bool); Element.GetIntersectingElementsOfCategory (element → Element[], category → Element[])
- Family Instance:** FamilyInstance.Transform (familyInstance → FamilyInstance, fromCoordinateSystem → CoordinateSystem, contextCoordinateSystem → CoordinateSystem); FamilyInstance.ByCoordinateSystem (familyType → FamilyInstance, coordinateSystem → CoordinateSystem); FamilyInstance.Room (familyInstance → Element); FamilyInstance.Space (familyInstance → Element)
- Element Type:** ElementType.ByName (name → ElementType); ElementType.Name (elementType → string); ElementType.FamilyName (elementType → string); ElementType.CanBeCopied (elementType → bool); ElementType.CanBeDeleted (elementType → bool); ElementType.CanBeRenamed (elementType → bool); ElementType.Duplicate (elementType → ElementType, name → string); ElementType.GetPreviewImage (elementType → var, size → int)
- Floor Type:** FloorType.GetThermalProperties (floorType → ThermalProperties); FloorType.GetStructuralMaterial (floorType → Material); FloorType.IsFoundationSlab (floorType → bool)
- Roof Type:** RoofType.GetThermalProperties (roofType → ThermalProperties)
- Wall Type:** WallType.GetThermalProperties (wallType → ThermalProperties); WallType.Kind (wallType → string); WallType.Width (wallType → double); WallType.Function (wallType → string); WallType.Name (wallType → string)
- Elevation Marker:** ElevationMarker.ByViewTypeLocation (viewFamilyType → ElevationMarker, location → Location, initialViewScale → double); ElevationMarker.CreateElevationByMarkerIndex (elevationMarker → SectorView, planView → SectorView, index → int); ElevationMarker.GetView (elevationMarker → SectorView, index → int); ElevationMarker.CurrentViewCount (elevationMarker → int)
- Family Document:** FamilyDocument.ByDocument (document → FamilyDocument); FamilyDocument.AddParameter (familyDocument → FamilyParameter, parameterName → string, parameterGroup → string, parameterType → string, idInstance → int); FamilyDocument.DeleteParameter (familyDocument → int, parameterName → string); FamilyDocument.GetFormula (familyDocument → string, parameterName → string); FamilyDocument.GetParameterByName (familyDocument → var[], parameterName → string); FamilyDocument.SetCategory (familyDocument → FamilyDocument, category → Category); FamilyDocument.SetFormula (familyDocument → FamilyDocument, parameterName → string, formula → string); FamilyDocument.SetParameterByName (familyDocument → FamilyDocument, familyTypeName → string, parameter → string, value → var); FamilyDocument.Category (familyDocument → Category); FamilyDocument.Parameters (familyDocuments → FamilyParameter[]); FamilyDocument.Types (familyDocument → string[])
- Group:** Group.ByElements (elements → Group); Group.Placement (location → Group, groupType → Group); Group.GetMembers (group → Element[]); Group.LingroupElements (group → Element[]); Group.AttachedDetailGroup (group → Element[]); Group.GroupType (group → Element); Group.IsAttached (group → bool); Group.Location (group → Point)
- Selection:** Select Model Element by Category (change → Element, Element: 999951); Select Model Elements by Category (change → Elements, Element: 422466 423107 425292 430997 431064 431144 431198 485452 485679 505974 704276 704280 704244 904937 93962, 940221); Rooms By Status (PlacedRooms, UnplacedRooms, NotEnclosedRooms, RedundantRooms); Roof Types (SI: Metal Panels roof, Roof Types); Sheets (Plans, Sheet); View Family Types (3D View, ViewFamilyType); Element By Id (id → Element)
- Space:** Space.ByLevelLocation (level → Space, location → Location, name → string, number → int); Space.IsPointInSpace (space → bool, point → Point); Space.SetName (space → Space, value → string); Space.SetNumber (space → Space, value → int); Space.Area (space → double); Space.CenterBoundary (space → Curve[]); Space.CoreBoundary (space → Curve[]); Space.CoreCenterBoundary (space → Curve[]); Space.FinishBoundary (space → Curve[]); Space.Height (space → double); Space.Location (space → Point); Space.Name (space → string); Space.Number (space → string); Space.Volume (space → double)
- Viewport:** Viewport.BySheetViewLocation (sheet → Viewport, view → Location, location → Location)
- Warnings:** All Warnings of Type (Warnings); Warning.GetFallingElements (warning → Element[]); Warning.GetWarnings (document → Warning[]); Warning.Description (warning → string); Warning.Severity (warning → string)
- Path of Travel:** PathOfTravel.InsertWayPoint (pathOfTravel → PathOfTravel, wayPoint → PathOfTravel, index → int); PathOfTravel.RemoveWayPoint (pathOfTravel → PathOfTravel, index → int); PathOfTravel.SetWayPoint (pathOfTravel → PathOfTravel, newPosition → PathOfTravel, index → int); PathOfTravel.GetWayPoints (pathOfTravel → var[], endPtList → var[]); PathOfTravel.LongestOfShortestExitPaths (floorPlan → PathOfTravel[], endPtList → var[])

# Dynamo for Revit: New nodes for Generative Design

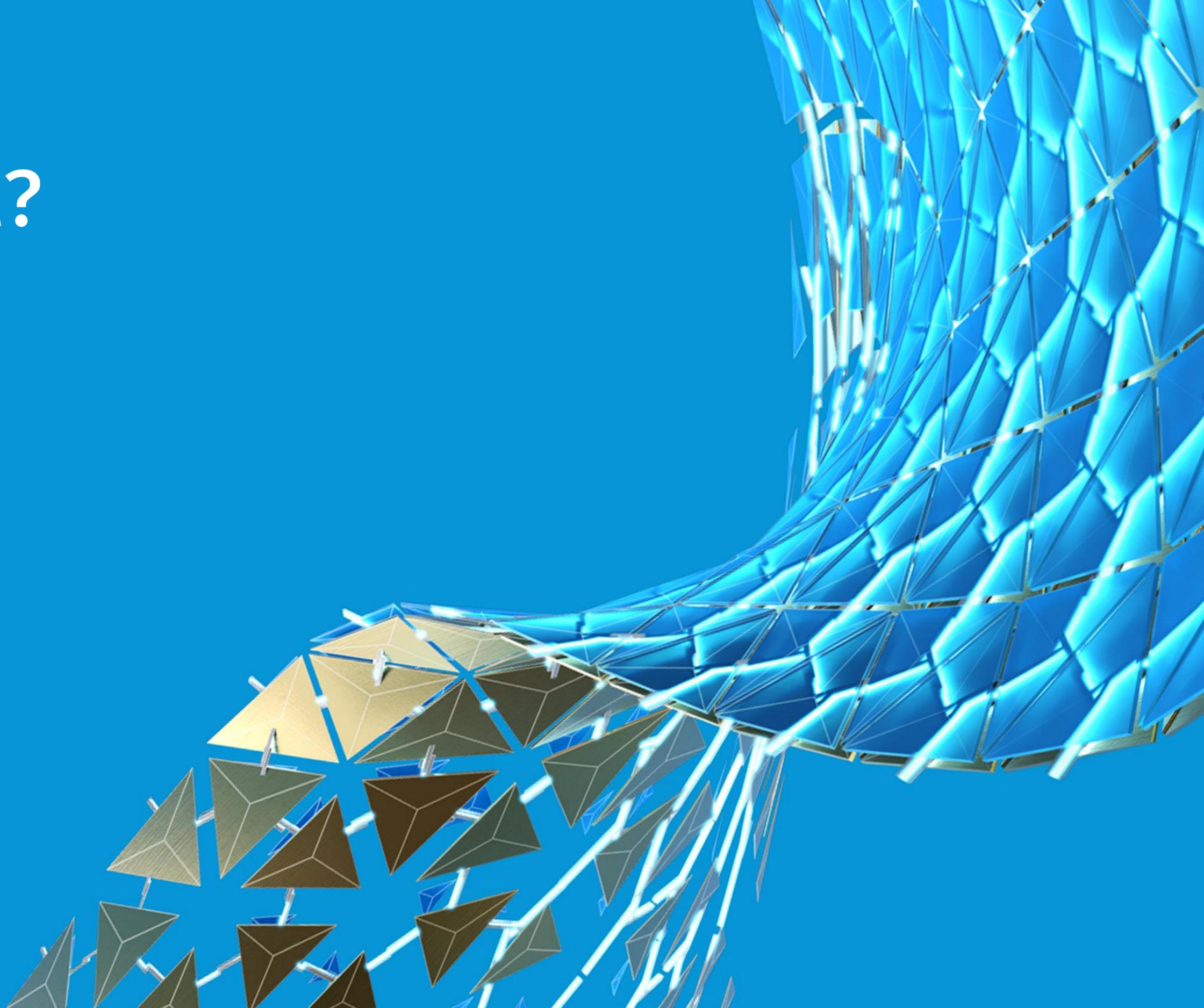
Lets study author  
set the context for  
the Revit Selection

The image shows a screenshot of the Revit software interface, specifically the 'Select Model Elements By Category' dialog box. The dialog has a title bar and two columns: 'Select' and 'Elements'. The 'Select' column has a dropdown menu currently set to 'Mass'. The 'Elements' column is empty. A list of categories is displayed below the dialog, with 'Rooms' highlighted in blue. A red '{2}' is visible in the 'Elements' column. A blue dotted line points from the text on the left to the 'Rooms' category in the list.

Select	Elements
Mass	

- Roofs - Cut Pattern
- Roofs - Fascias
- Roofs - Finish 1 [4]
- Roofs - Finish 2 [5]
- Roofs - Gutters
- Roofs - Interior Edges
- Roofs - Membrane Layer
- Roofs - Roof Soffits
- Roofs - Structure [1]
- Roofs - Substrate [2]
- Roofs - Surface Pattern
- Roofs - Thermal/Air Layer [3]
- Room Tags
- Rooms**
- Rooms - Color Fill
- Rooms - Interior Fill
- Rooms - Reference
- Routing Preferences
- RVT Links
- Schedule Graphics
- Schedules
- Scope Boxes
- Section Boxes
- Section Line

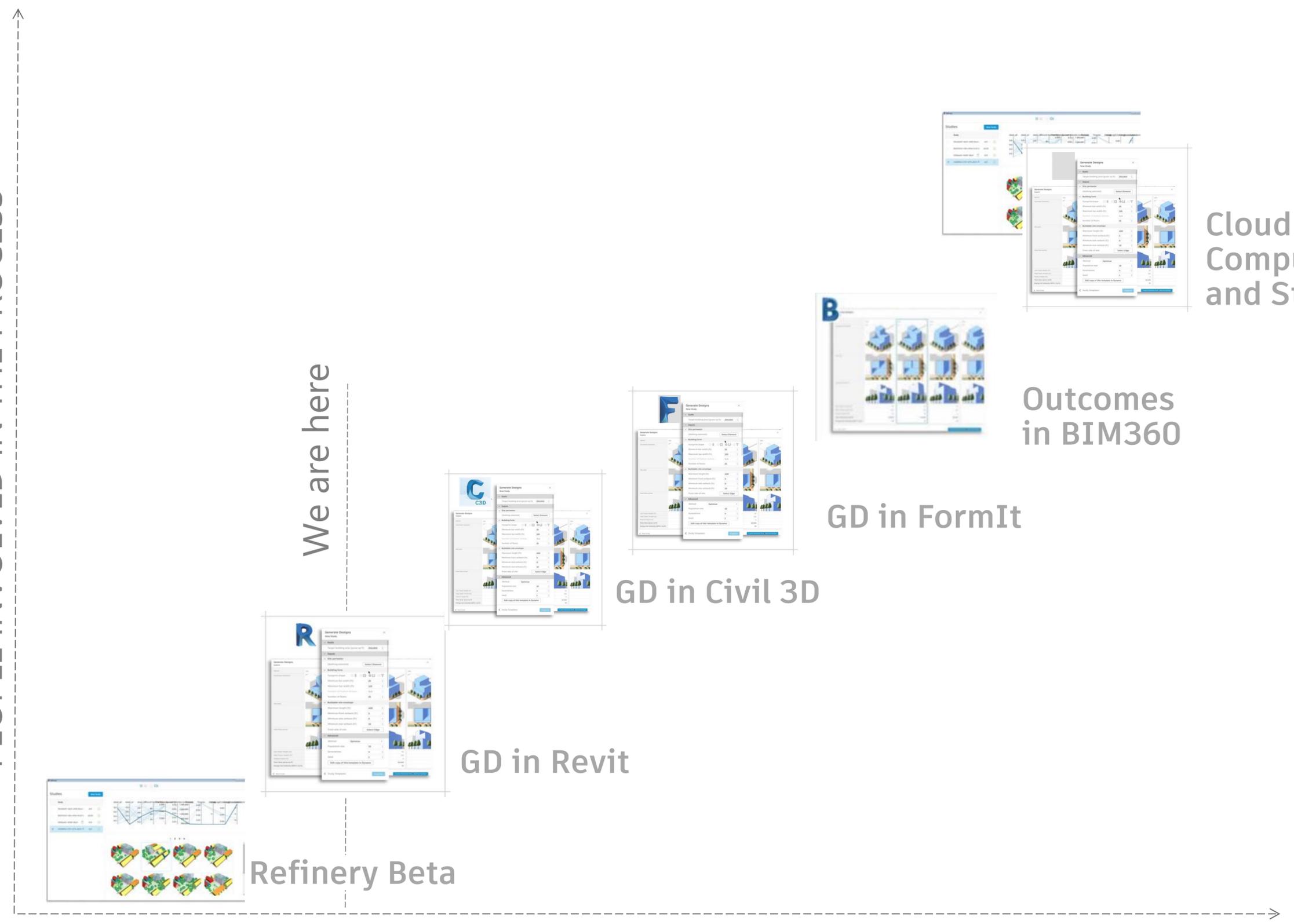
What's Next?



# Roadmap

- CLIENT 
- PROJECT MANAGER 
- MORE PROJECT DESIGNERS 
- PROJECT DESIGNER 
- DESIGN TECHNOLOGIST 

PEOPLE INVOLVED IN THE PROCESS



CAPABILITIES

# 1. Study Type Editing



# Study Type Editing: Help placing the remember node

The screenshot displays the Dynamo software interface. The main workspace shows a workflow with three main sections: "Manual Inputs", "Room Boundary", "Get Windows/Curtain Walls Locations", and "Surface from Obstacles". The "Manual Inputs" section contains several nodes, with two of them highlighted by red boxes. The "Room Boundary" section contains a series of nodes connected by lines. The "Get Windows/Curtain Walls Locations" section contains a series of nodes, with one node highlighted by a red box. The "Surface from Obstacles" section contains a series of nodes, with one node highlighted by a red box. A dialog box titled "Export for Generative Design" is open in the foreground, displaying a warning message: "1 issue(s) found. Fix the issues then try again." The message lists the following nodes that need to be cached using a Data.Remember node: "Element.Faces" and "Element.Geometry". The dialog box also includes the instruction: "Place Remember nodes after all listed nodes." The background workflow is partially obscured by the dialog box. The status bar at the bottom of the window shows "Run completed with warnings." and the system tray at the bottom right shows the time "7:00 PM" and date "10/15/2020".

# Study Type Editing Workflow Improvements

**Generative Design - Warning**

**! Missing Dependencies**

The Generative Design study you are opening was exported with third-party packages or custom nodes that aren't currently installed in Dynamo. How would you like to resolve the issue?

Load temporarily

*All missing dependencies will be loaded in Dynamo for this session only. The packages will not be loaded the next time you open Dynamo.*

Ok

Library: Dictionary, Display, Geometry, ImportExport, Input, List, Math, Revit, Script, String, Add-ons: Ampersand, Analyze, BIM4Struc, Clockwork, DropdownUI, DynamoText, GenerativeDesign, GenFloor, RefineryToolkits, Revit, SolidConvexHull, SpaceAnalysis

Generative Design - Info Issues

Options: Color nodes by application, Suggest Remember and Gate nodes

The graph needs to be run in order to check if issues have been fixed. Click the Run button.

The following nodes need to be cached using a Data.Remember node: Element.BoundingBox, FamilyInstance.ByPoint, Element.ElementType. Place Remember nodes after all listed nodes.

These Input nodes have the same name: Integer Slider, Integer Slider. Provide a unique name for each Input node.

3 issues found Create Study Type

Manual Run Run completed with warnings.

## 2. Study Type Sharing



# Sharing Generative Design study types - before

The image shows a screenshot of Autodesk Revit 2021 with two file explorer windows overlaid. The left window shows a list of files in the 'AEC Generative Design' folder, including various study types and their dependencies. The right window shows the same folder structure but with a different set of files, indicating a change in the study types available. A large blue arrow points from the left window to the right window, suggesting a transition or comparison between the two states.

**Left File Explorer Window:**

- Name
- .Grid Object Placement.RefineryResults
- .Maximize Window Views.RefineryResults
- .Randomize Object Placement.RefineryResults
- .Stepped Grid Object Placement.RefineryResults
- .Stepped Grid Object Placement2.RefineryResults
- .Three Box Massing.RefineryResults
- .Three Box Massing\_Variance\_Solar\_OpenSpace.RefineryResults
- .Workspace Layout.RefineryResults
- Grid Object Placement.Dependencies
- Maximize Window Views.Dependencies
- Randomize Object Placement.Dependencies
- Stepped Grid Object Placement.Dependencies
- Three Box Massing.Dependencies
- Three Box Massing\_Variance\_Solar\_OpenSpace.Dependencies
- Workspace Layout.Dependencies
- Grid Object Placement.dyn
- Maximize Window Views.dyn
- Randomize Object Placement.dyn
- Stepped Grid Object Placement.dyn
- Stepped Grid Object Placement2.dyn
- Three Box Massing.dyn
- Three Box Massing\_Variance\_Solar\_OpenSpace.dyn
- Workspace Layout.dyn

**Right File Explorer Window:**

- Name
- .Grid Object Placement.RefineryResults
- .Maximize Window Views.RefineryResults
- .Randomize Object Placement.RefineryResults
- .Stepped Grid Object Placement.RefineryResults
- .Stepped Grid Object Placement2.RefineryResults
- .Three Box Massing.RefineryResults
- .Three Box Massing\_Variance\_Solar\_OpenSpace.RefineryResults
- .Workspace Layout.RefineryResults
- Grid Object Placement.Dependencies
- Maximize Window Views.Dependencies
- Randomize Object Placement.Dependencies
- Stepped Grid Object Placement.Dependencies
- Three Box Massing.Dependencies
- Three Box Massing\_Variance\_Solar\_OpenSpace.Dependencies
- Workspace Layout.Dependencies
- Grid Object Placement.dyn
- Maximize Window Views.dyn
- Randomize Object Placement.dyn
- Stepped Grid Object Placement.dyn
- Stepped Grid Object Placement2.dyn
- Three Box Massing.dyn
- Three Box Massing\_Variance\_Solar\_OpenSpace.dyn
- Workspace Layout.dyn

# Sharing Generative Design study types - improved

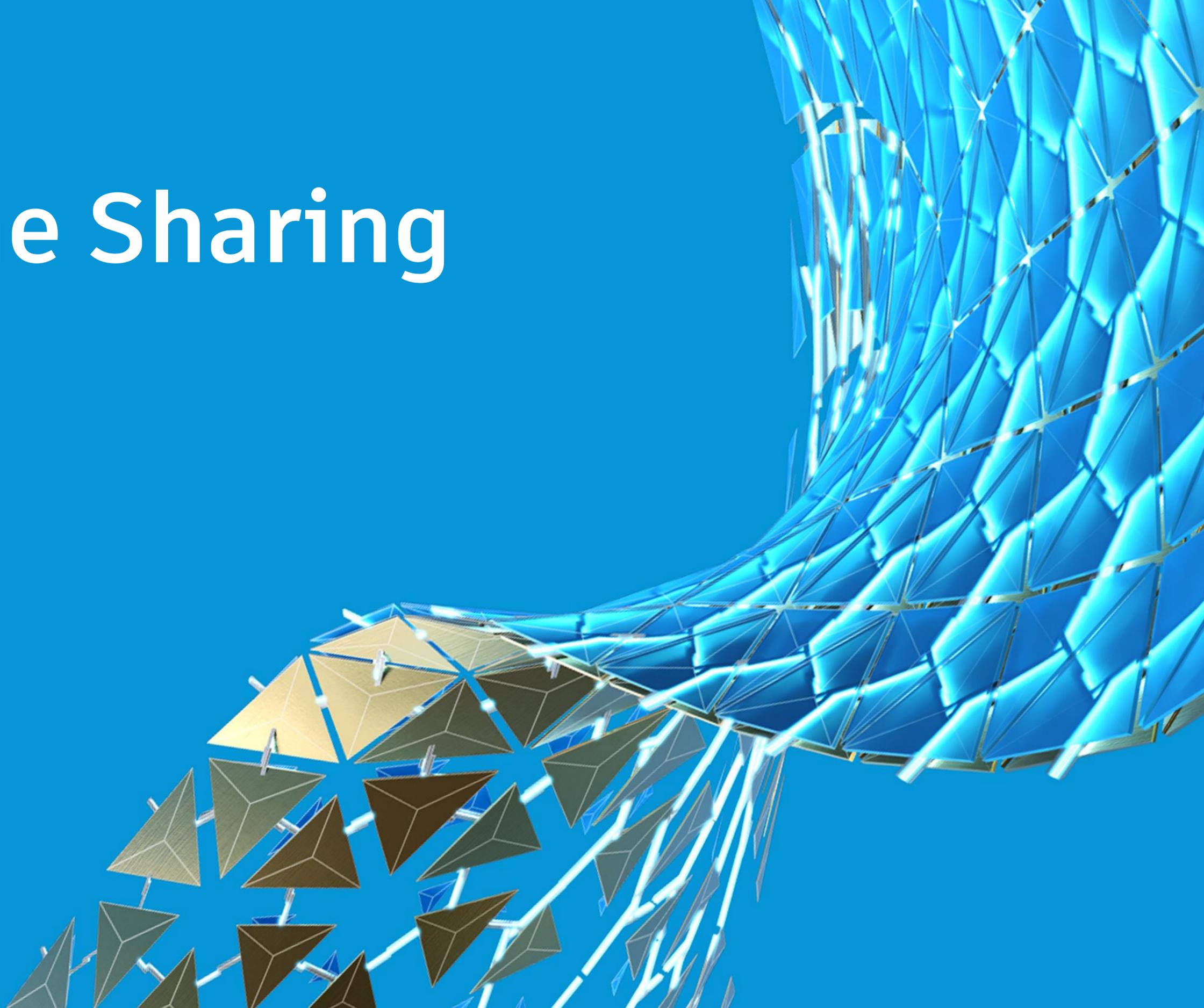
The screenshot displays the Autodesk Revit 2021.1 interface. The main window shows a floor plan of Level 1 with a room layout. A 'Create Study' dialog box is open on the right, titled 'Select a study type'. The dialog has a 'Choose Folder' dropdown set to 'AEC Generative Design'. Two study types are listed:

- Three Box Massing**: Generates simple massing models by varying the heights and relative positions of three boxes. Calculates facade area and floor area.
- Workspace Layout**: Generates rows of desks in a room, considering doors, windows, and columns. Calculates distance to exits, views to outside, and more.

The dialog also includes a 'How do I add study types?' link and a 'Cancel' button. The background shows the Revit interface with the 'Manage' tab active, a Properties panel on the left, and a Project Browser on the bottom left.

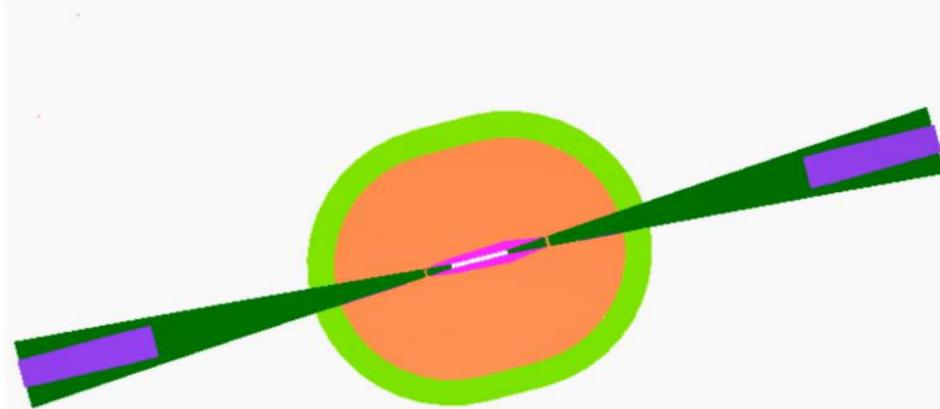
Click to select, TAB for alternates, CTRL adds, SHIFT unselects.

# 3. Outcome Sharing

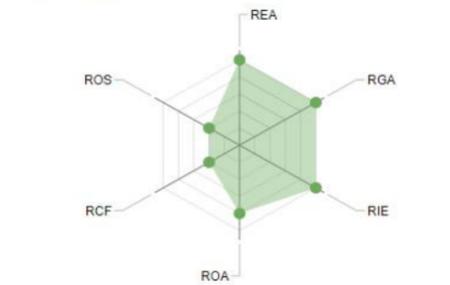


# Outcome Sharing

Calculated Proposed Runway OLS and Layout Plan



Hall of Fame



**0.82 %**  
Runway Long Grade

**-0.09 %**  
Taxiway Long Grade

**171.87 m**  
Taxiway Length

**[REA] 0**  
Existing Road Geometry Points above OLS

**[RGA] 0**  
New Runway Points Above Existing Runwa...

**[ROS] 211524 sqm**  
Area Outside Site Boundary

**[RIE] 0 sqm**  
Area Intersection of Existing Runway

**[RCF] 3745950 cum**  
Cut / Fill Balance

**[ROA] 22**  
Number of Intersect Points with OLS

## ODAP Generative Design

### Results

**0**  
Solution ID

**360401573**

CAPEX

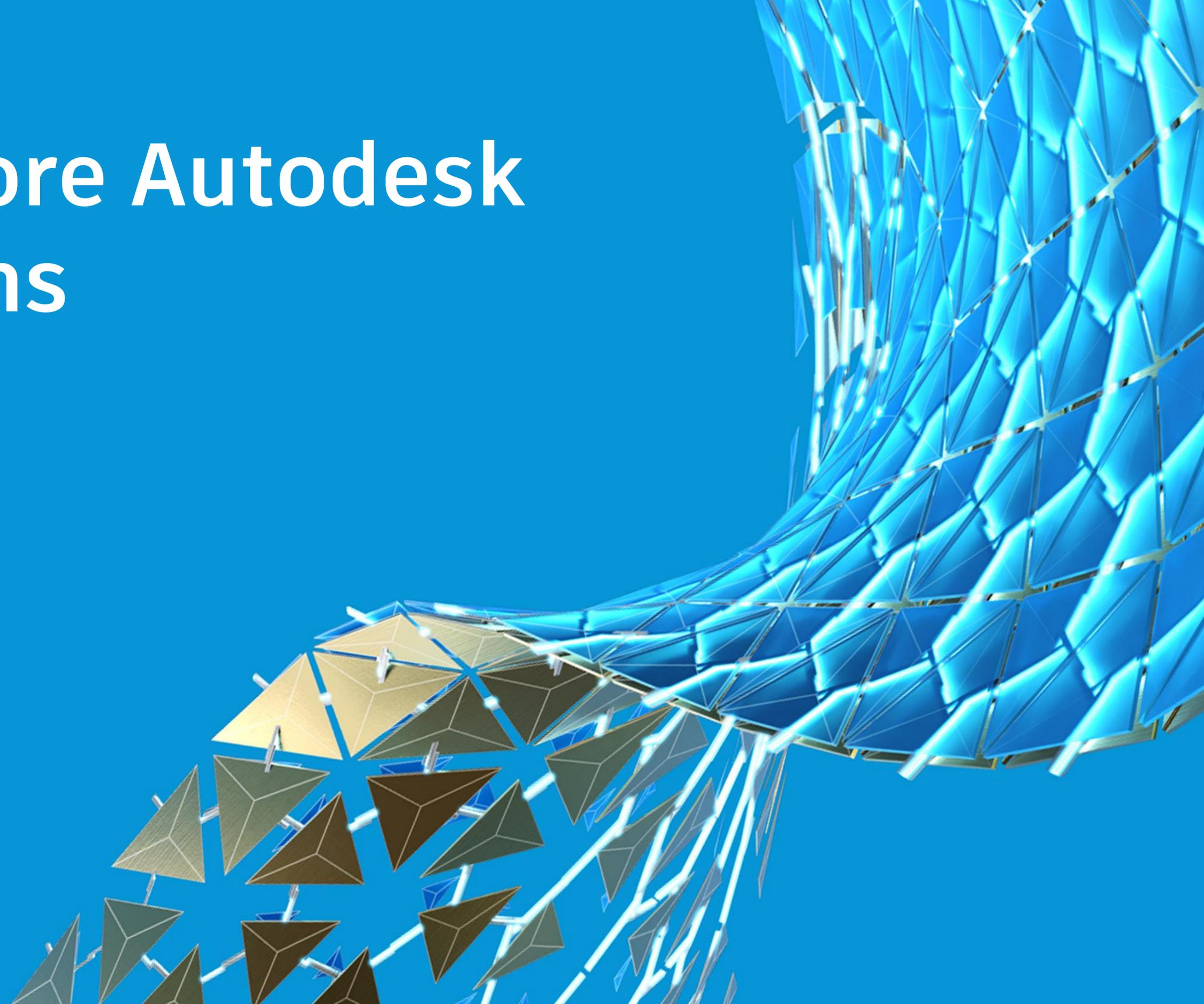
**-127351602**

NPV

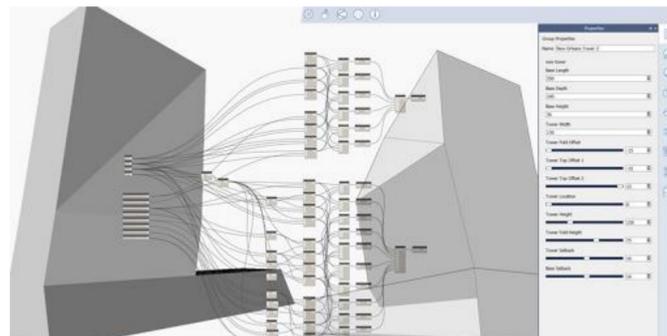
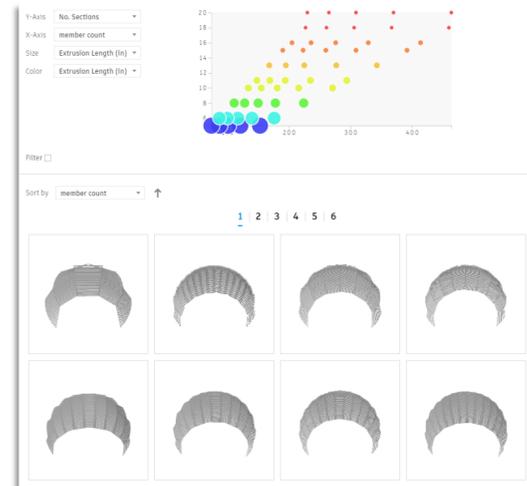
Globalid	CAPEX (MIN.)	OPEX	Cut / Fill Balance (MIN.)	Average of TaxiwayLength
0	360,401,573.44	-127,351,601.88	3,745,950.41	171.87
1	91,832,401.51	55,729,878.11	18,999.46	119.98
2	385,456,938.46	-144,431,646.01	1,159,681.46	182.69
3	306,363,434.39	-90,514,229.95	144,183.82	118.47
4	97,846,235.56	51,630,295.01	316,011.78	53.61
5	131,940,300.31	28,388,640.77	5,403,159.09	69.79
6	192,038,617.26	-12,579,906.48	201,249.80	75.25
7	103,773,645.43	47,589,626.59	1,729,977.07	142.46
8	105,728,770.56	46,256,833.26	2,026,356.02	142.83
9	196,041,206.37	-15,308,439.82	1,958,947.16	133.03
10	103,208,320.12	47,975,004.39	1,162,048.05	165.14
11	155,218,323.60	12,520,196.43	500,367.40	105.75
12	122,456,604.37	34,853,601.27	402,379.24	84.98
13	166,195,083.60	5,037,425.98	219,800.52	90.89
14	115,002,828.83	39,934,781.10	3,400,448.56	39.53
15	98,122,034.13	51,442,285.31	1,248,763.05	39.51
16	99,724,787.84	50,349,700.78	1,052,388.52	114.27
17	107,817,600.38	44,832,894.49	2,526,480.06	34.20
18	341,702,005.11	-114,604,254.07	3,088,534.48	155.90
19	219,750,110.03	-31,470,611.89	757,718.81	131.35

Better export so that people can use their automatically generated design data in other programs such as PowerBI and Excel.

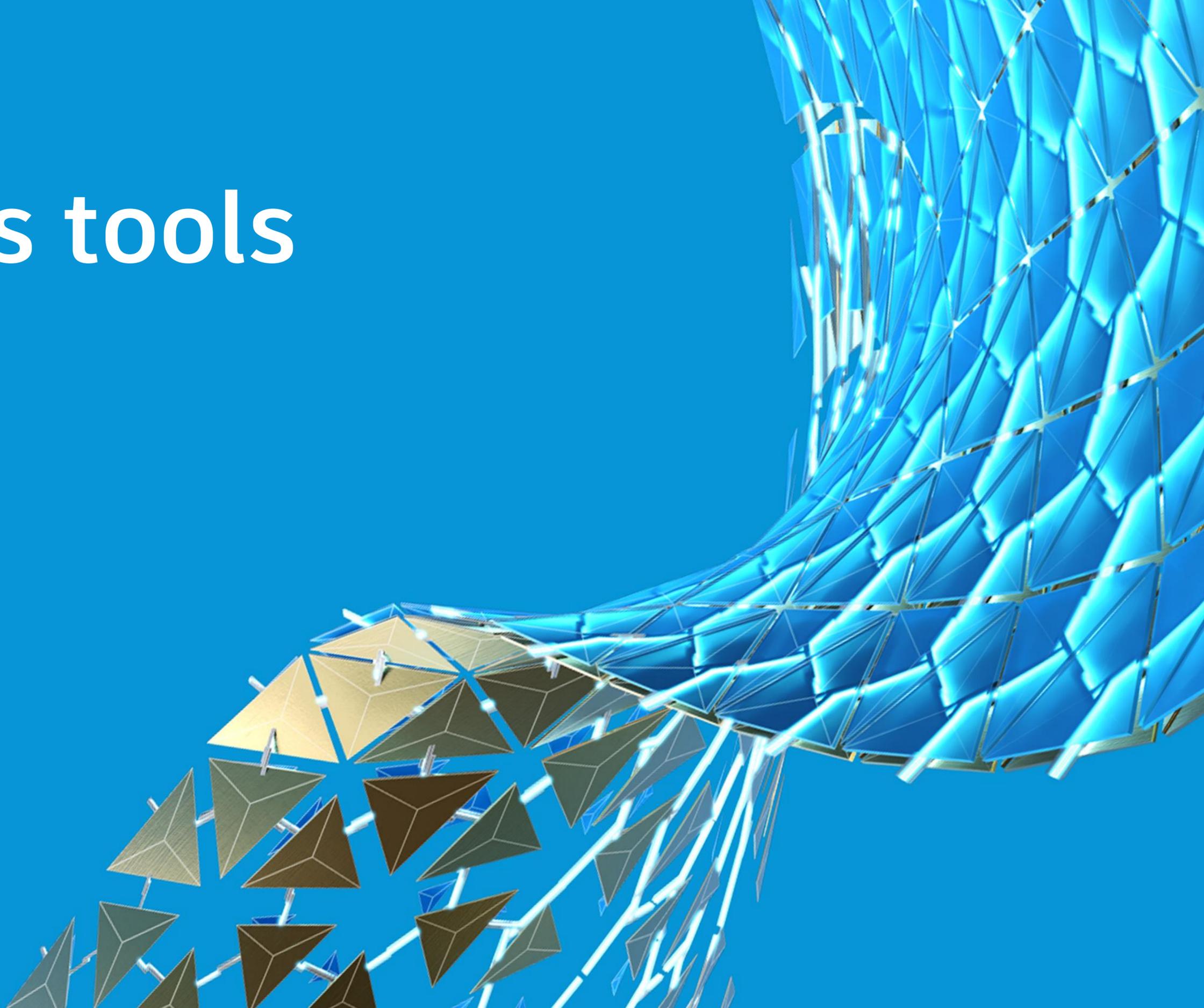
# 4. GD in more Autodesk Applications



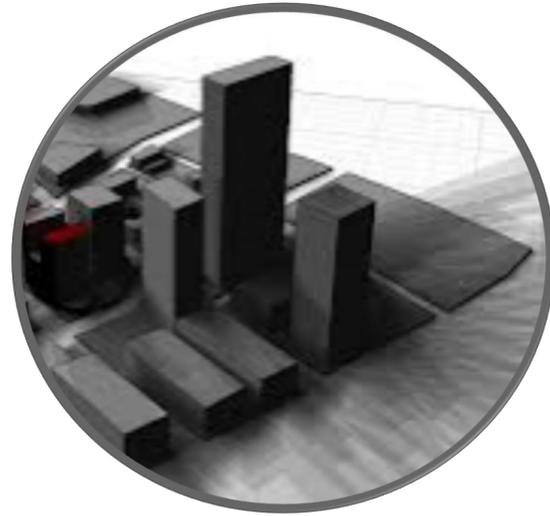
# Generative Design in More Autodesk Applications



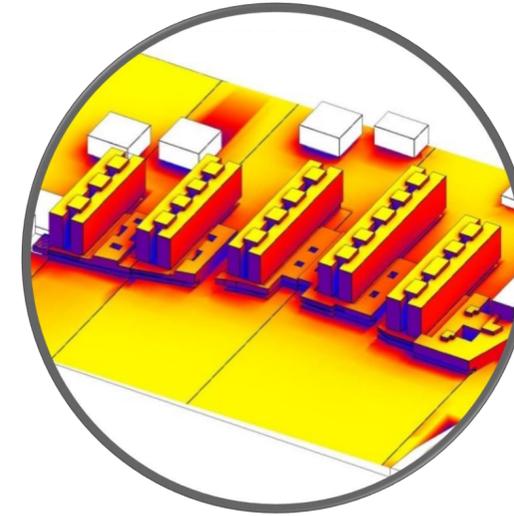
# 5. Analysis tools



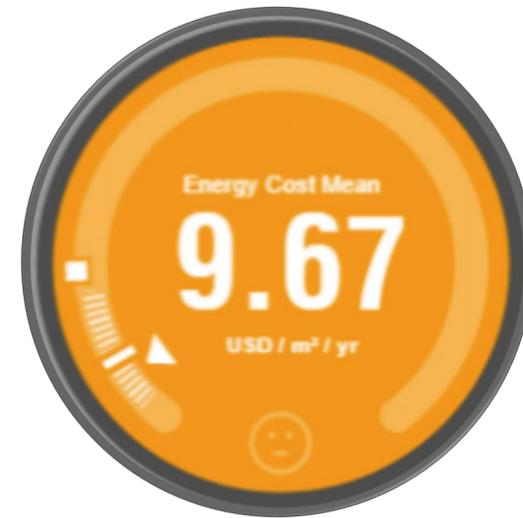
# Generative Design access to analysis tools



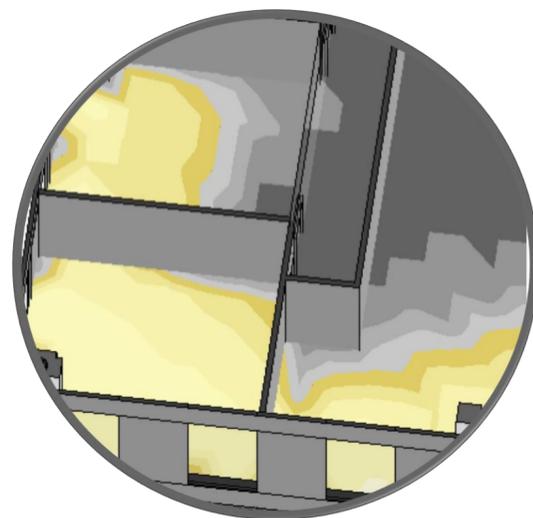
Sun and Shadow Studies



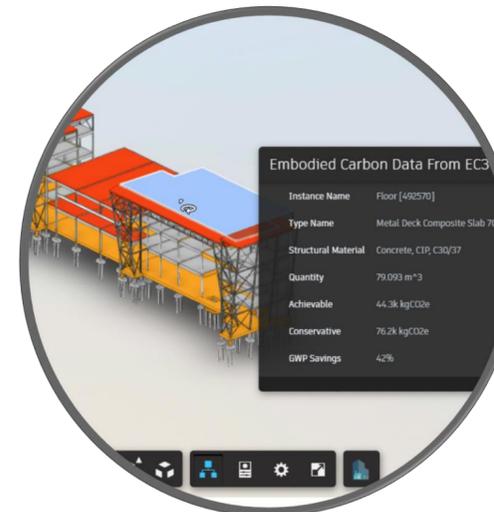
Solar Radiation Studies



Energy Analysis



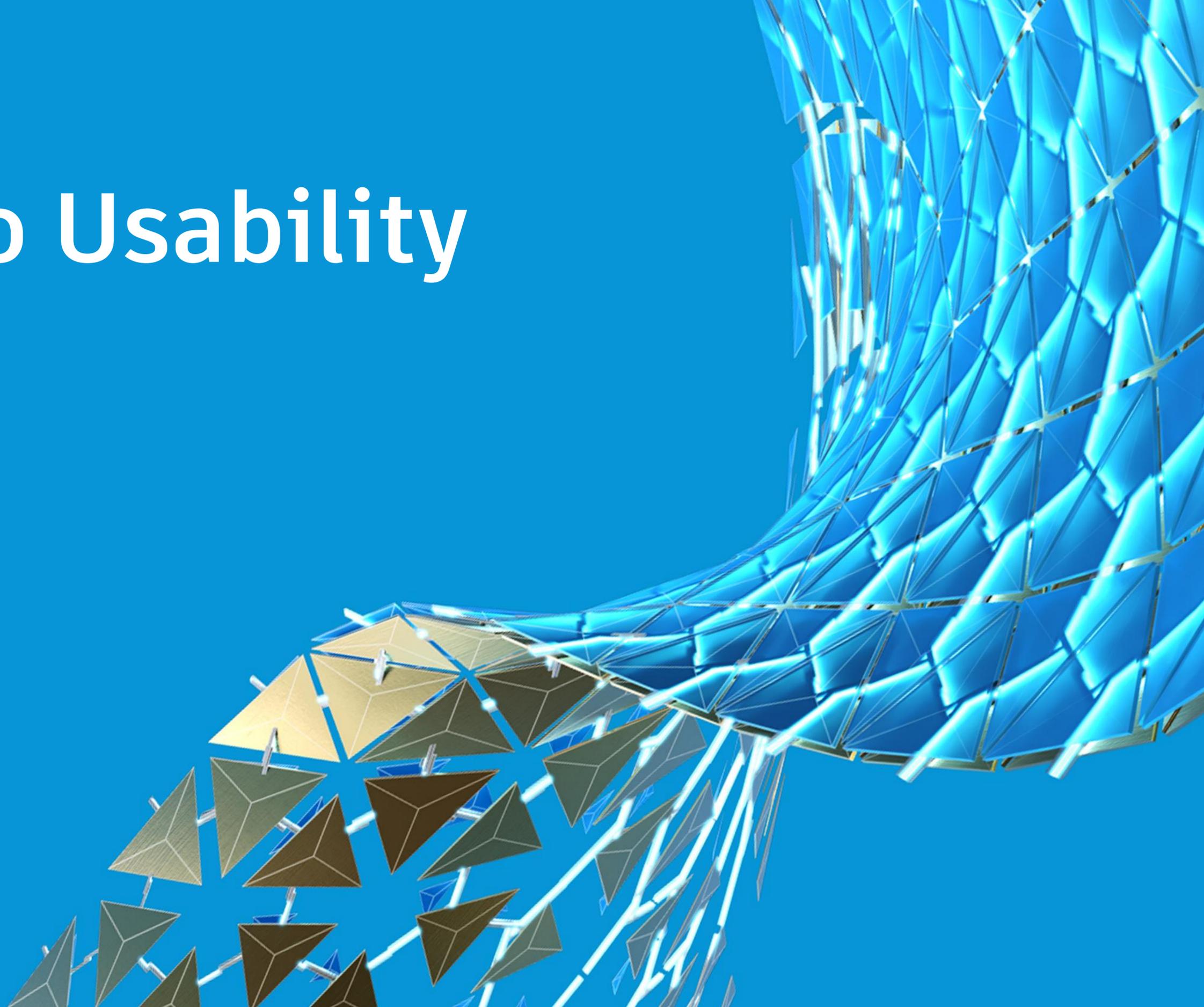
Daylighting Studies



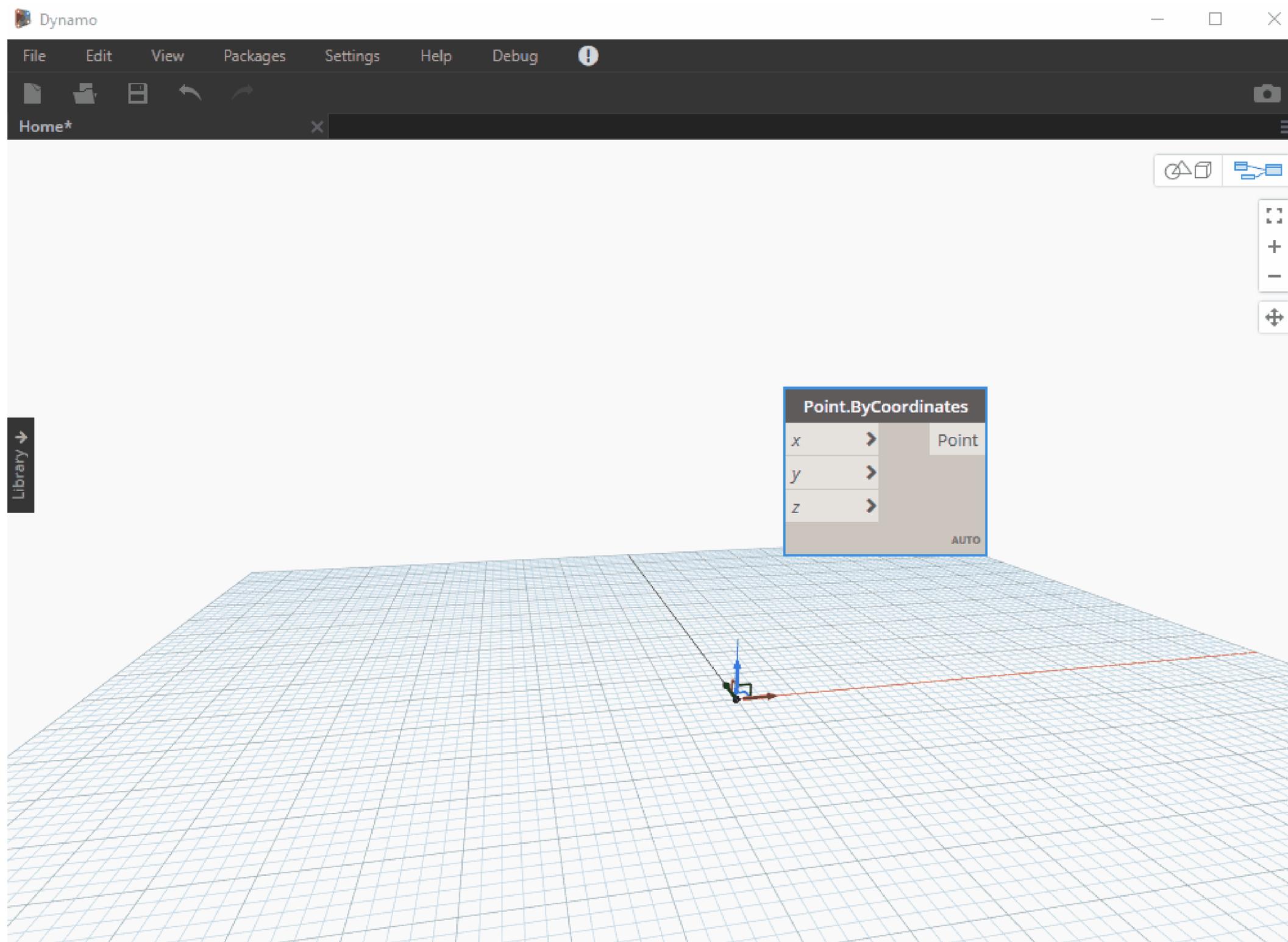
Embodied Carbon Analysis

Embodied Carbon Data From EC3	
Instance Name	Floor [492570]
Type Name	Metal Deck Composite Slab 70/2
Structural Material	Concrete, C1P, C30/37
Quantity	79.093 m <sup>3</sup>
Achievable	44.3k kgCO <sub>2</sub> e
Conservative	76.2k kgCO <sub>2</sub> e
GWP Savings	42%

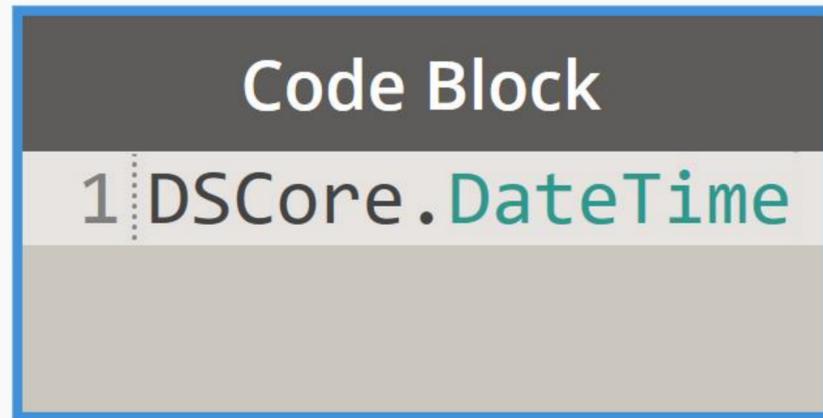
# 6. Dynamo Usability



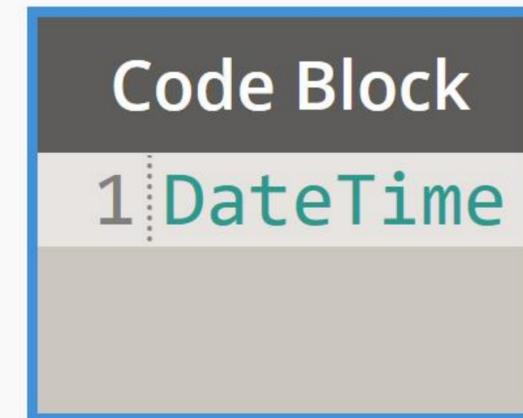
# Dynamo Usability: Node Auto-complete



## Dynamo Usability: Friendlier code block nodes



OLD WAY



NEW APPROACH

# Dynamo: Python 3

The screenshot shows the Dynamo Python Script node interface. On the left, a 'Python Script' node is shown with 'IN[0]', '+', '-', and 'OUT' buttons. Below it, a table displays the output of the script:

	Name	Age	Sex
0	Odinson, Thor	1505	male
1	Maximoff, Wanda	24	female
2	Banner, Dr. Bruce	54	male
3	Romanoff, Natasha	39	female
4	Stark, Tony	53	male
5	Danvers, Carol	65	female
6	Rogers, Steve	38	male

In the center, a 'Python Script' editor window shows the following code:

```
1 import pandas as pd
2
3 dataframe = pd.DataFrame({
4     "Name": ["Odinson, Thor",
5             "Maximoff, Wanda",
6             "Banner, Dr. Bruce",
7             "Romanoff, Natasha",
8             "Stark, Tony",
9             "Danvers, Carol ",
10            "Rogers, Steve"],
11     "Age": [1505, 24, 54, 39, 53, 65, 38],
12     "Sex": ["male", "female", "male",
13            "female", "male", "female",
14            "male"]
15 })
16
17 OUT = repr(dataFrame)
```

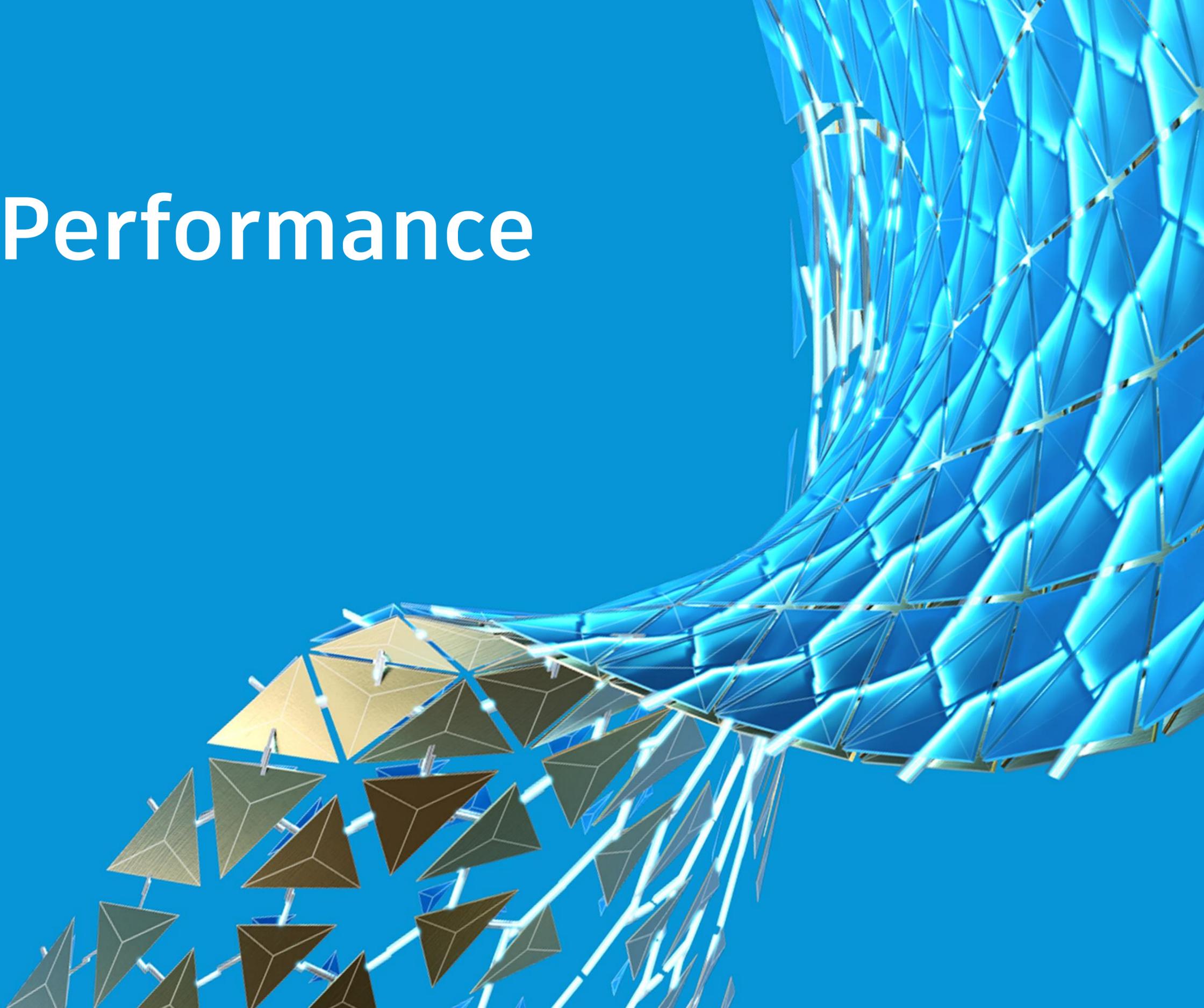
At the bottom of the editor, there is a 'Run' button, a dropdown menu set to 'CPython3', and other controls. On the right, a 'Documentation Browser' is open, showing a page about Python 3 node issues and backwards compatibility.

Node indicates selected Python engine outside of editor window

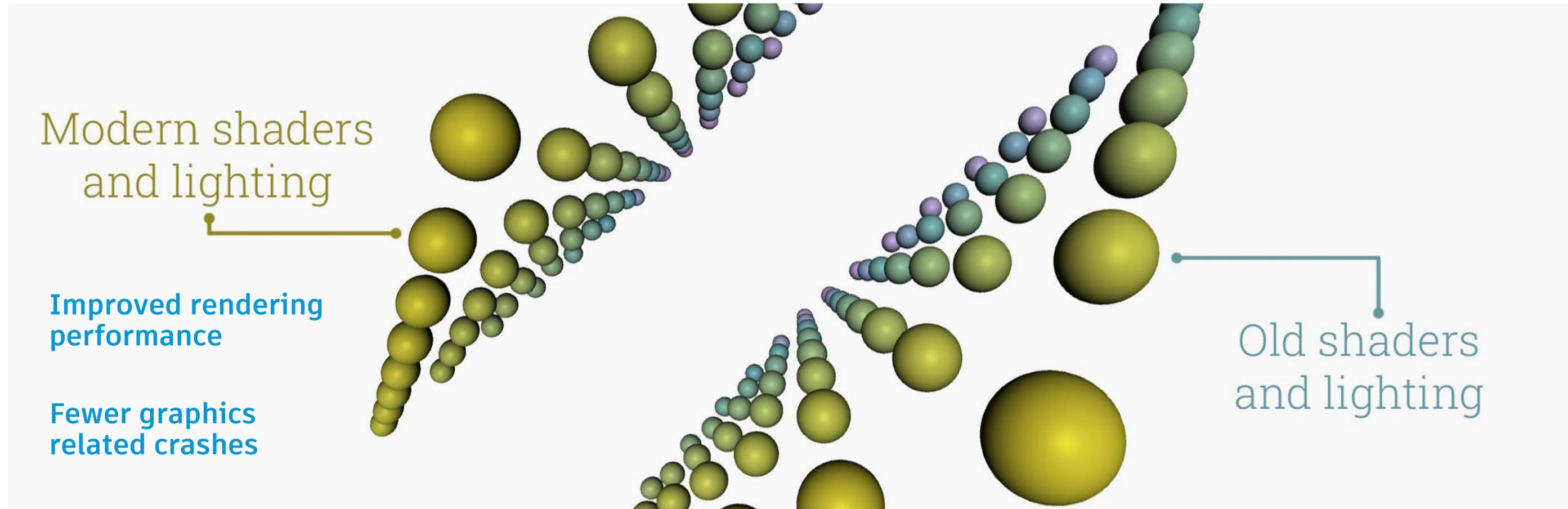
Graph author can choose the Python engine

Graph author can understand context in the Documentation Browser

# 7. Dynamo Performance



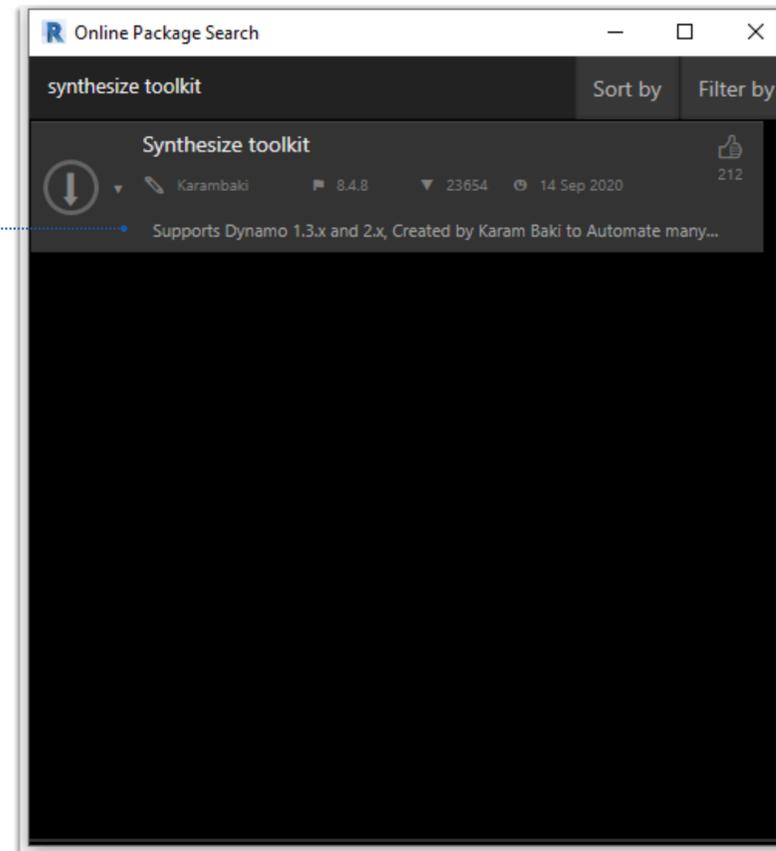
# Dynamo Performance: updated graphics engine



More info: <https://dynamobim.org/dynamo-graphics-updates/>

# Dynamo Performance Improvements

Package Manager speed improvements of up to 25x



A graphic featuring a light blue background with a large, dark blue starburst shape in the center. The words "Pop Quiz!" are written in a bold, white, sans-serif font across the middle of the starburst.

**Pop Quiz!**

# Roadmap Themes Feedback Wanted

Please visit <http://autode.sk/AU20GDinRevitFeedback> and tell us what you think about our roadmap!

- 1. Study Type Editing** make graph authors more successful in creating design study types for use in Generative Design.
- 2. Study Type Sharing** make it easier for graph authors to share generative design study types with Revit designers to run in Generative Design in Revit.
- 3. Outcome Sharing** make it easier to export results for sharing with stakeholders and telling data-backed design story
- 4. Generative Design in more Autodesk Applications**
  - extend Generative Design tools to other Dynamo enabled applications including Civil 3D, Robot Structural, and FormIt.
- 5. Analysis Tools for Dynamo and Generative Design**
  - provide access to environmental and other kinds of analysis tools for generative workflows.
- 6. Dynamo Usability** – make Dynamo more friendly and easy to use
- 7. Dynamo Performance** – make Dynamo faster and more stable



# Resources

## 2020 AUTODESK UNIVERSITY COURSES

- Generative Design in Revit for Workspace Layout - Tomasz Fudala
- Non-Geeks Guide to Optimizing Daily Workflows with Generative Design - Raquel Bascones Recio
- Using Generative Design and Machine Learning for Faster Analysis Feedback - Varvara Toulkeridou
- Generative Design at Hogwarts: Using Tech Instead of Magic - Jacob Small
- Generative Design für Revit in der Praxis - Lejla Secerbegovic
- Diseño Generativo en Revit para todos los públicos - Raquel Bascones Recio
- Generative Design—Daylighting and CFD: A Practical Application for a Nonprofit - Luc Wing
- Generative Design of Landforms with Dynamo in Civil 3D - Andreas Luka

# Resources

## GENERATIVE DESIGN PRIMER

<https://www.generativedesign.org>

## DYNAMO PRIMER, FORUM & BLOG

<https://primer.dynamobim.org/>

<https://forum.dynamobim.com/>

<https://dynamobim.org/blog/>

## PAST AUTODESK UNIVERSITY COURSES

- [Geometry Systems for AEC Generative Design: Codify Design Intents into the Machine](#)
- [MEP Explore: Generative Design for MEP Designers](#)
- [Getting Started with Generative Design for AEC](#)
- [Using Generative Design in Construction Applications](#)

## PRODUCT HELP

[Product help](#)

[Release notes](#)



Autodesk and the Autodesk logo are registered trademarks or trademarks of Autodesk, Inc., and/or its subsidiaries and/or affiliates in the USA and/or other countries. All other brand names, product names, or trademarks belong to their respective holders. Autodesk reserves the right to alter product and services offerings, and specifications and pricing at any time without notice, and is not responsible for typographical or graphical errors that may appear in this document.

© 2020 Autodesk. All rights reserved.

