

# Non-Geeks Guide to Optimizing Daily Workflows with Generative Design

**Raquel Bascones Recio**

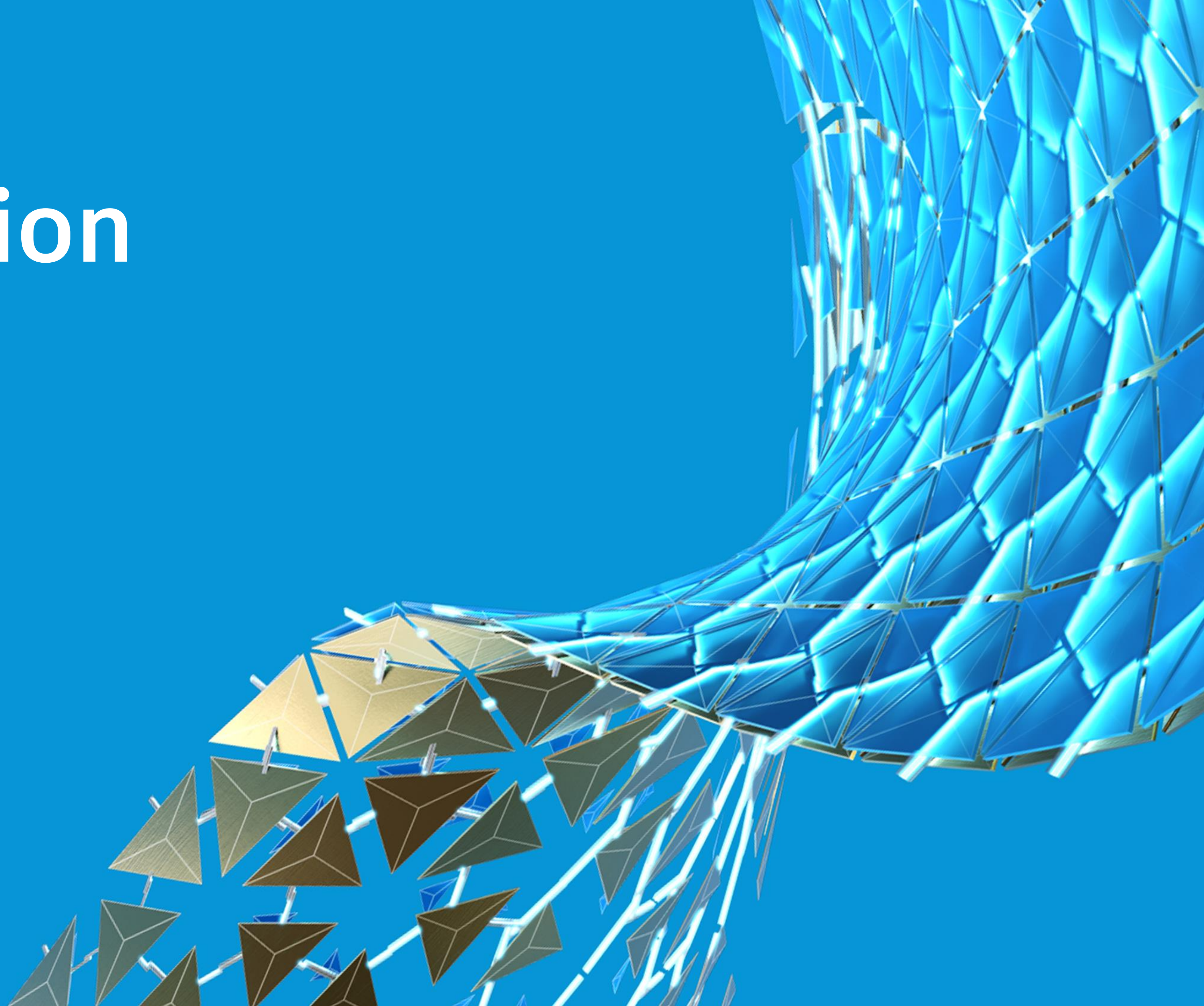
Senior Implementation Consultant, Autodesk | @raquel\_bascones

**Paolo Emilio Serra**

Principal Implementation Consultant, Autodesk | @PaoloESerra



# Introduction







# Raquel Bascones Recio

**Sr. Implementation Consultant**

**2010 – 2017: Architect & Landscape Architect**

**2017 – 2019: Autodesk Global Product Support**

**2020: Autodesk Consulting**

**[raquel.bascones.recio@autodesk.com](mailto:raquel.bascones.recio@autodesk.com)**

**[Twitter](#)**

**[LinkedIn](#)**





# Paolo Emilio Serra

Pr. Implementation Consultant

**2008 – 2014 BIM Manager**

**2013 – Revit API & Dynamo**

**2014 – Autodesk Consulting**

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[@PaoloESerra](#)

[puntorevit.blogspot.com](http://puntorevit.blogspot.com)



# Learning Objectives

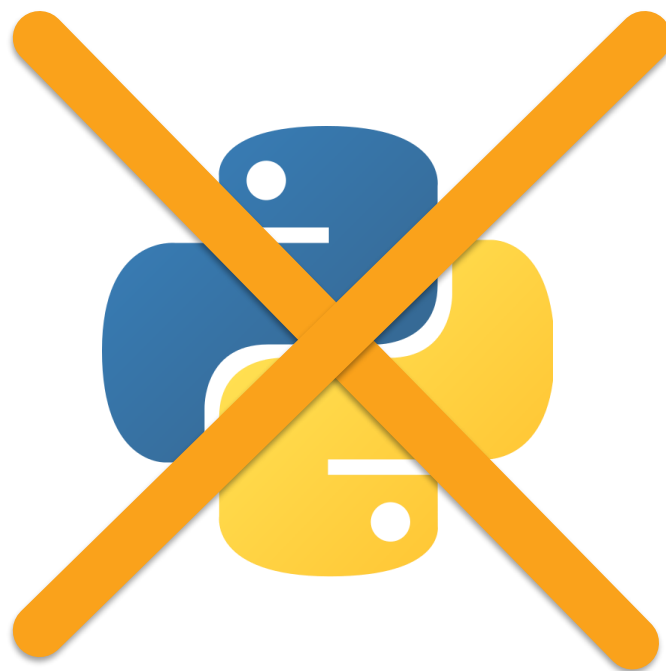
- Discover potential workflows for optimization
- Learn how to compose Dynamo graphs ready for Generative Design in Revit
- Learn how to implement Generative Design to optimize repetitive tasks
- Learn how to adapt given examples to custom needs



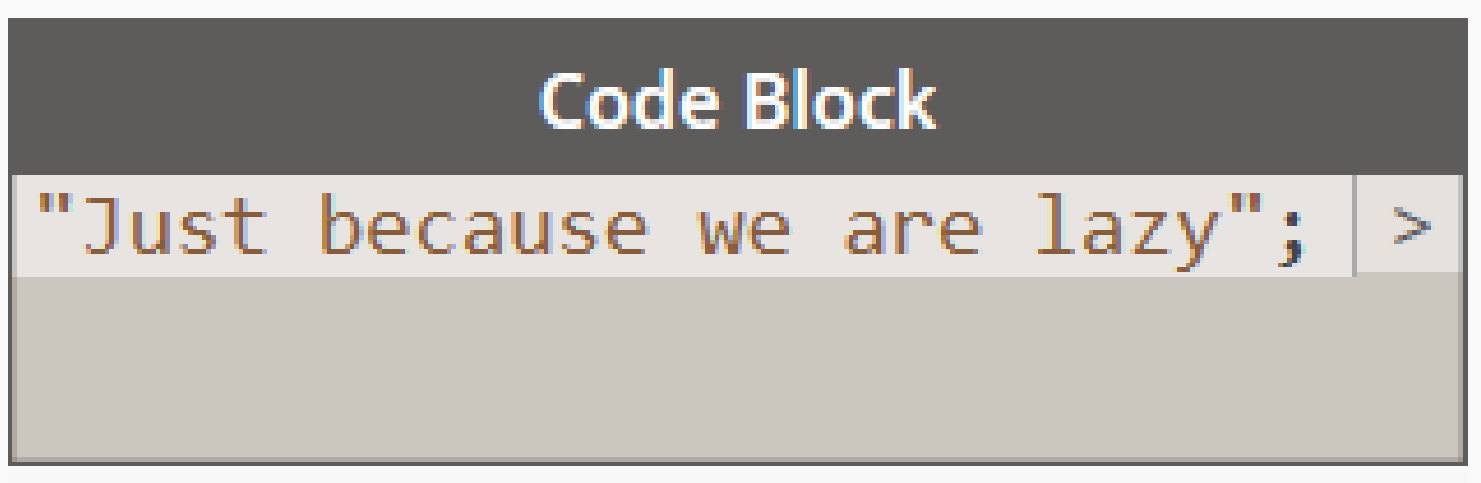


# Why Non-Geek?

NO PYTHON SCRIPTING



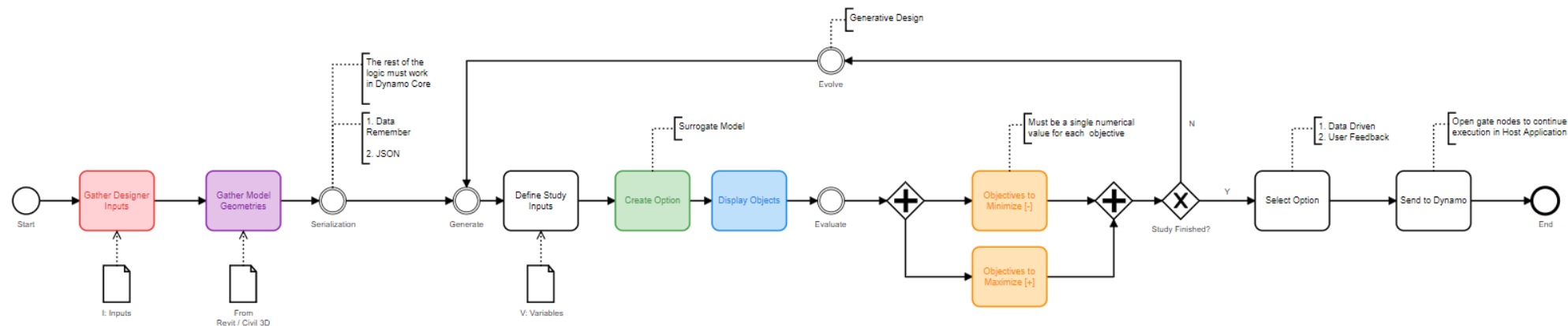
LIMITED DESIGNSCRIPT USE



NO THIRD-PARTY PACKAGES REQUIRED

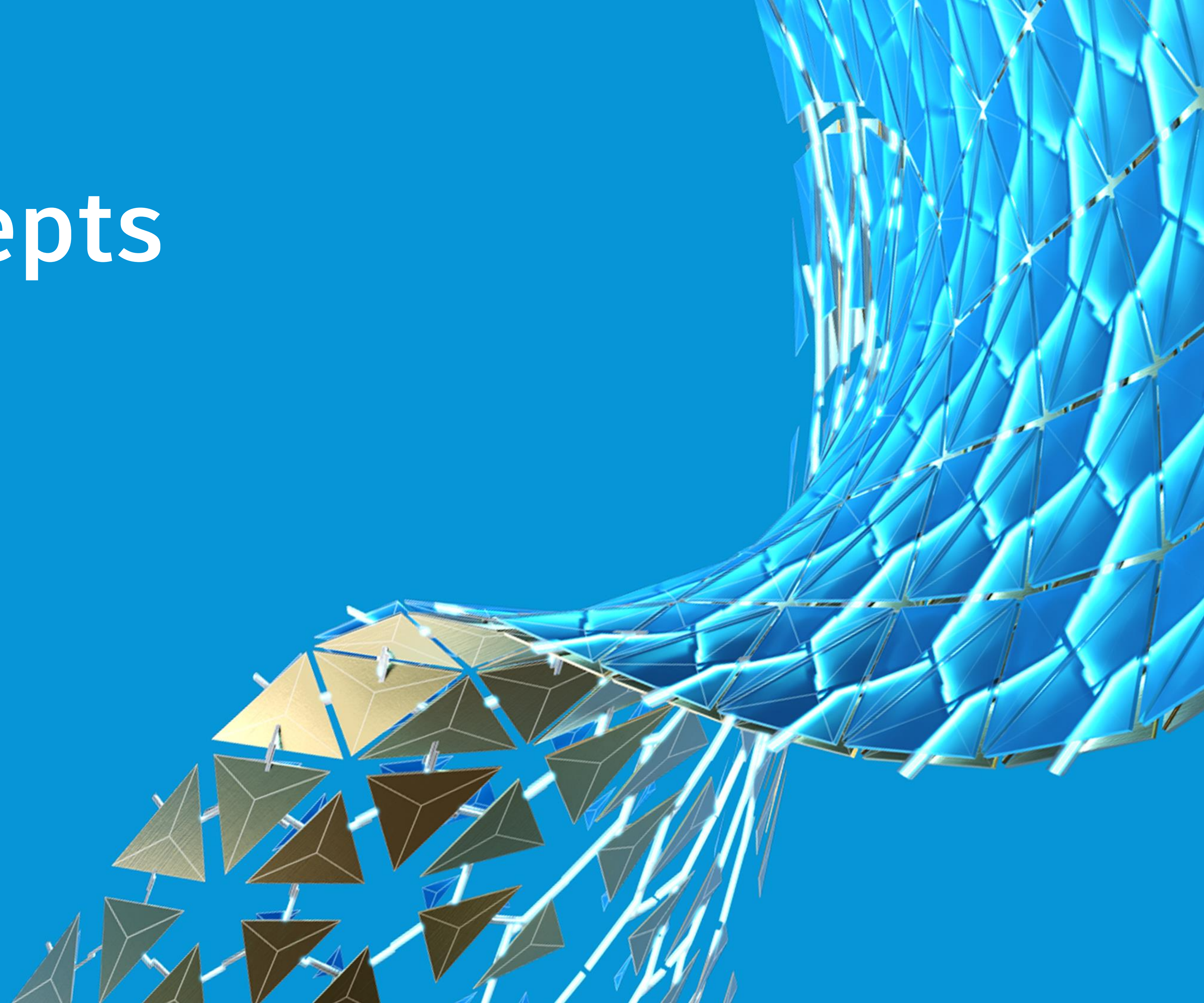


EASY TO FOLLOW TEMPLATE





# Key Concepts





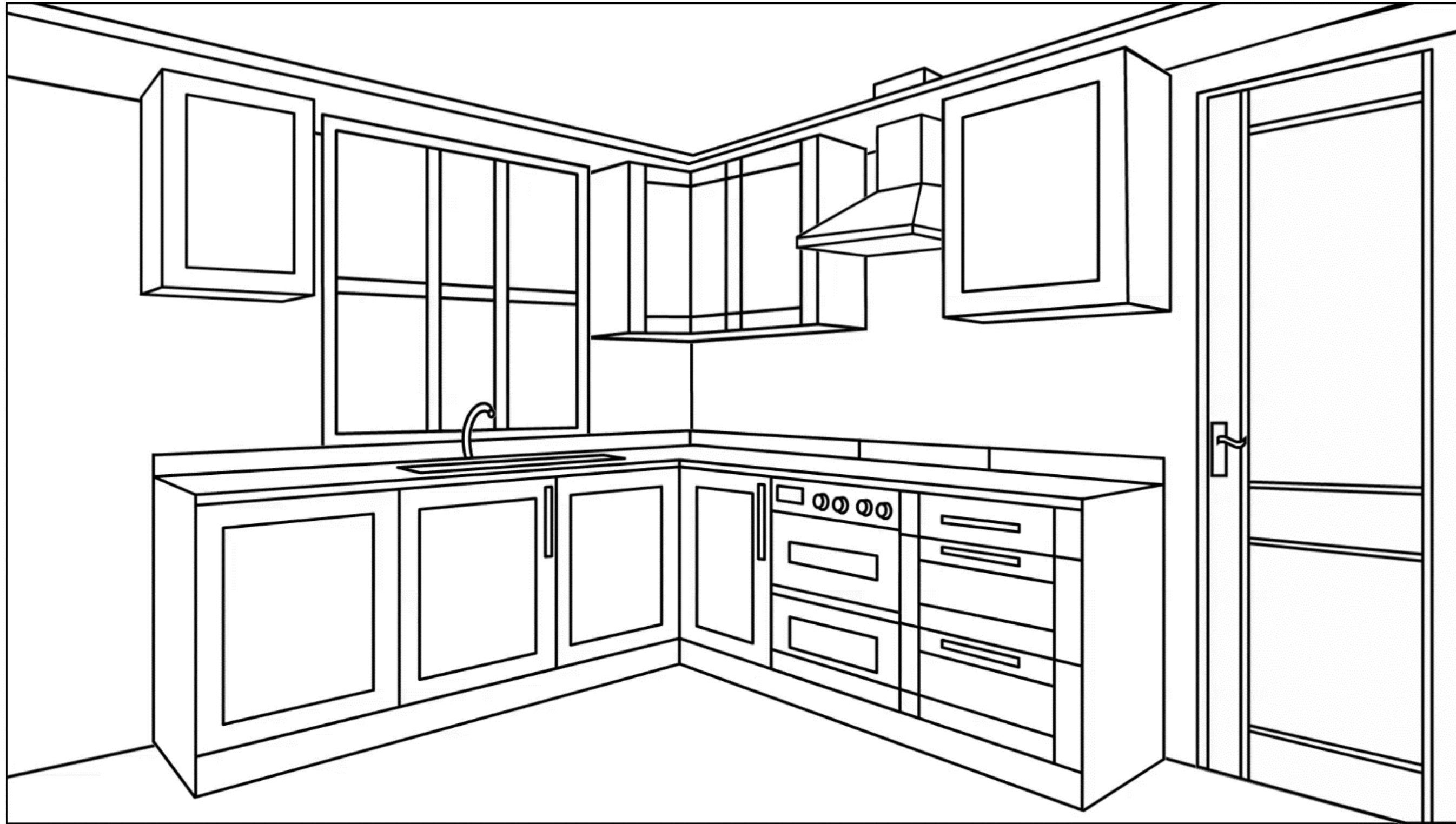
# ***Algorithm***

[æɪ.lɡə.rɪ.ðəm]

a set of mathematical instructions or rules that, especially if given to a computer,  
will help to calculate an answer to a problem



# Algorithm



[Link](#)



# *Generative Design*

['dʒen.ər.ə.tɪv dɪ'zain]

a process that uses iteration to refine the potential solutions to a problem against certain metrics and constraints.



# Generative Design



[Link](#)



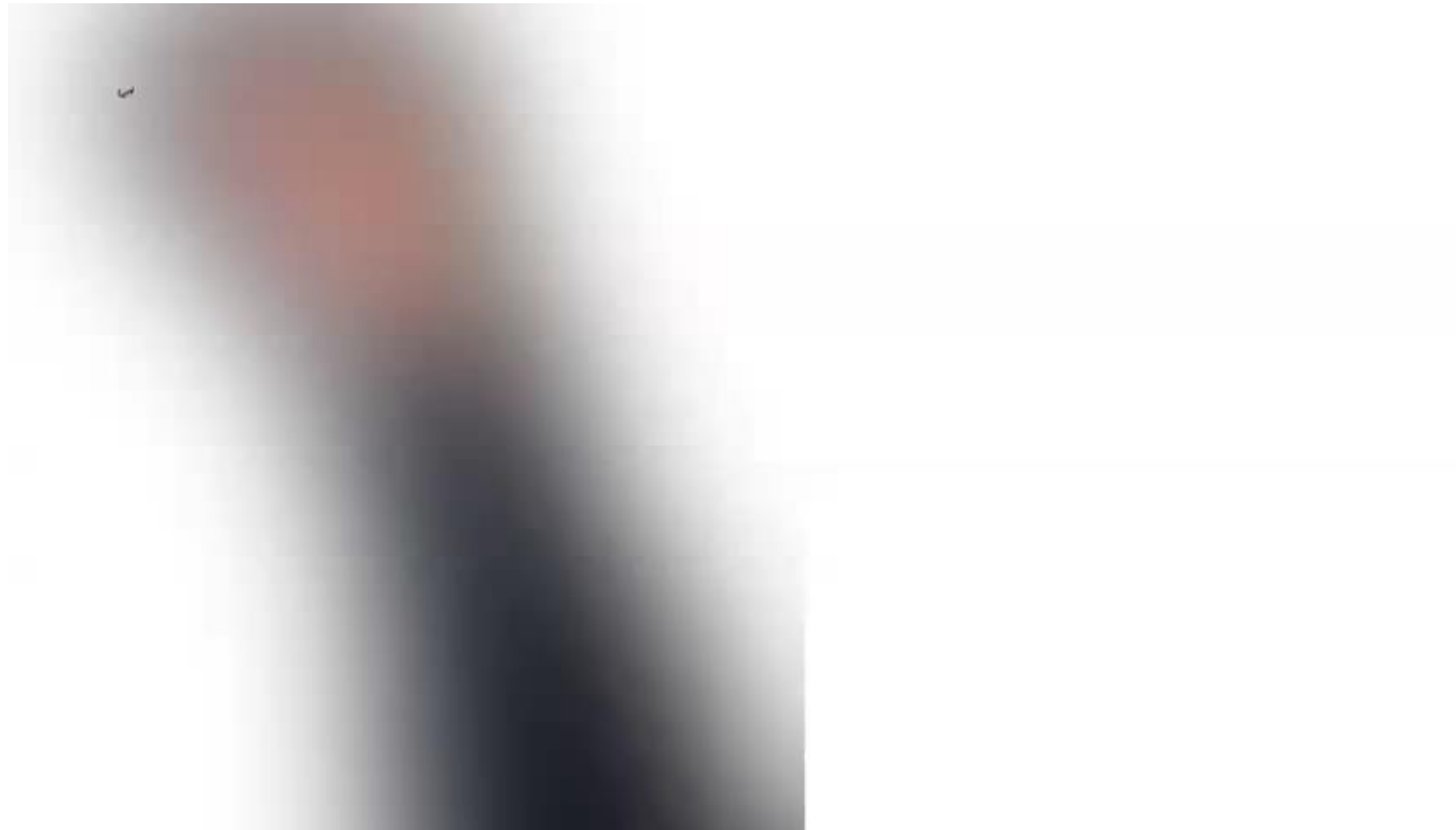
# ***Machine Learning***

[mə'ʃiːn 'lɜːnɪŋ]

computer algorithms that improve automatically through experience.



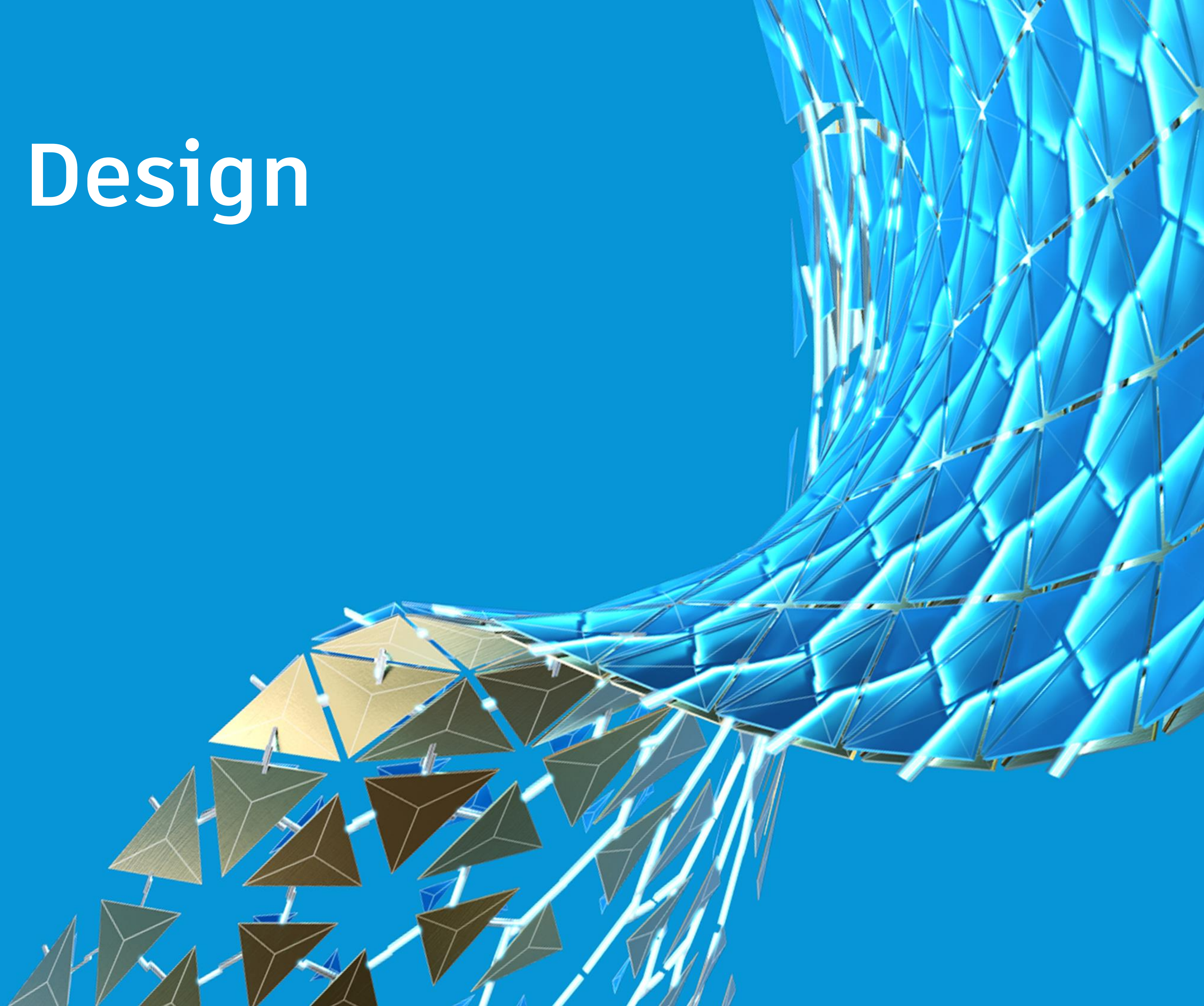
# Machine Learning



[Link](#)



# Generative Design Workflow





# Generative Design Workflow



[Link](#)



# Try, Learn, Repeat

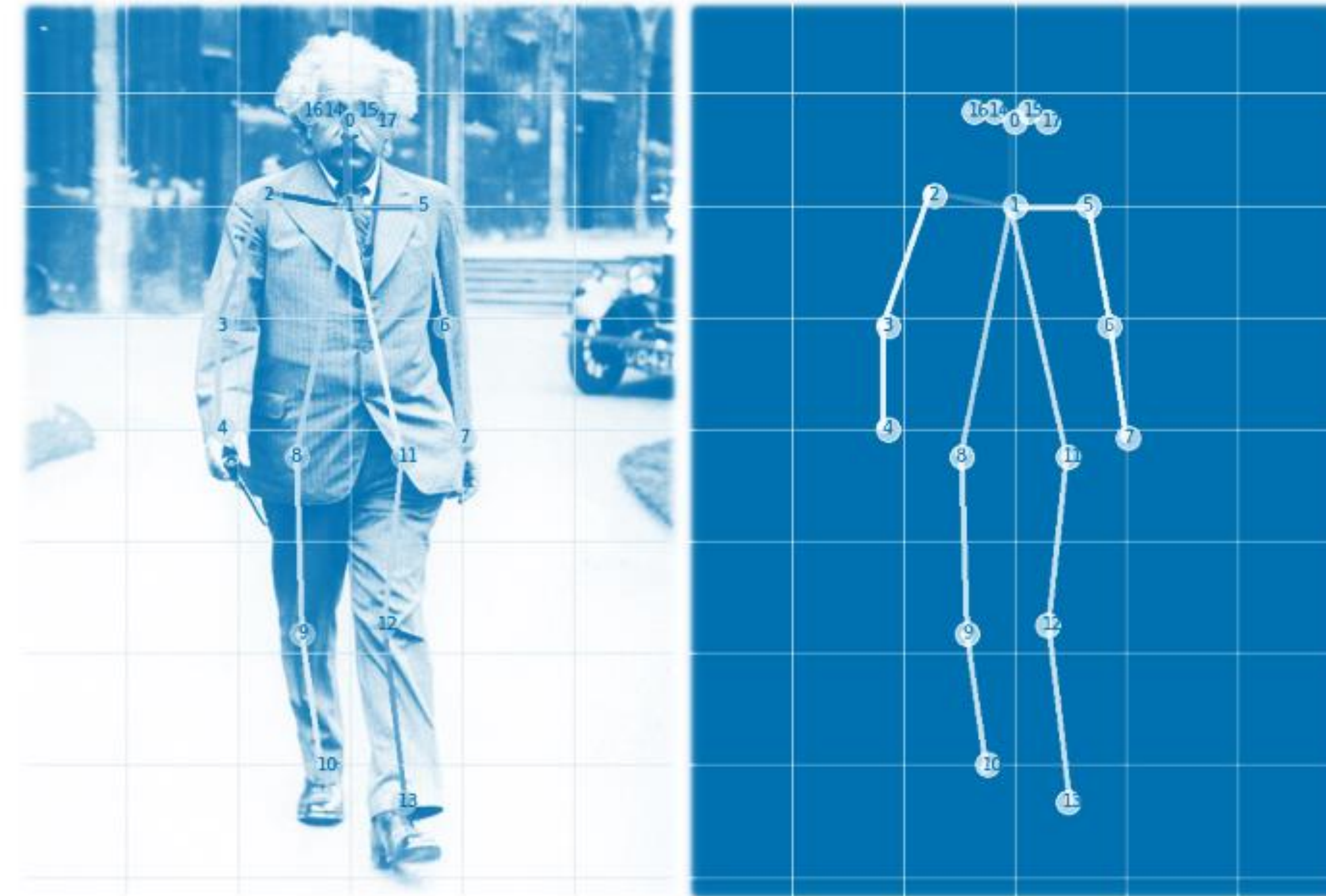
- **Goal** Sank as many ships as possible
- **Design Space** Grid of cells with two coordinates
- **Strategy**
  - Pick a cell (Generate)
  - Wait for result (Evaluate)
  - Decide next move (Evolve)
- **Winning Criterion**
  - Maximize sank ships
  - Maximize hits
  - Minimize attempts

	A	B	C	D	E	F	G	H	I	J
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										



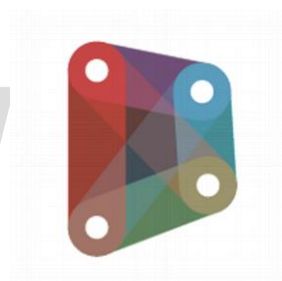
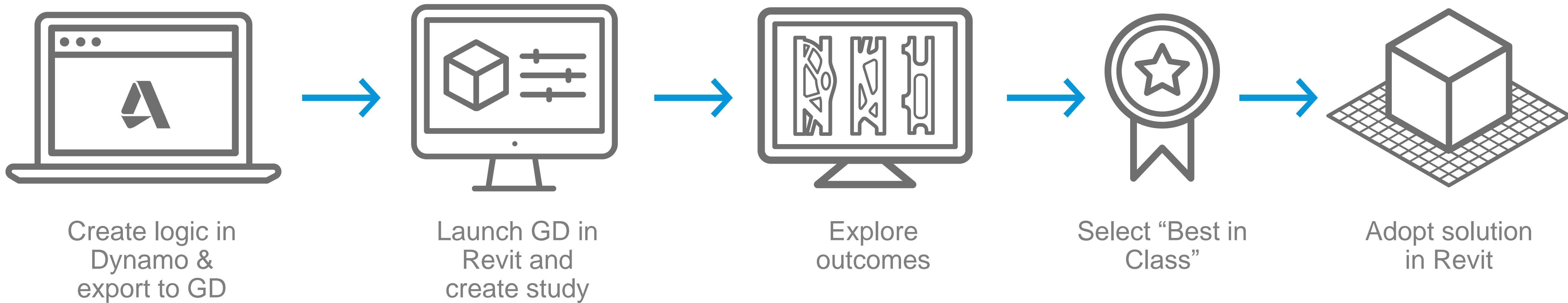
# Surrogate Model

- **Abstract representation of a real problem**
  - It is the result of the initial analysis
  - It helps focusing on the key features
  - It supports the visualization of parts





# Generative Design in Revit





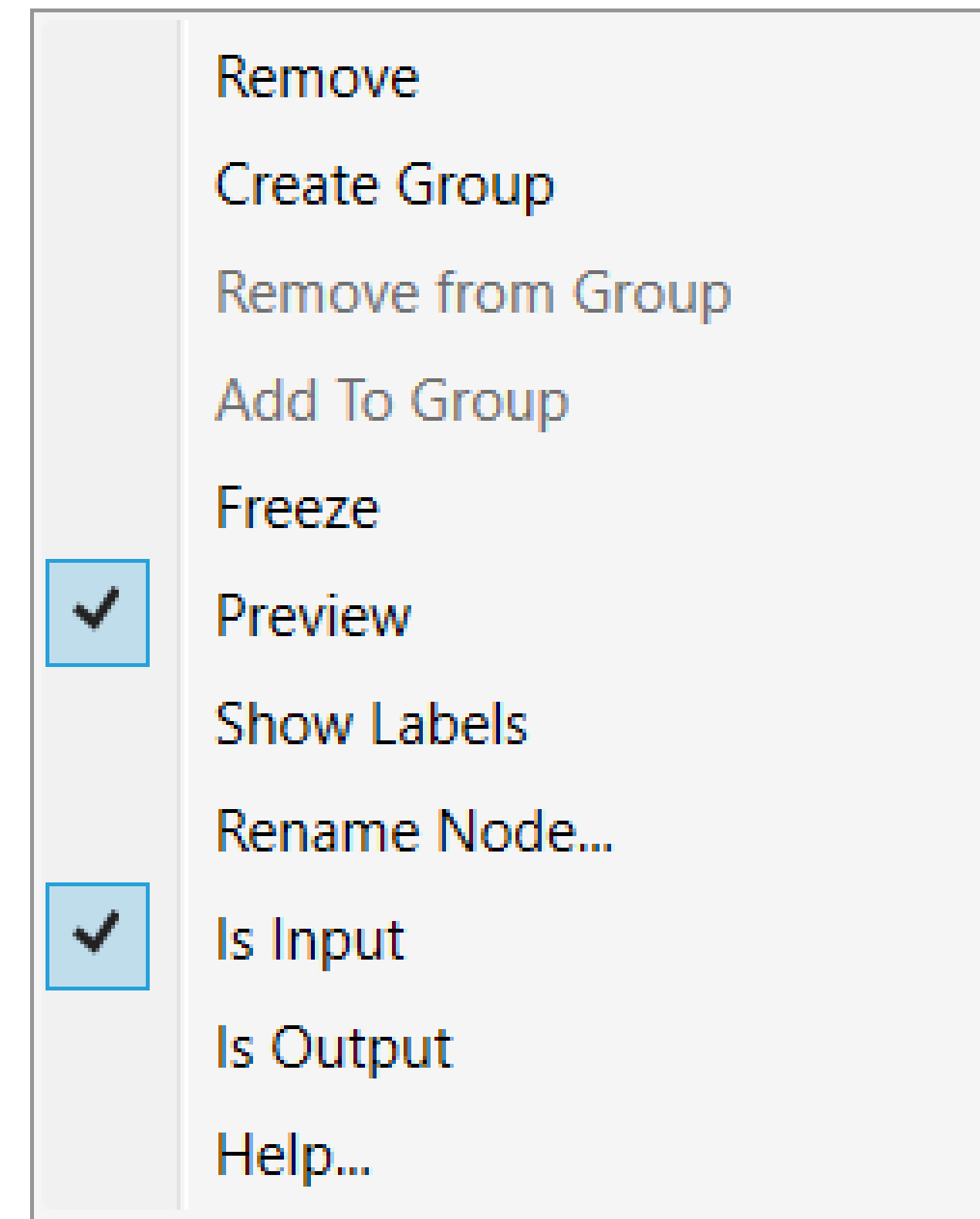
# Dynamo Graphs for GD

## INPUTS & VARIABLES

- Number/Integer slider, Boolean or Revit Selection nodes
- Check “*Is Input*” for each input node
- Rename nodes to a unique name

## OUTPUTS & METRICS

- Only Watch nodes with a *Number* value
- Check “Is Output” for each output node
- Rename nodes to a unique name

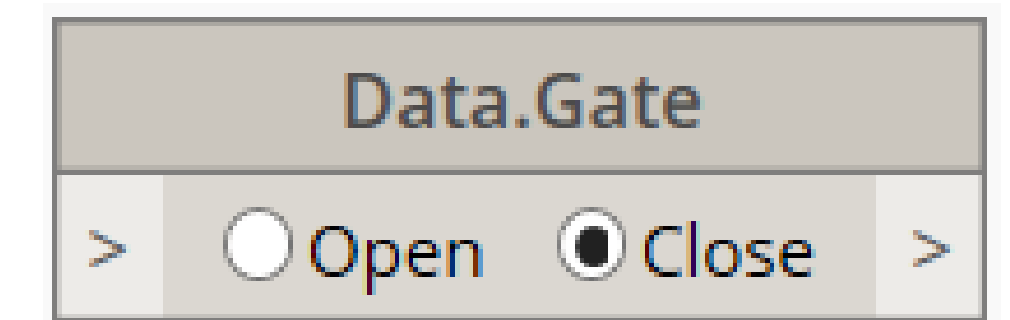
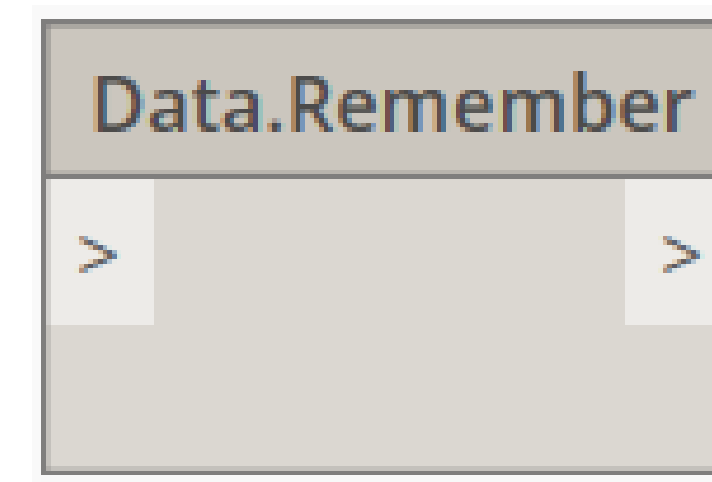




# Dynamo Graphs for GD

## INTERACTION WITH REVIT

- Generation can only be executed with Dynamo code
- All references to Revit data should be stored in a *Data.Remember* node
- *Data.Gate* node will create or modify elements in Revit when you select “Create Revit Elements”

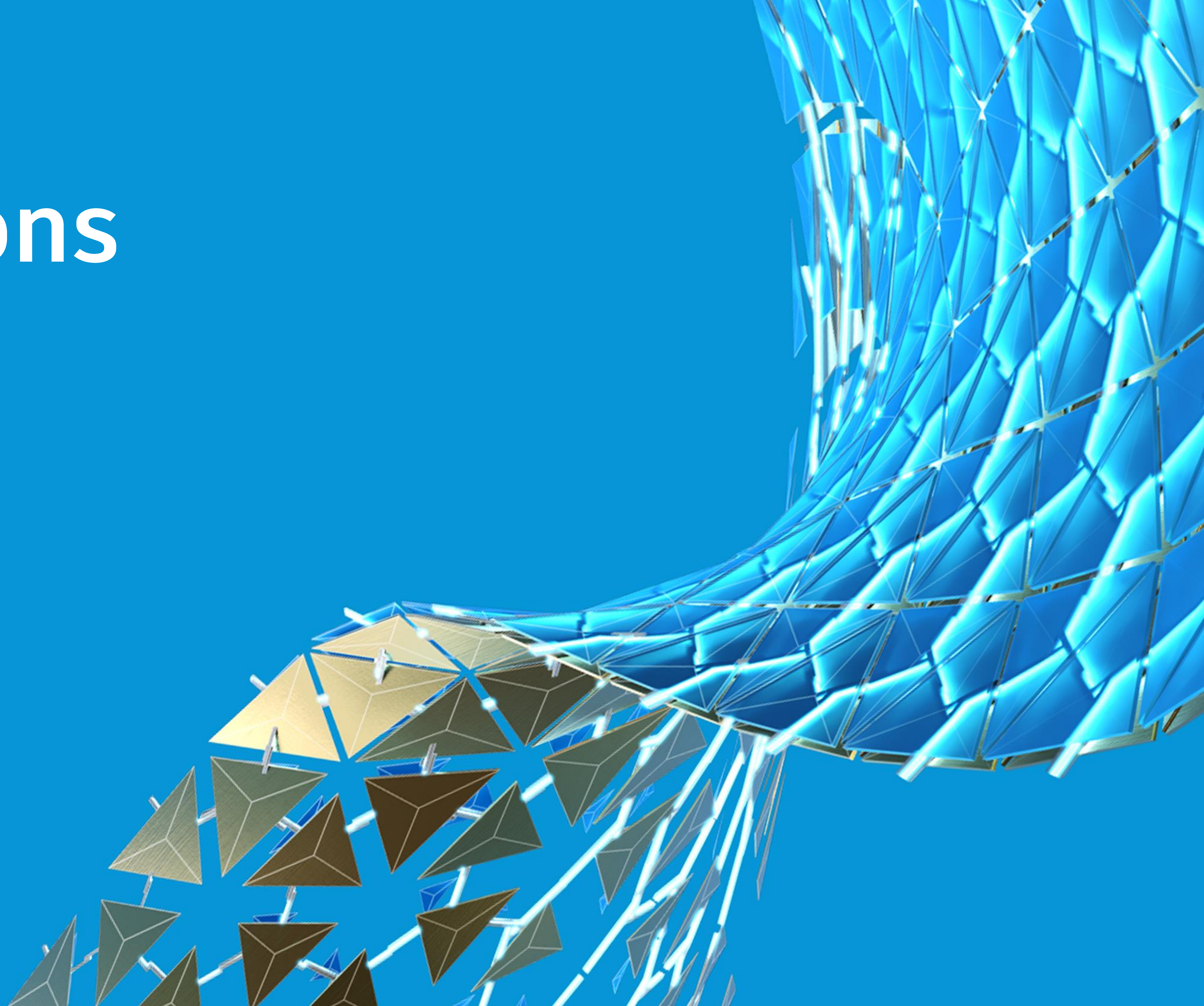


## DISPLAY

- The geometry for the different options in the study will be displayed as in the Dynamo Graph when it was exported
- It is highly recommended to colour the geometry with codes for visual comparison



# Applications





# 01 Pick Apartment





# 01 Pick Apartment | *Problem Statement*

**Find the option from a list that has the most favourable combination of price, area, number of rooms, management costs, energy costs, most recent construction, on an intermediate level, with a lift and possibly with furniture**

**To finalize the selection there is need to examine the pictures, visit the apartment and evaluate the surroundings, etc.**





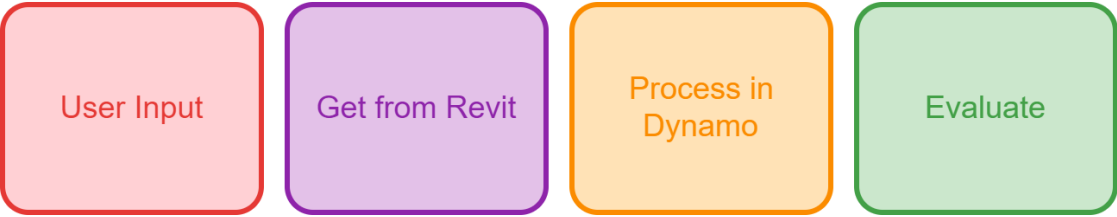
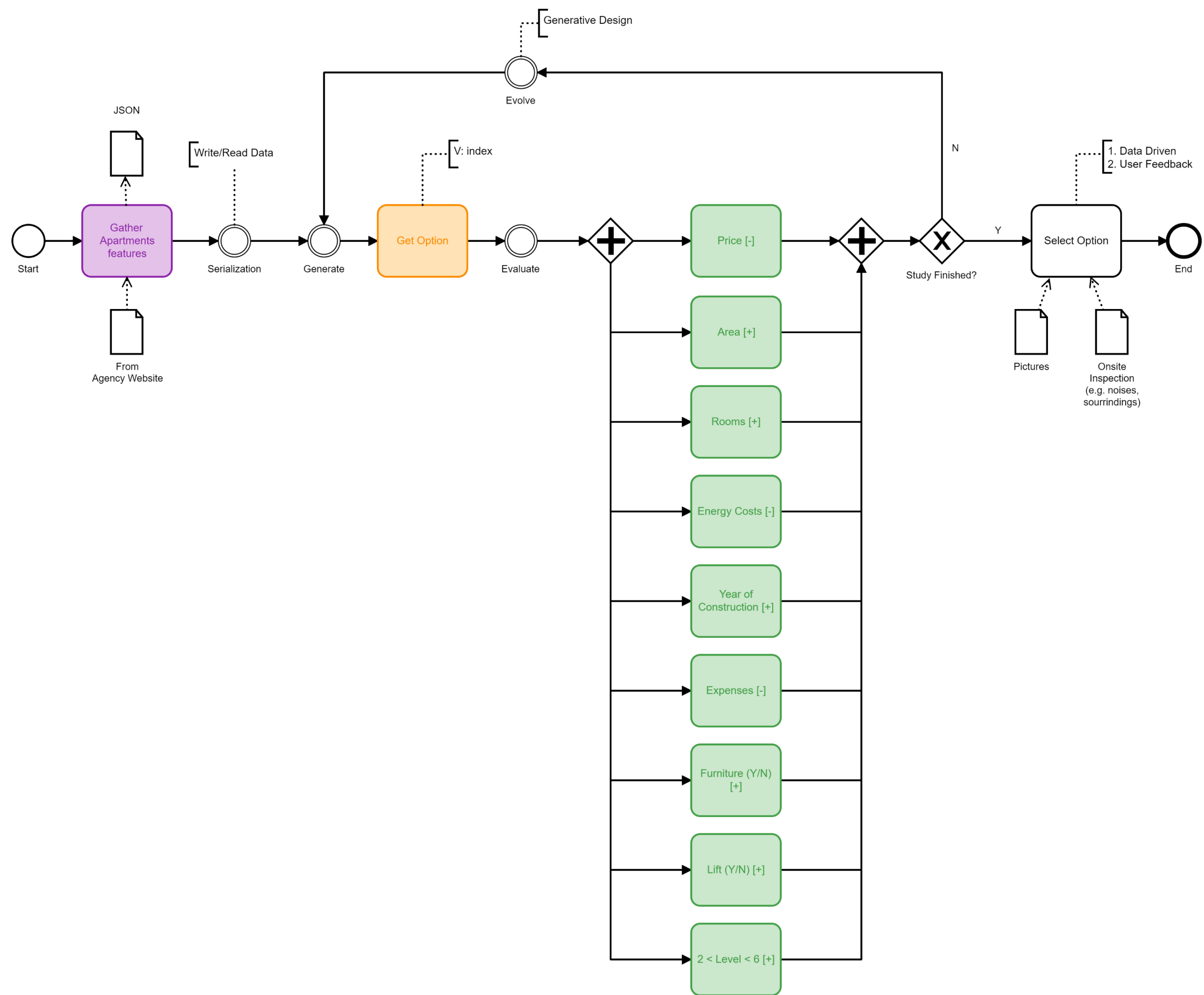
# 01 Pick Apartment | *Problem Statement*

- **Inputs / Constraints**
  - The catalog with all characteristics of the apartments
- **Variables**
  - The index of the apartment
- **Objectives**
  - Price/Costs [-]
  - Area [+]
  - Rooms [+]
  - Year of Construction [+]
  - Intermediate level 2-6 [+]
  - Lift Y/N [+]
  - Furniture Y/N [+]





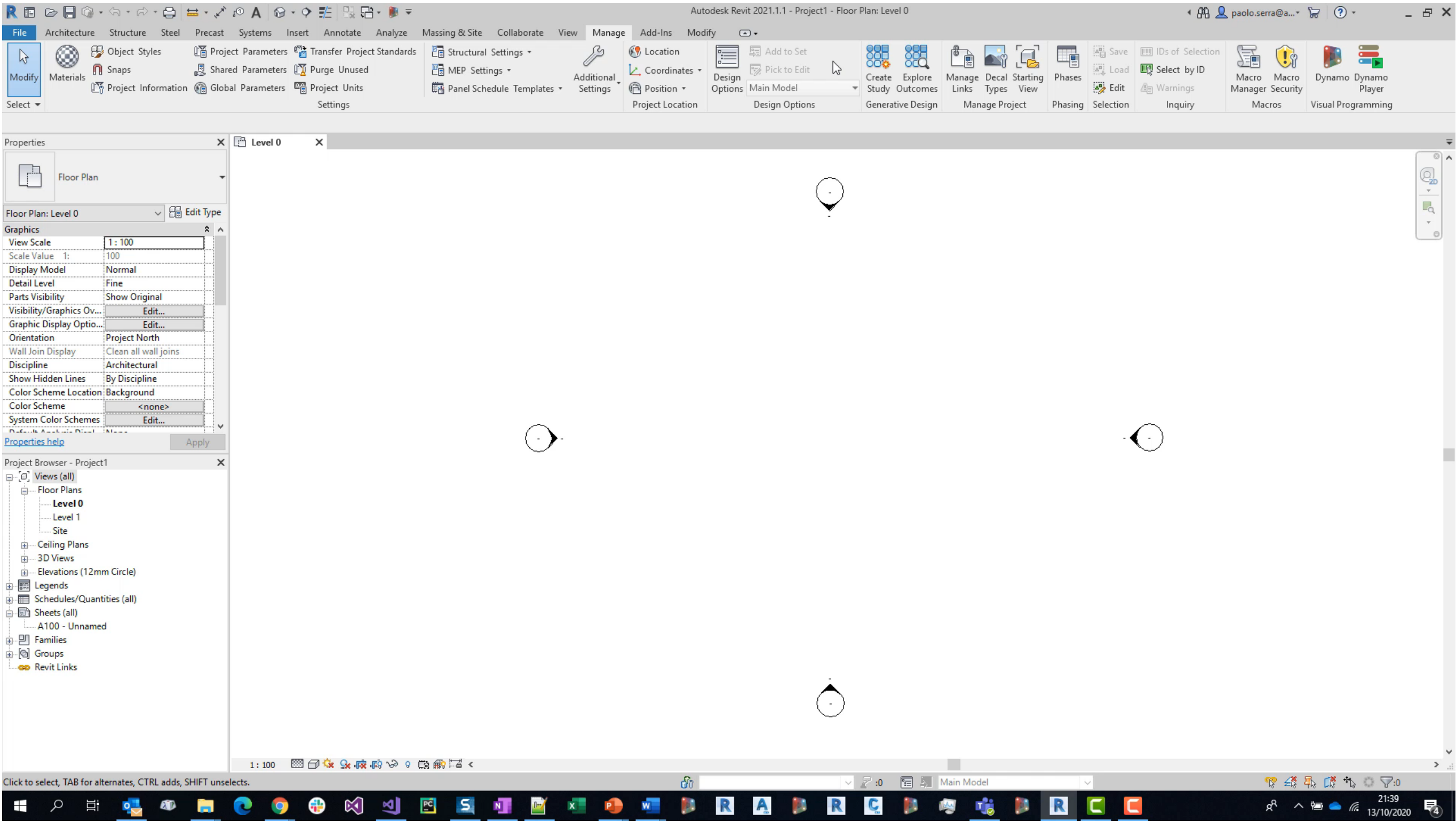
# 01 Pick Apartment | *Process Diagram*



[Link](#)



# 01 Pick Apartment | *Study in action*



[Link](#)



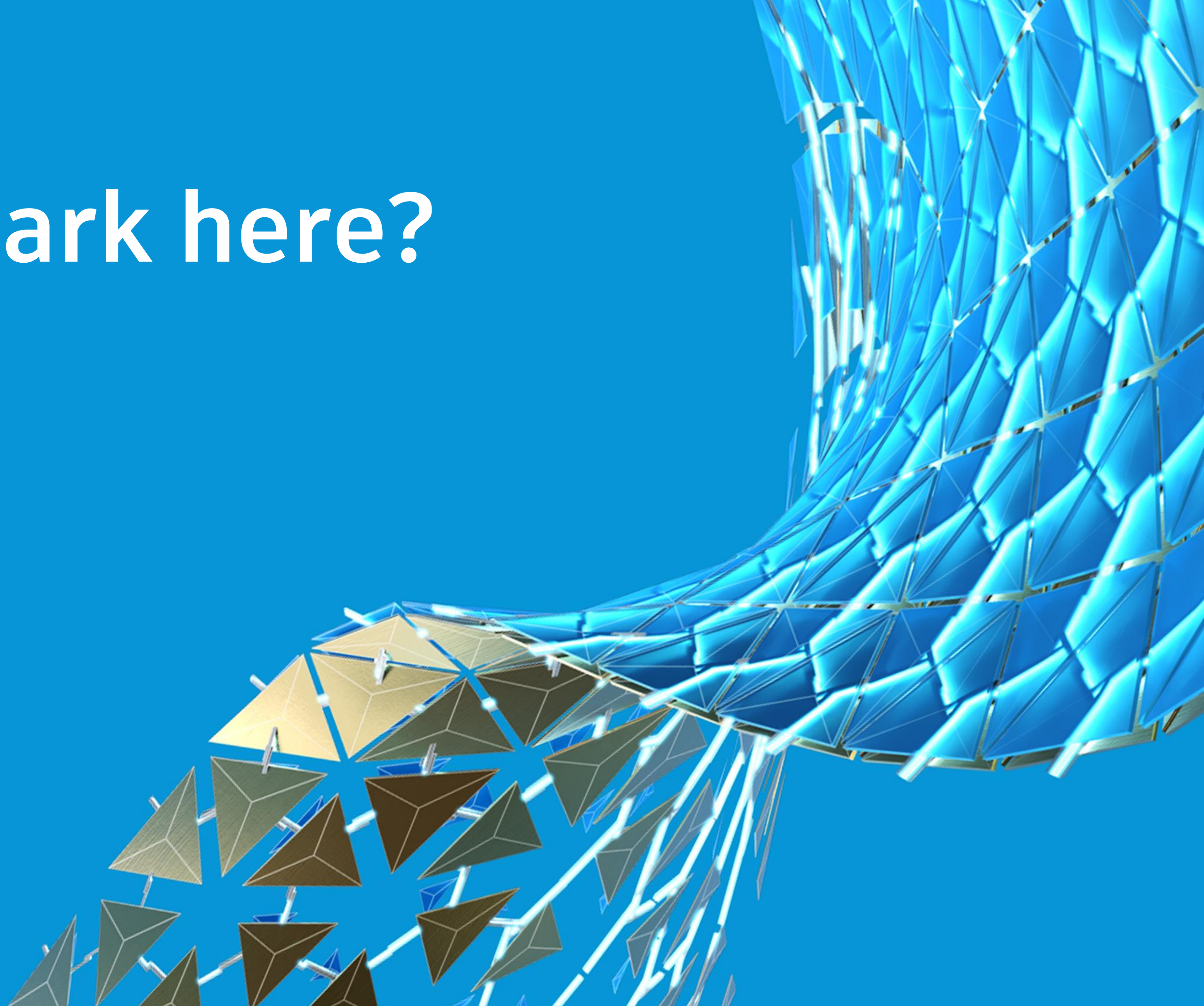


## 01 Pick Apartment | *Similar applications*

- Selection of equipment types/models
- Selection of Cross-Sections
- Selection of Materials



# 02 Can I park here?





## 02 Can I park here?| *Problem Statement*

*Optimize the position of the car inside a parking bay so the driver's door can open, the vehicle is inside the designated area, and there are no clashes*





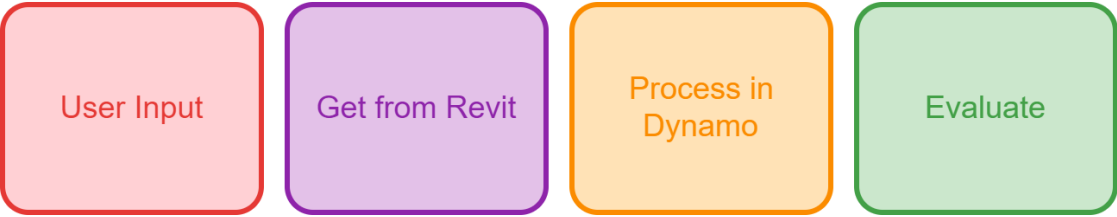
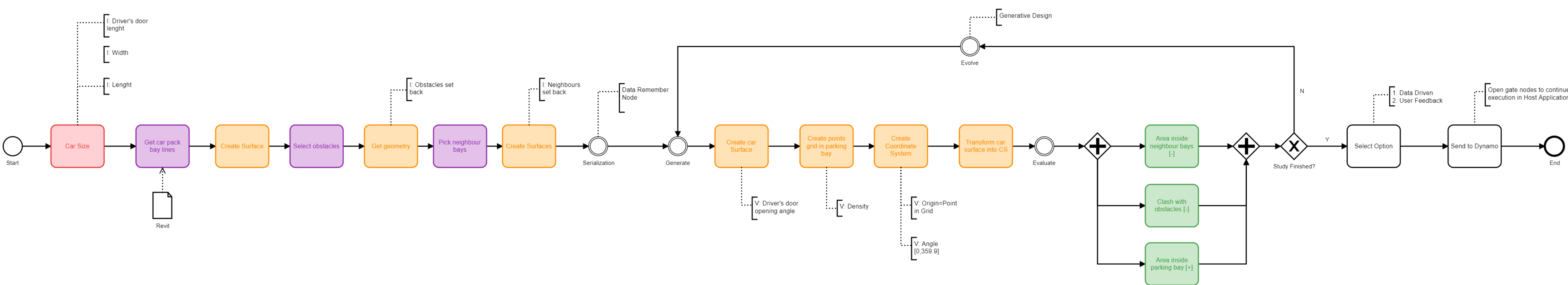
## 02 Can I park here?| *Problem Statement*

- **Inputs / Constraints**
  - Car size
  - Parking bay shape & dimensions
  - Obstacles (i.e. walls, columns, etc.)
  - Neighbouring parking bays
  - Distances allowances
- **Variables**
  - Driver's door opening angle
  - Density of the grid of origin points
  - Origin point
  - Rotation angle
- **Objectives**
  - Intersection with neighbours [-]
  - Clashes with obstacles [-]
  - Area inside parking bay [+]





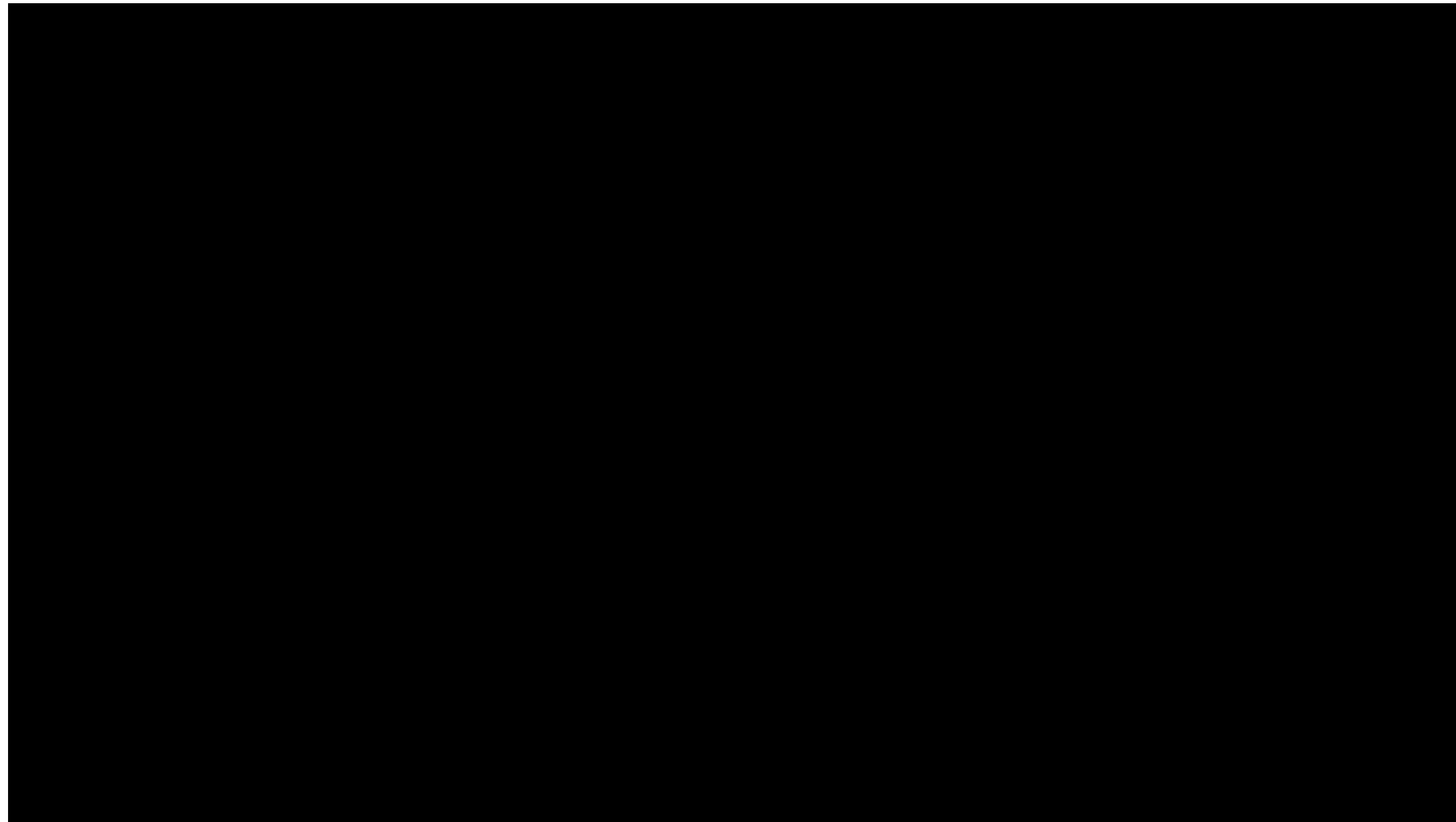
# 02 Can I park here?| *Process Diagram*



[Link](#)



## 02 Can I park here?| *Study in action*



[Link](#)





## 02 Can I park here? | *Similar applications*

- Logistics planning
- Building outline in plot
- Tree planting in urban environments



# 03 Shape arrangement

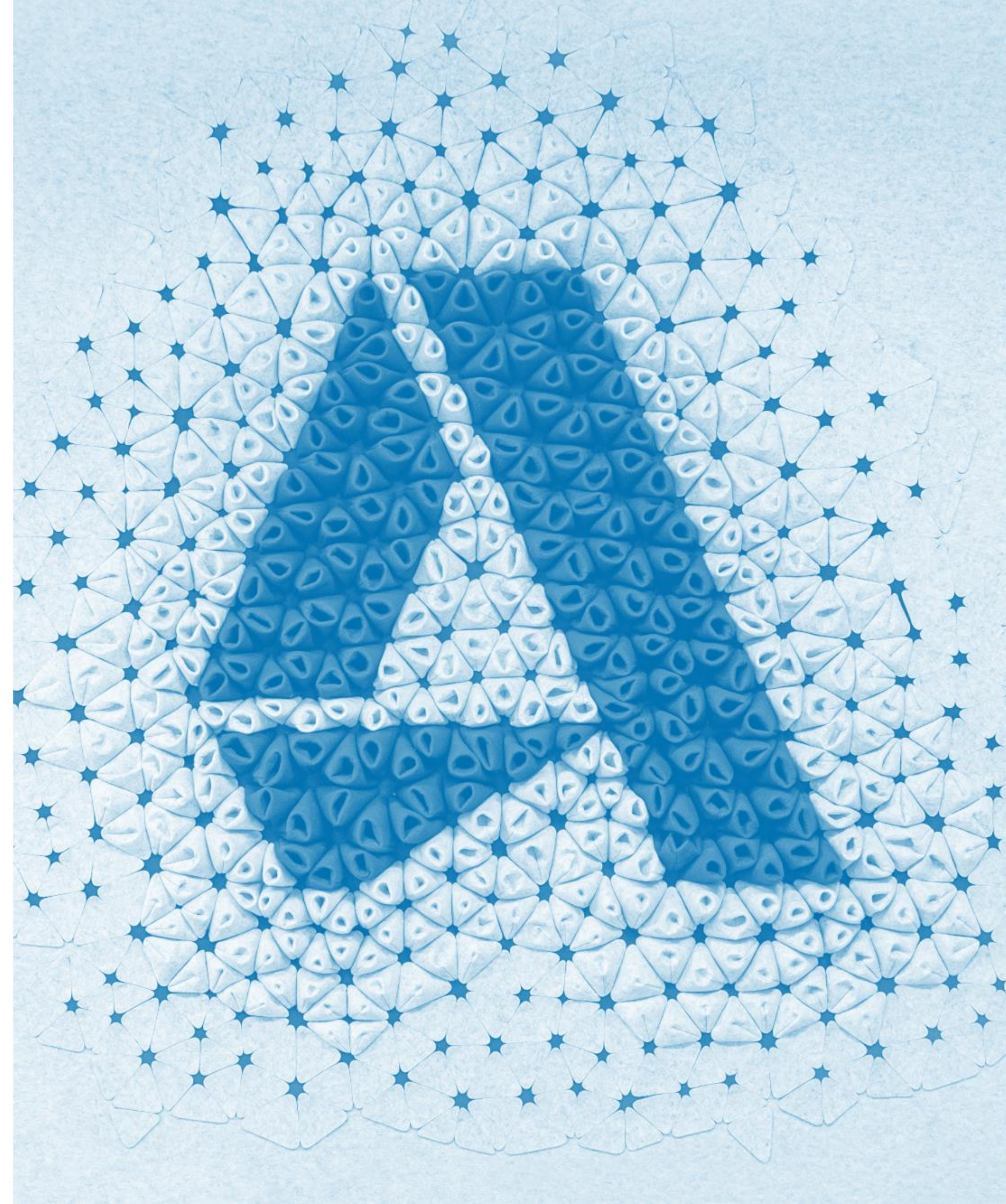




# 03 Shape arrangement |

## *Problem Statement*

**Find an arrangement of any number of shapes with any number of sides so that there are no overlaps, and the result is esthetically pleasing whilst compact**

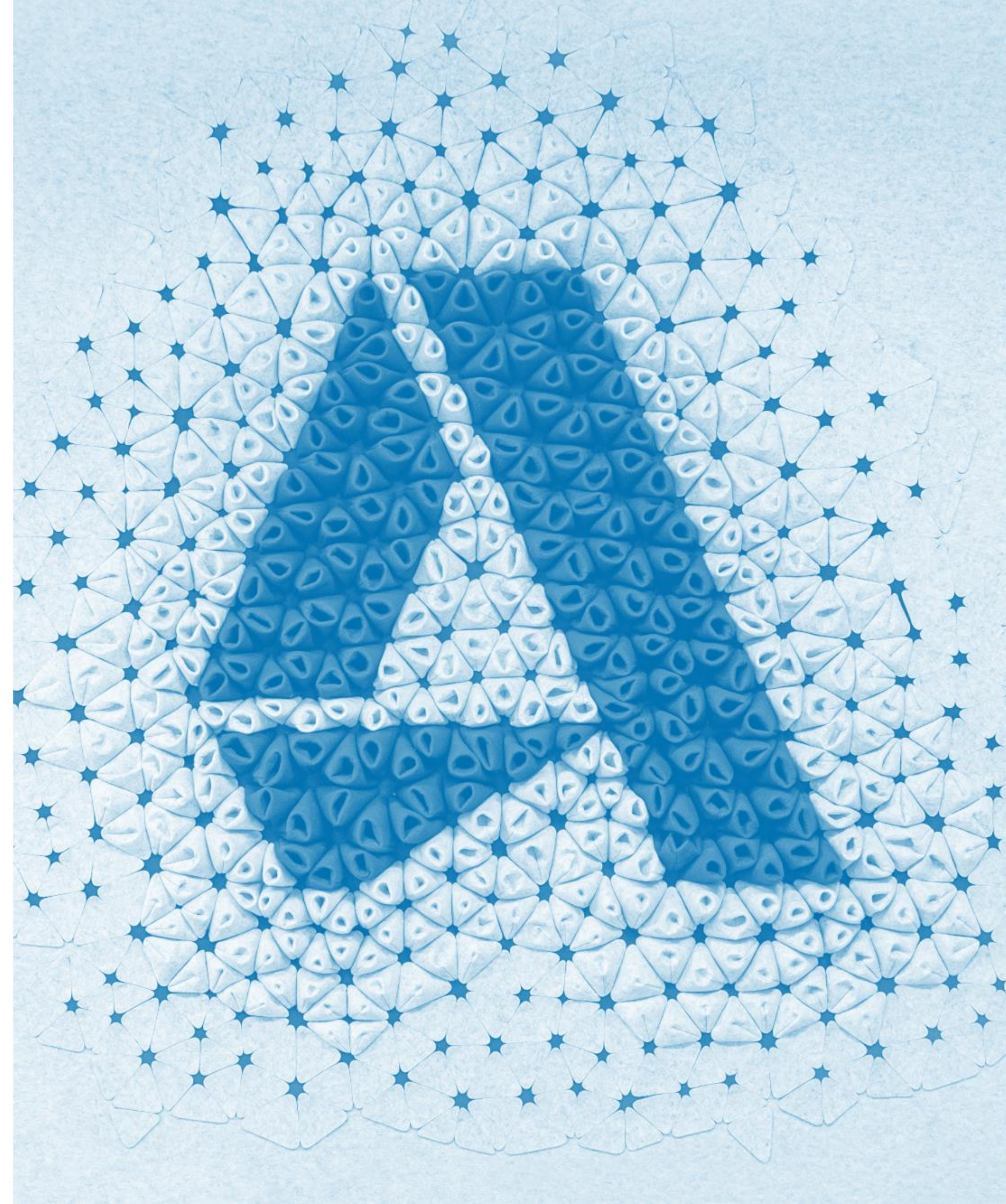




# 03 Shape arrangement |

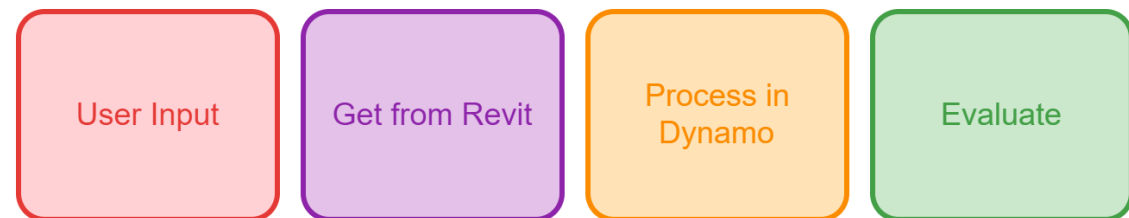
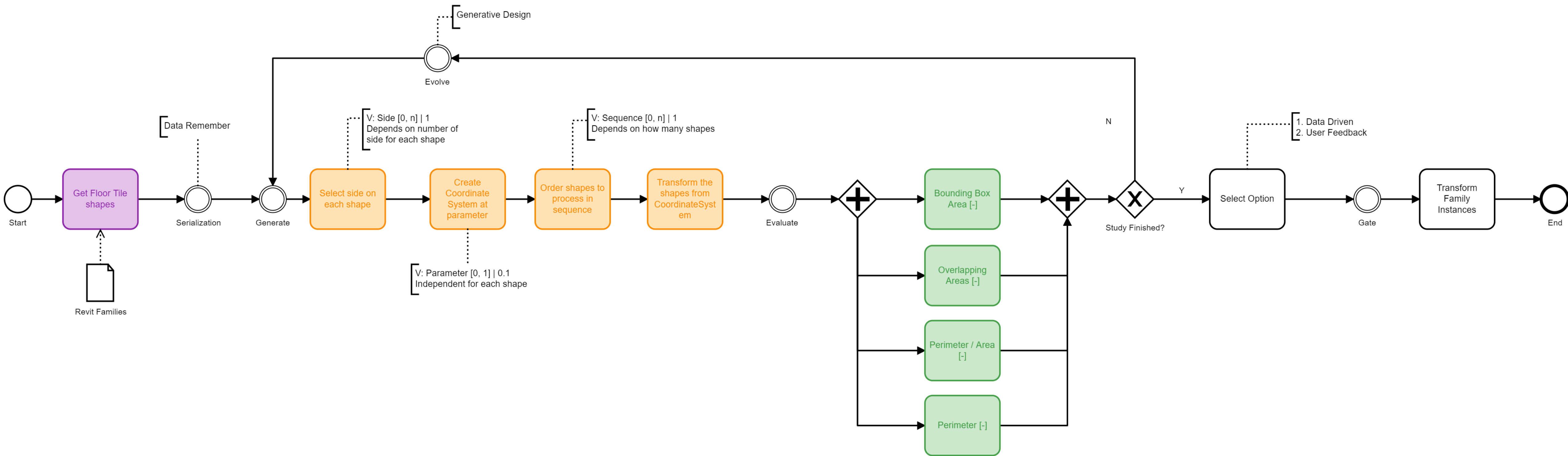
## *Problem Statement*

- **Inputs / Constraints**
  - The geometrical shapes
- **Variables**
  - The order/sequence in which the shapes are processed
  - The side used to connect the next shape
  - The parameter along the side used as anchor point for the following shape
- **Objectives**
  - Bounding Box Area [-]
  - Overlapping Area [-]
  - Perimeter [-]
  - Perimeter over Area [-]





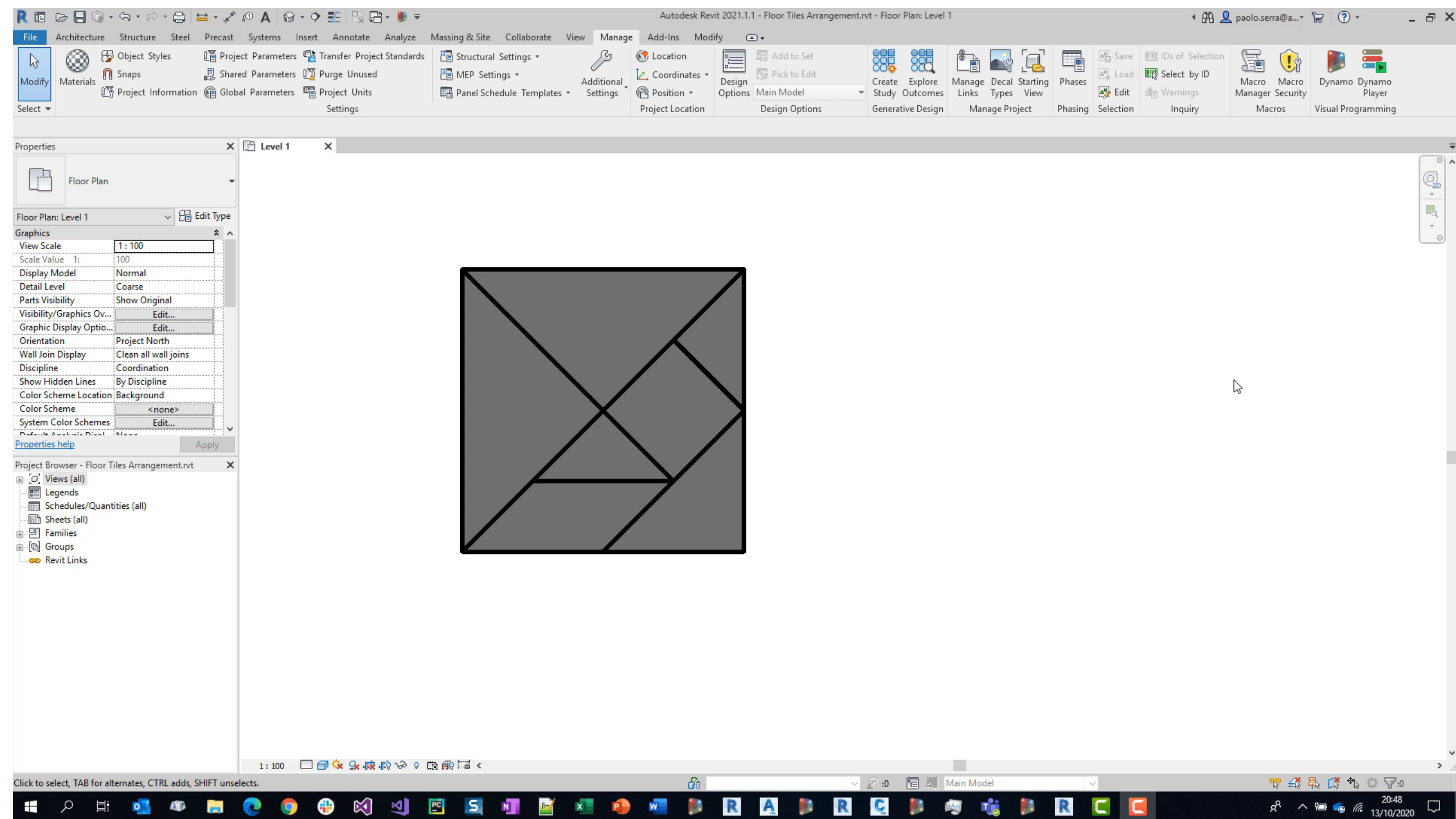
# 03 Shape arrangement | *Process Diagram*



[Link](#)



# 03 Shape arrangement | *Study in action*



[Link](#)



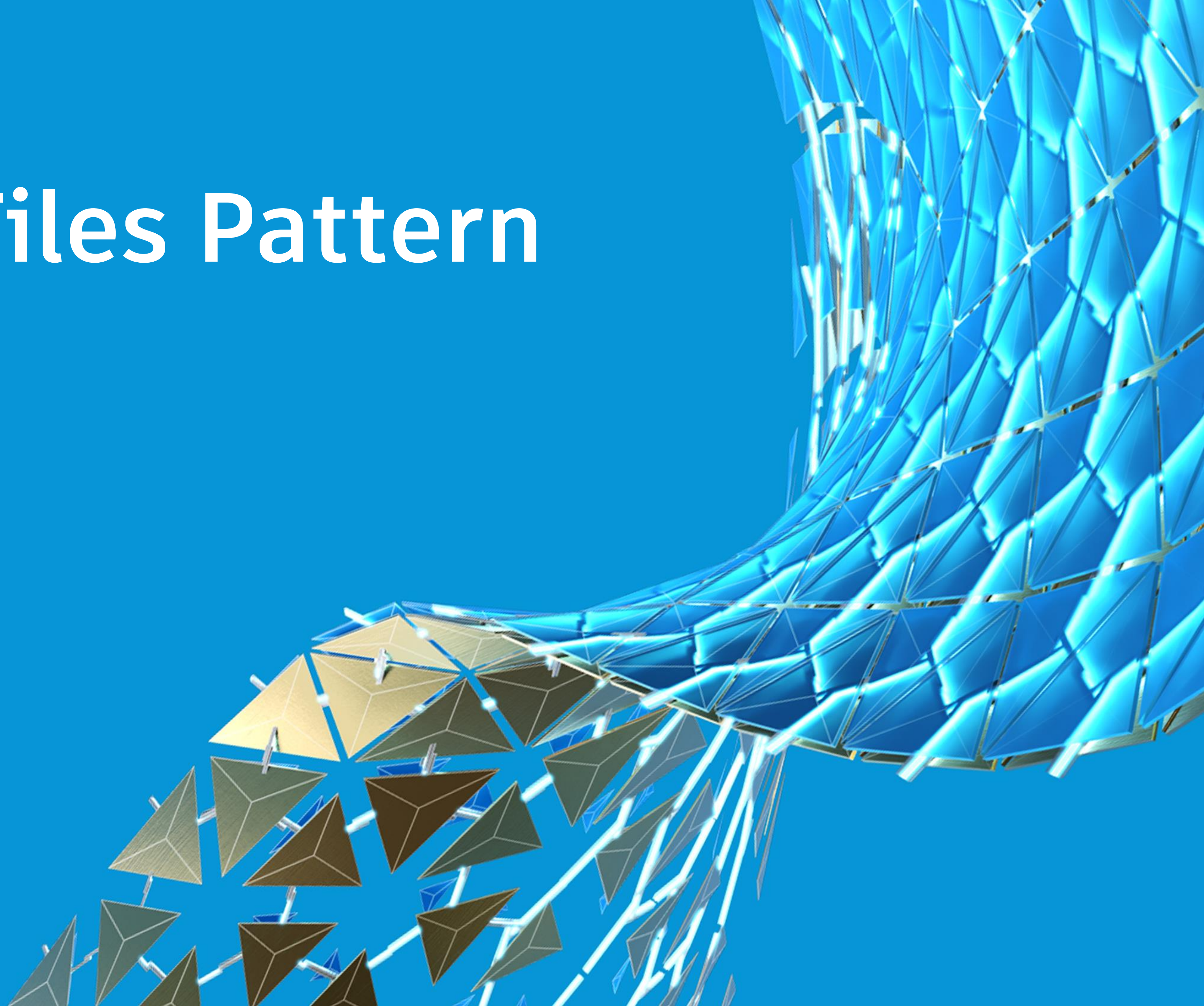


## 03 Shape arrangement | *Similar applications*

- Tile / façade patterns
- Floor planning
- Site layout



# 04 Floor Tiles Pattern





## 04 Floor Tiles Pattern | *Problem Statement*

*Reducing waste on site is one of the priorities to achieve a greener construction industry. By optimizing the pattern and location, less time and material will be required.*





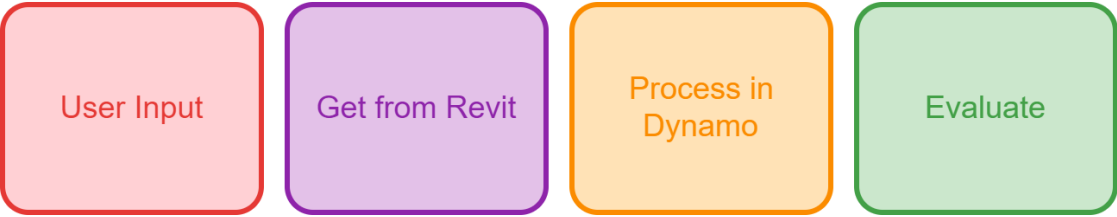
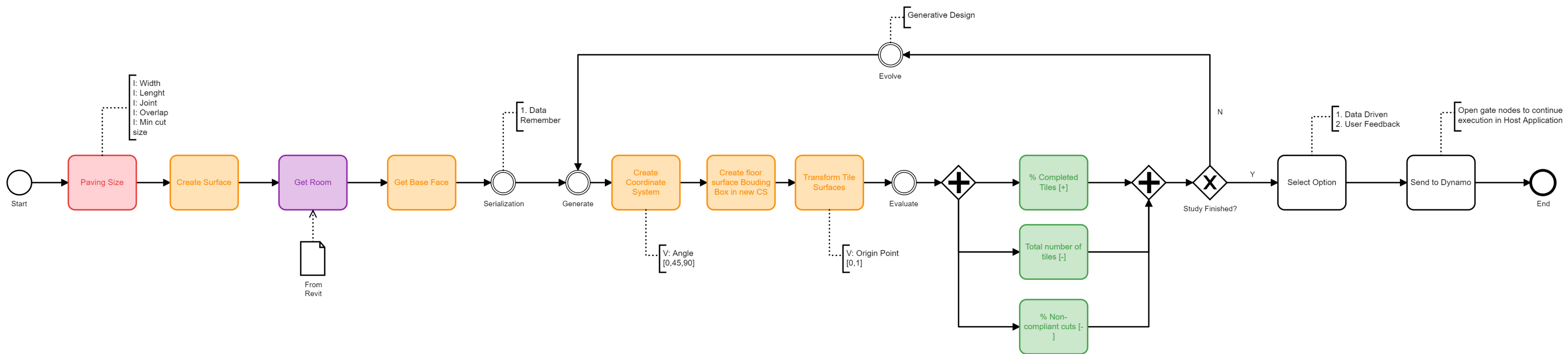
# 04 Floor Tiles Pattern | *Problem Statement*

- **Inputs / Constraints**
  - Tile size (Width/Length)
  - Joint size
  - Overlap
  - Minimum cut size
  - Floor geometry
- **Variables**
  - Angle
  - Origin of the first tile
- **Objectives**
  - Number of tiles [-]
  - % Completed tiles [+]
  - % Non-compliant cuts [-]





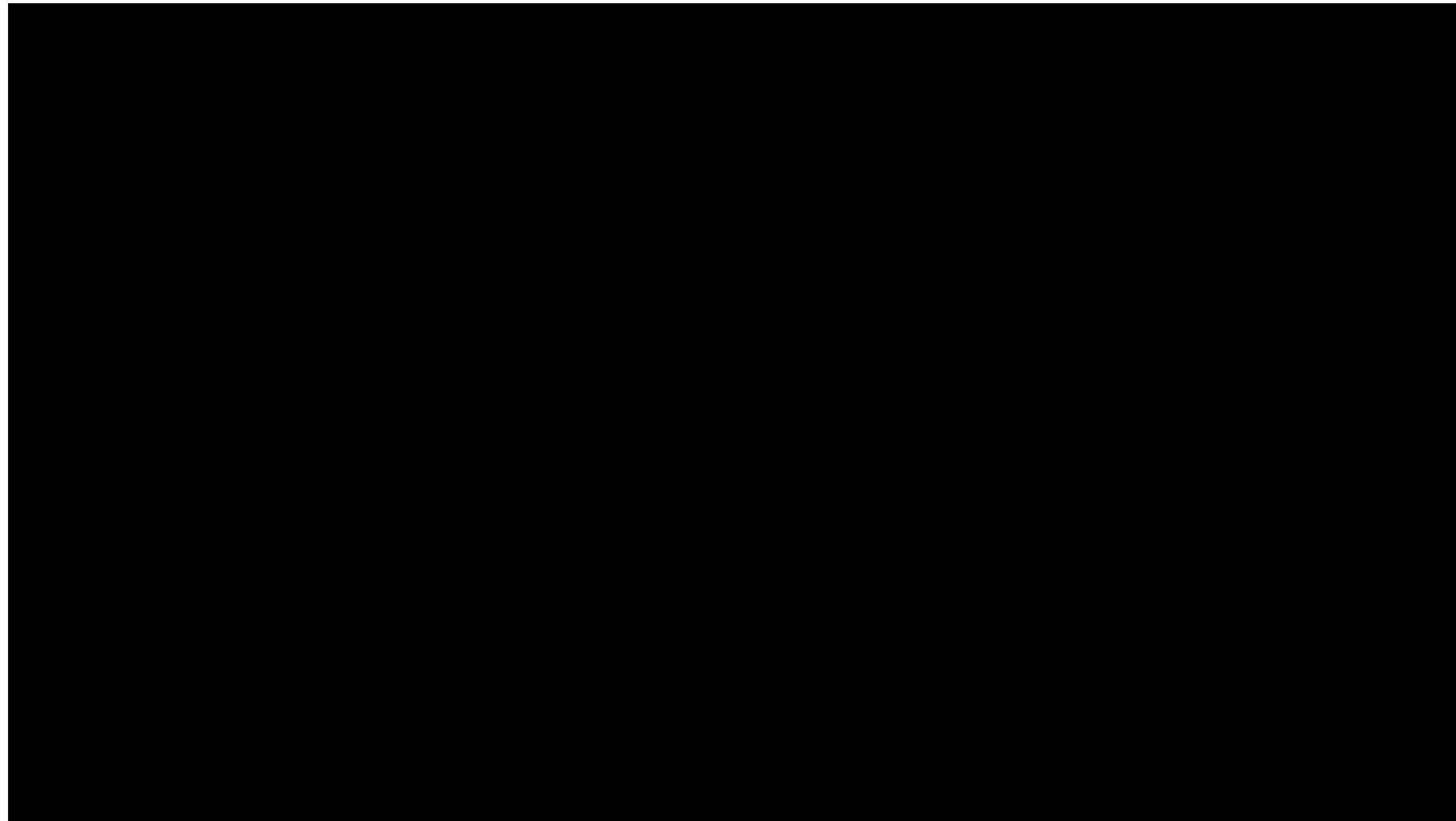
# 04 Floor Tiles Pattern | *Process Diagram*



[Link](#)



## 04 Floor Tiles Pattern | *Study in action*



[Link](#)



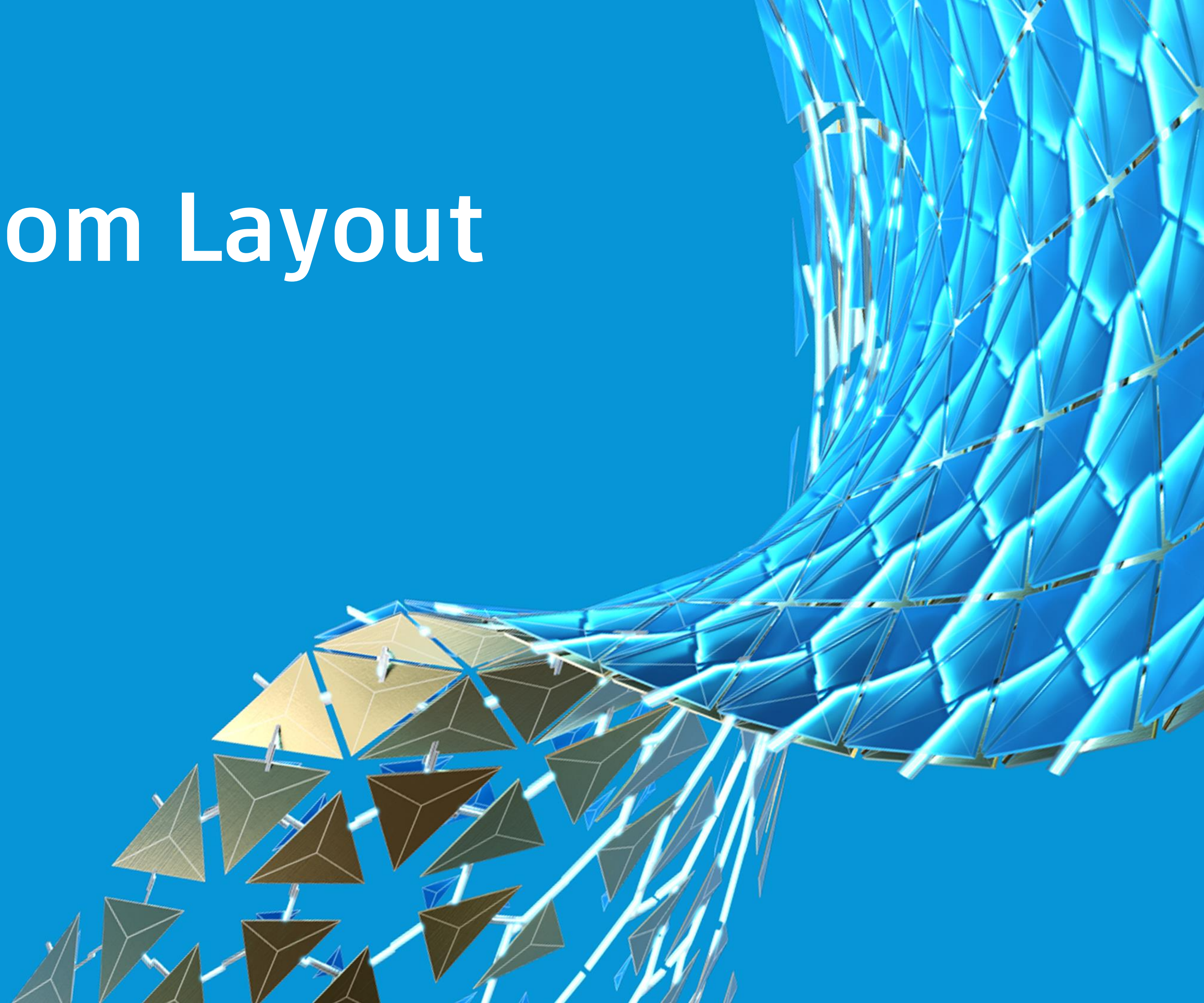


## 04 Floor Tiles Pattern | *Similar applications*

- Wall & façade panels
- Archives & warehouse layout
- Open office/ classroom design



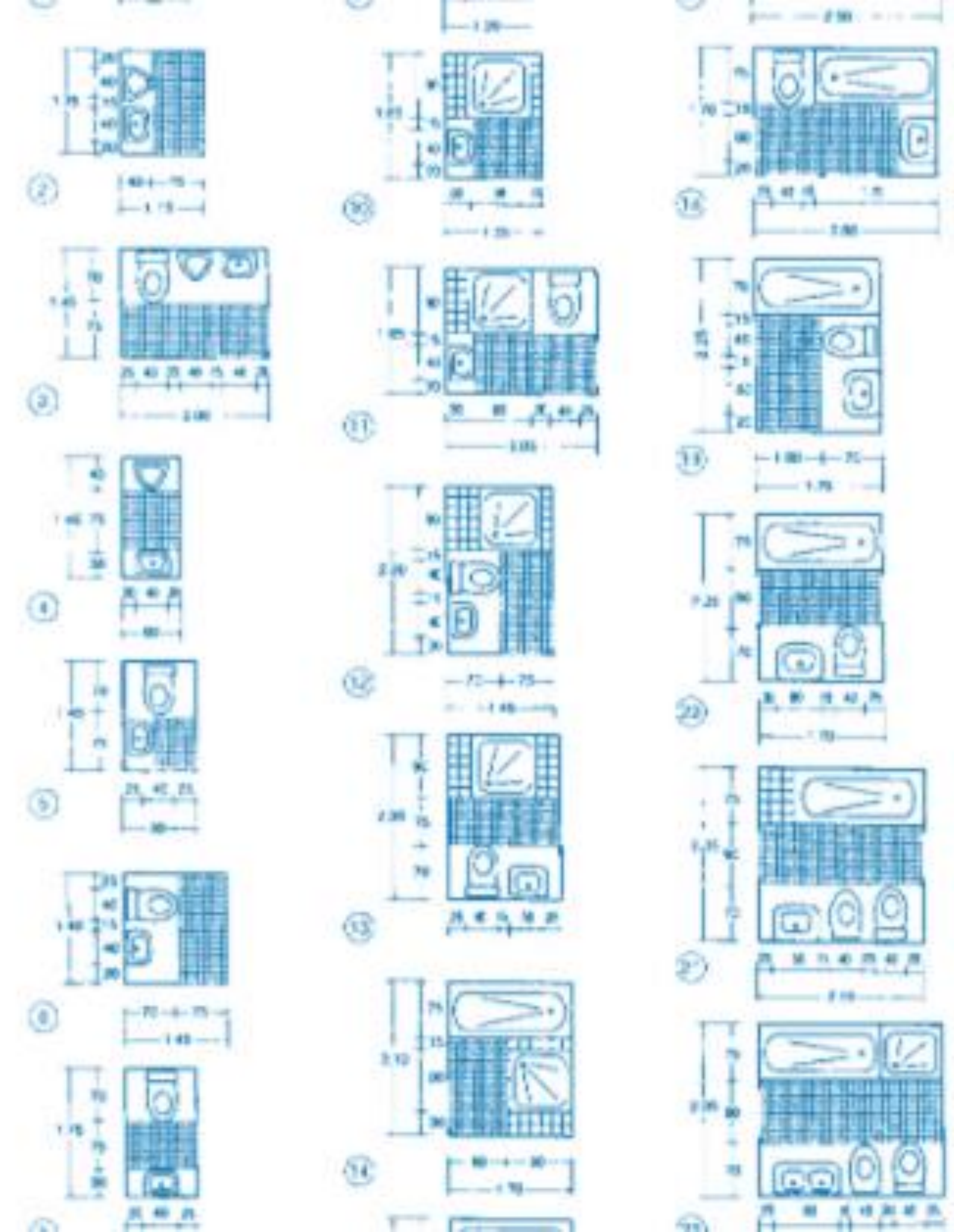
# 05 Bathroom Layout





# 05 Bathroom Layout | *Problem Statement*

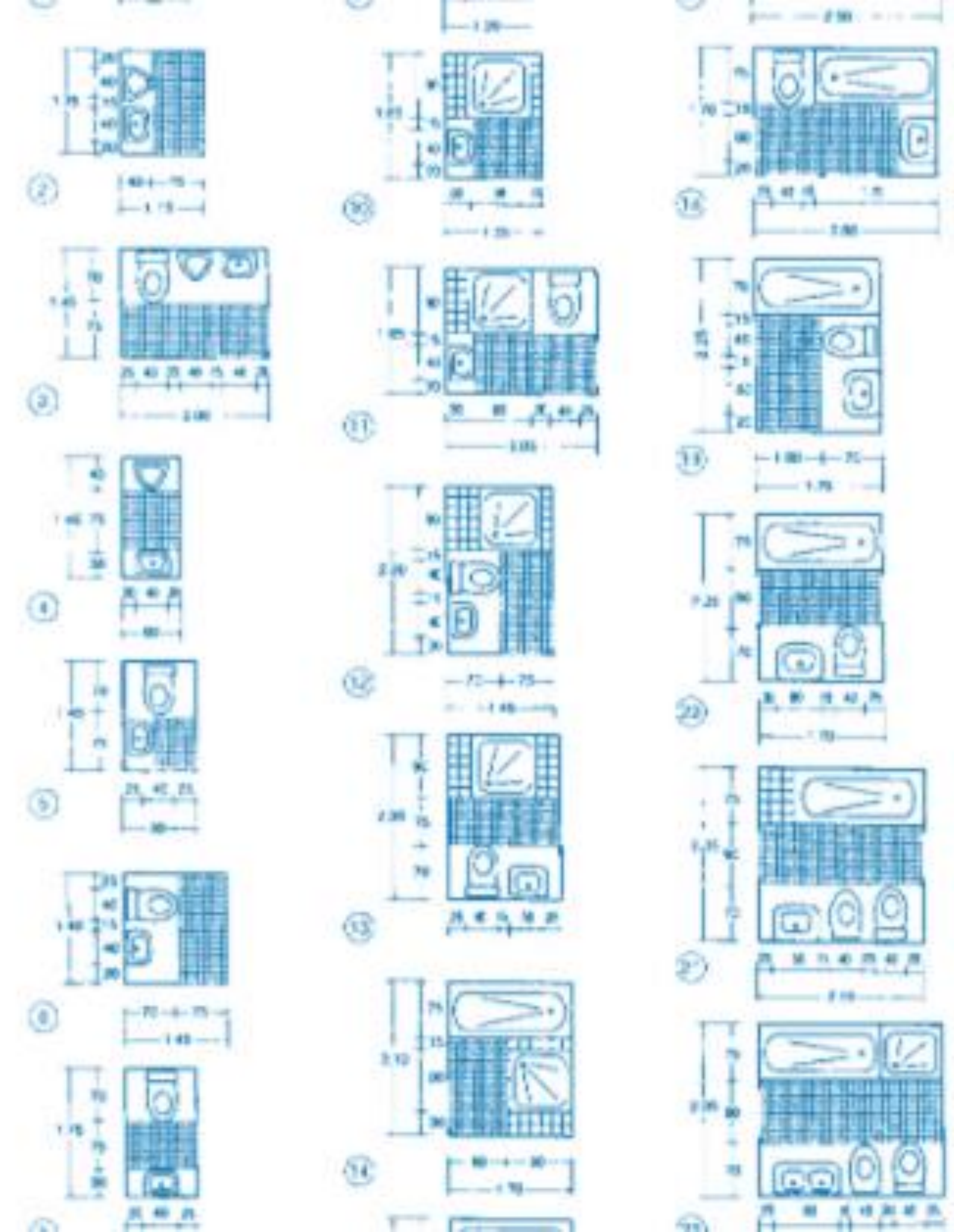
*Bathroom elements have clear needs of space and use area, as well as relationship with other plumbing elements and walls. However, there is no single option so computer and designer should work hand by hand in finding the best solution for each situation.*





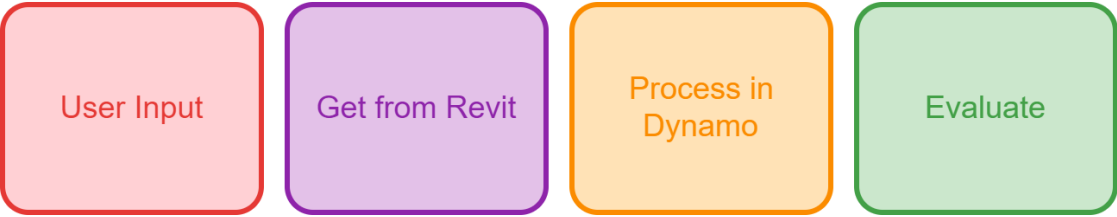
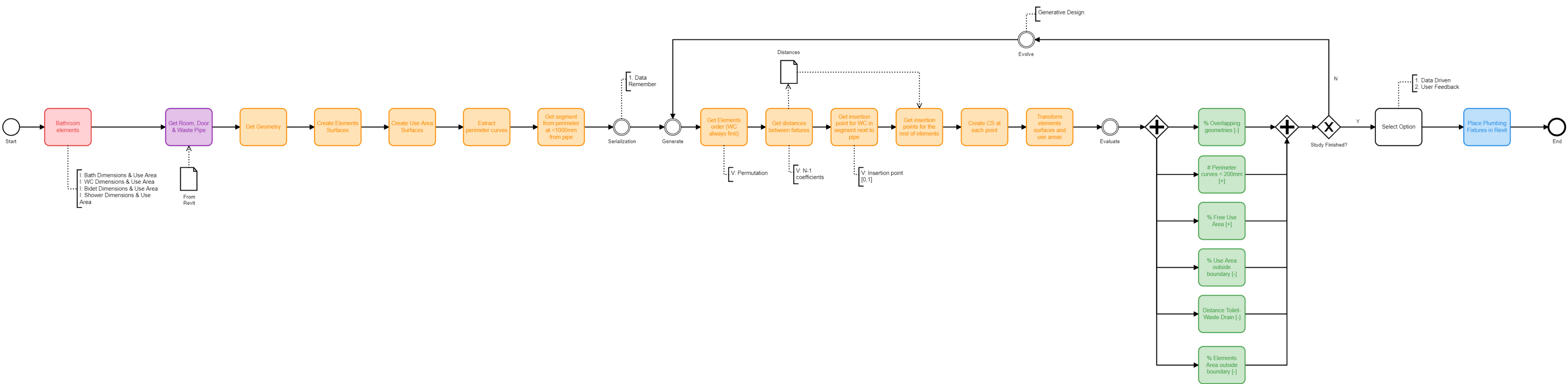
# 05 Bathroom Layout | *Problem Statement*

- **Inputs / Constraints**
  - Type of fixtures
  - Size of fixtures
  - Space geometry and conditions (i.e. doors, windows...)
- **Variables**
  - Permutation (order of the fixtures)
  - Origin point
  - Distance between fixtures
- **Objectives**
  - % Fixtures geometry outside boundary [-]
  - Element clashes [-]
  - % Free use area [+]
  - % Use area outside boundary [-]
  - Distance to waste pipe [-]
  - Perimeter curves < 200mm long [-]





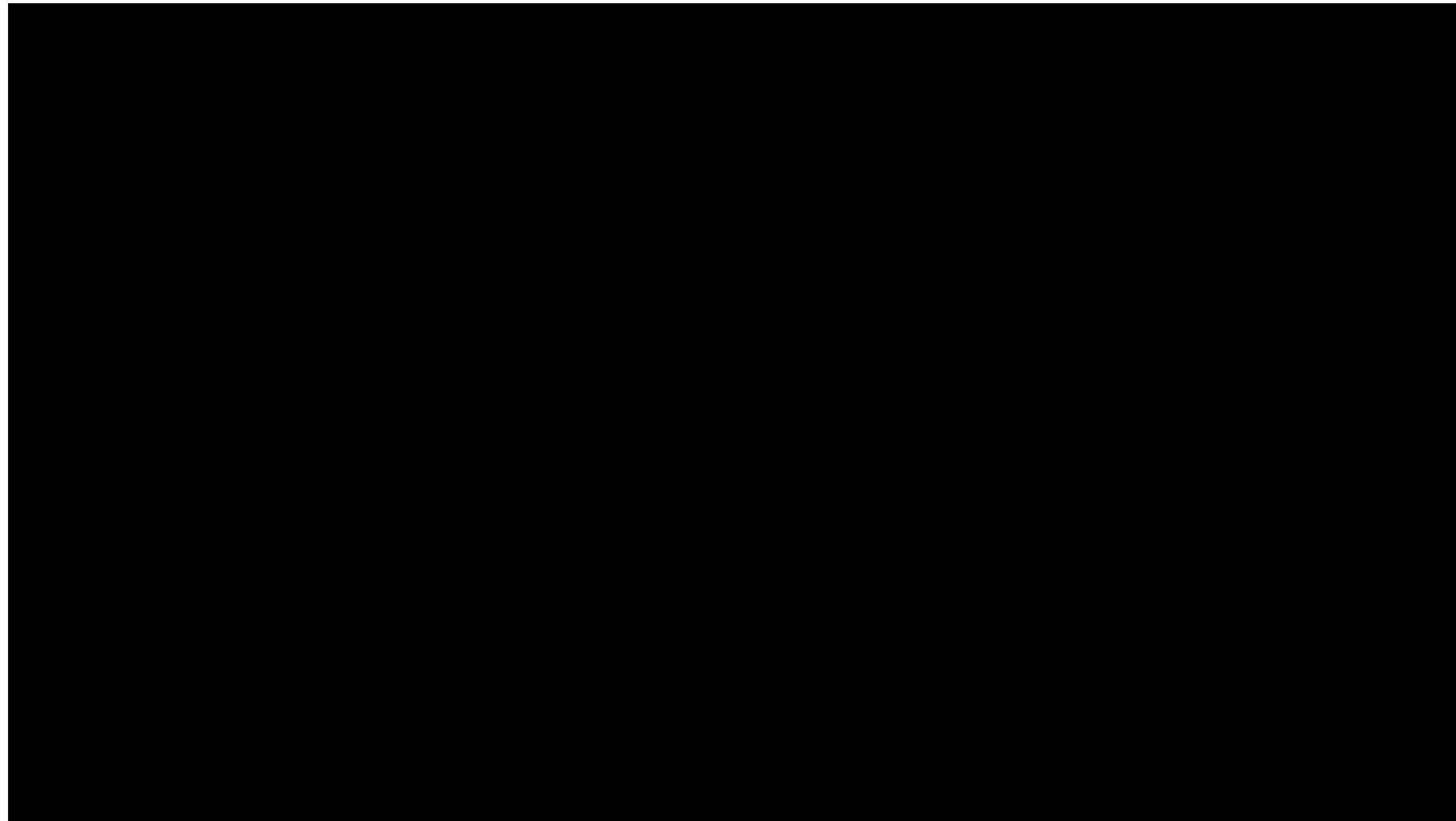
# 05 Bathroom Layout | *Process Diagram*



[Link](#)

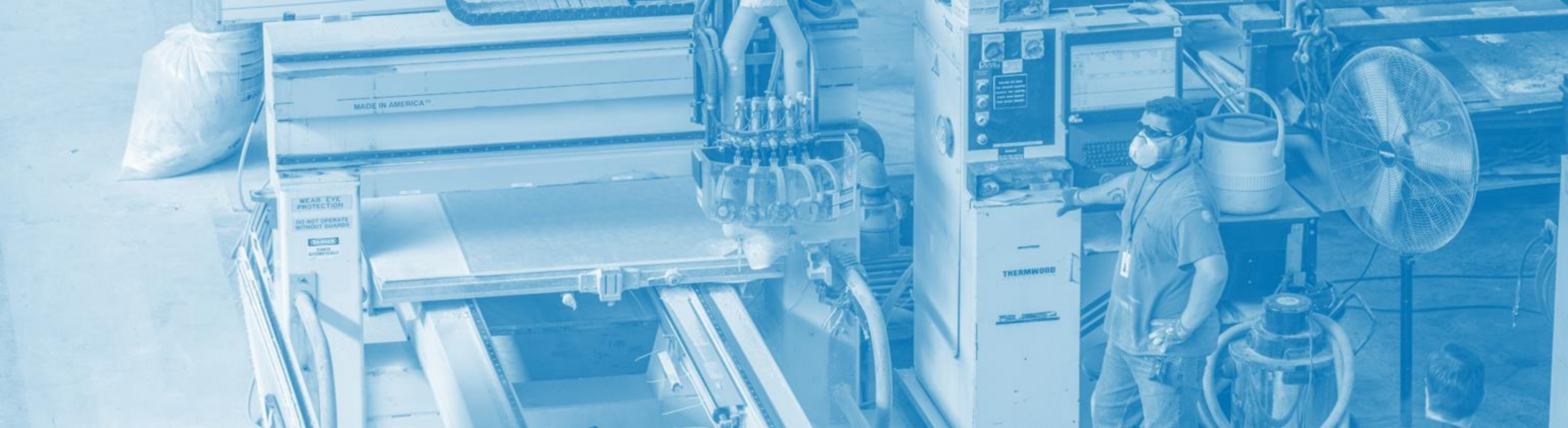


## 05 Bathroom Layout | *Study in action*



[Link](#)



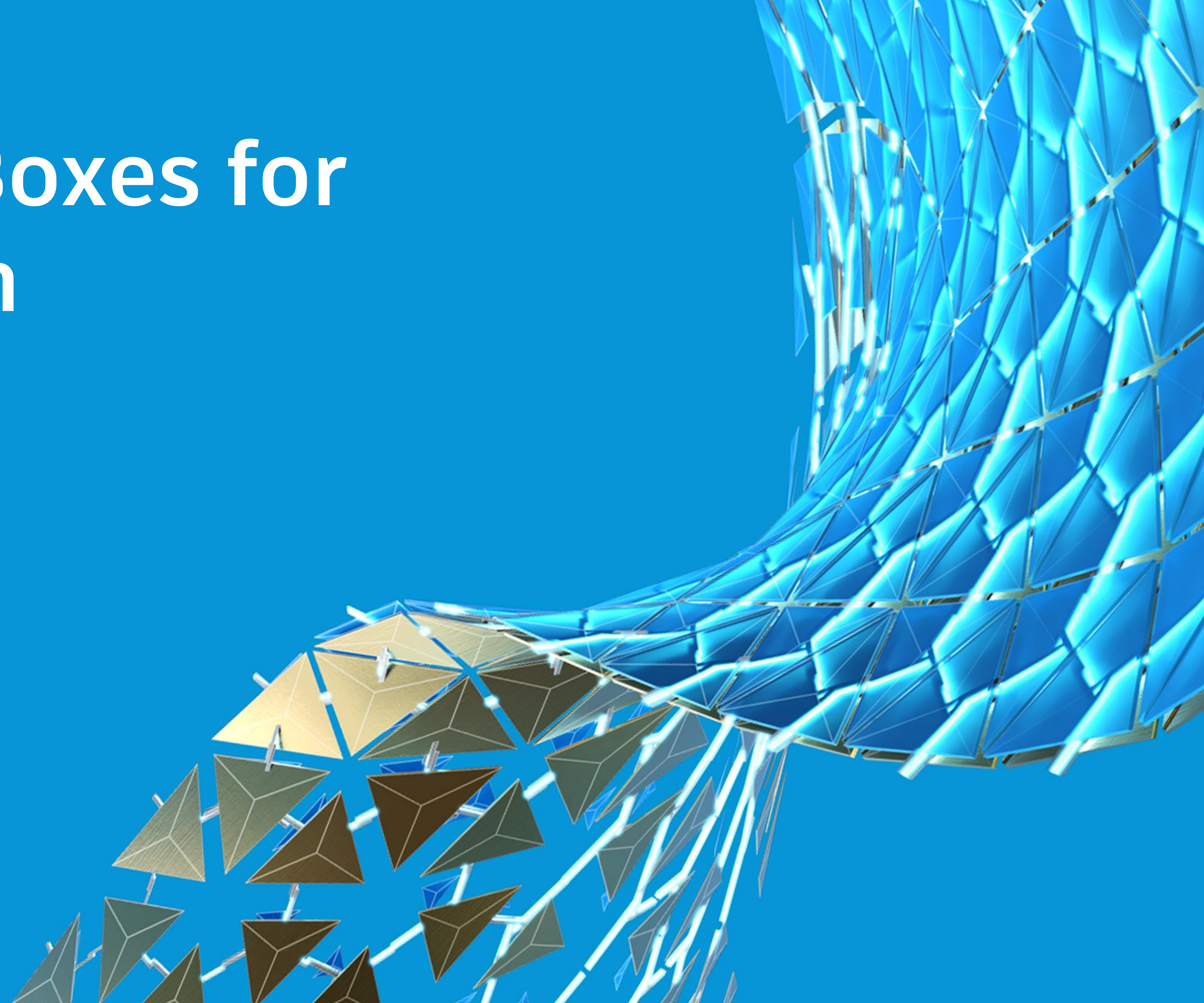


## 05 Bathroom Layout | *Similar applications*

- Interior design
- Warehouse layout
- Planting plan
- Site planning
- Factory layout



# 06 Scope Boxes for Masterplan





# 06 Scope Boxes for Masterplan

## | *Problem Statement*

**Find the orientation and distribution of scope boxes that covers an entire site with the maximum dimensions compatible with the title block and scale factor, minimizing the areas out of scope and total number of drawing sheets**





# 06 Scope Boxes for Masterplan

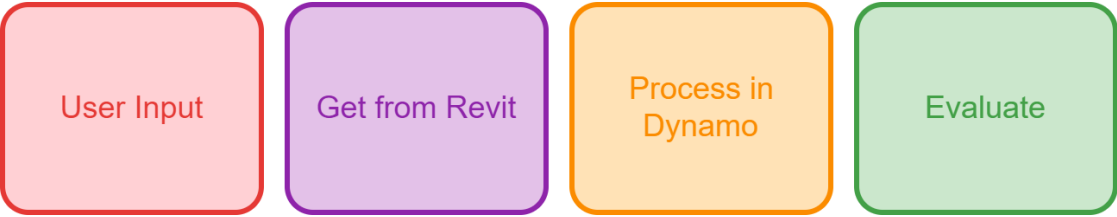
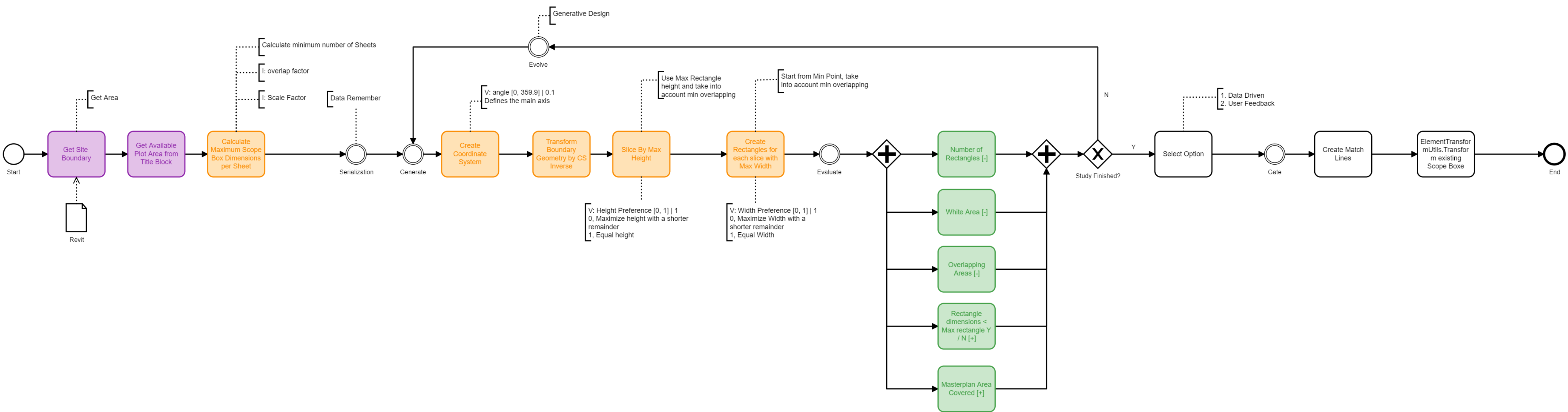
## | *Problem Statement*

- **Inputs / Constraints**
  - The site boundary
  - The scale factor and the available plot dimensions of the title block
  - Overlap factor
- **Variables**
  - Rotation angle
  - Fixed Height / Width
- **Objectives**
  - Site Area covered [+]
  - Number of Scope Boxes [-]
  - Out of scope area [-]
  - Dimensions within maximum allowed [+]





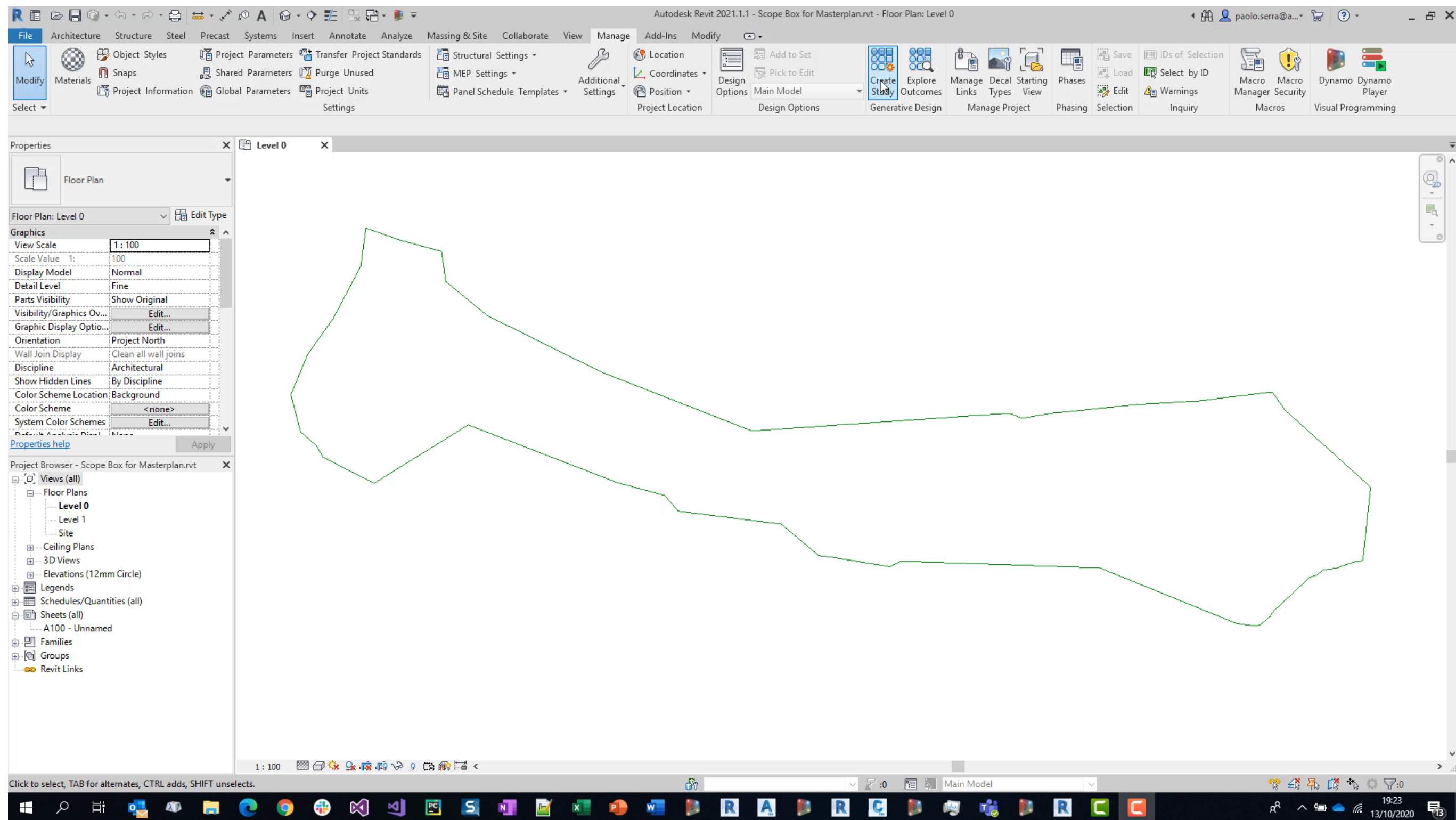
# 06 Scope Boxes for Masterplan | *Process Diagram*



[Link](#)

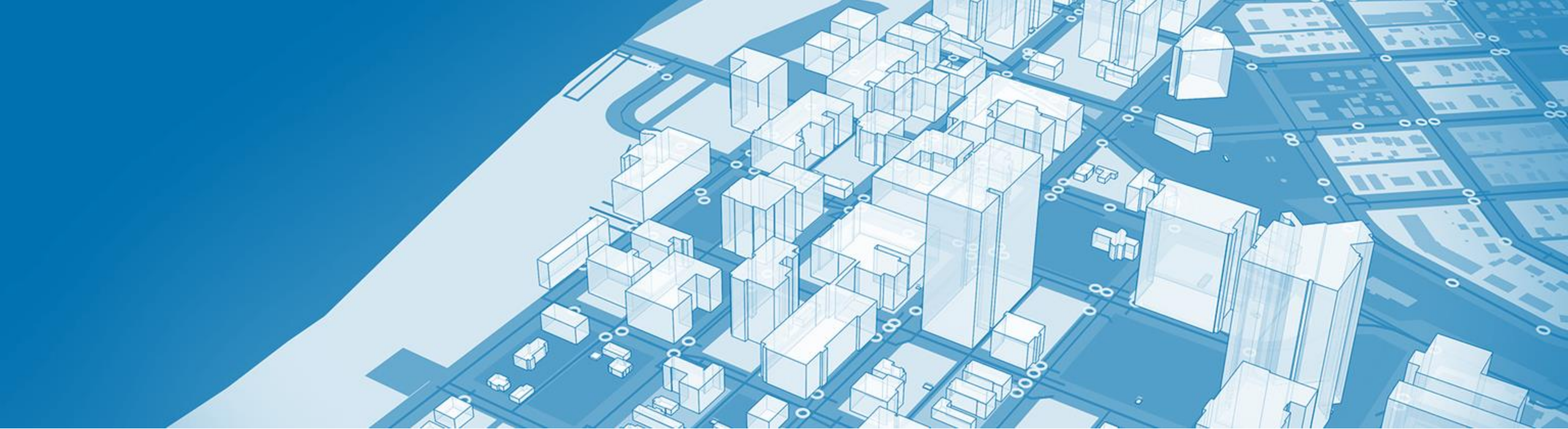


# 06 Scope Boxes for Masterplan | *Study in action*



[Link](#)



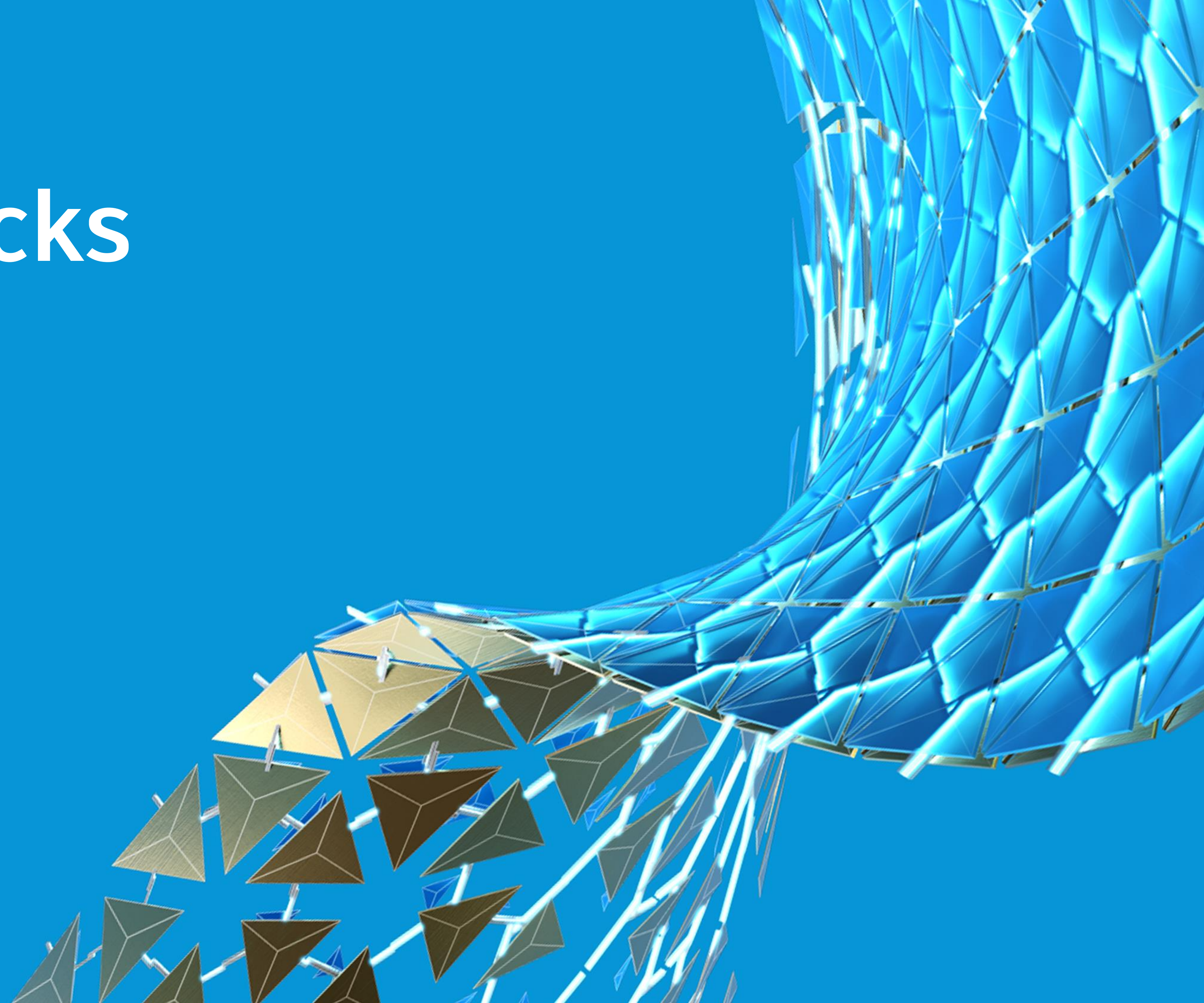


## 06 Scope Boxes for Masterplan | *Similar applications*

- Parceling
- Site planning
- Façades



# Tips & Tricks





# Dimensions

Car Width *Renamed*

1.75

Car Length *Renamed*

4.584

Door Length *Renamed*

## Choose variables

- ☒ Rotation Angle 0 to 90
- ☒ Tile Origin 0 to 1

## Set goals

- ☒ Number of Tiles [-] ☒ Minimize ☐ Maximize
- ☒ % Completed Tiles [+1] ☒ Minimize ☐ Maximize

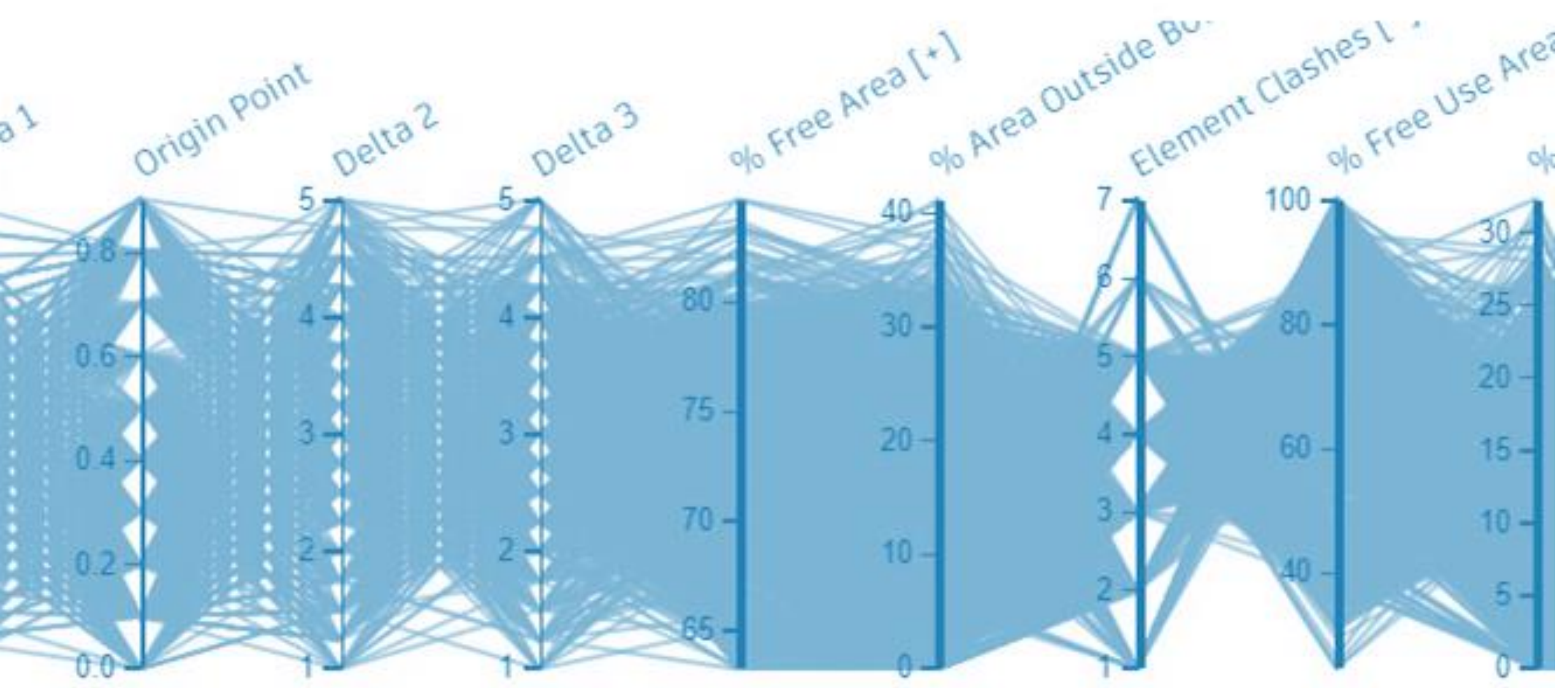
## Inputs

- Only selection inputs can be changed from the Generative Design “Create Study” dialog

## Variables

- Narrow down the potential values to get meaningful results (repeat the studies as necessary)
- Use normalized values when possible (i.e. 0-1)





## Generation Settings

Population Size

Generations

Seed

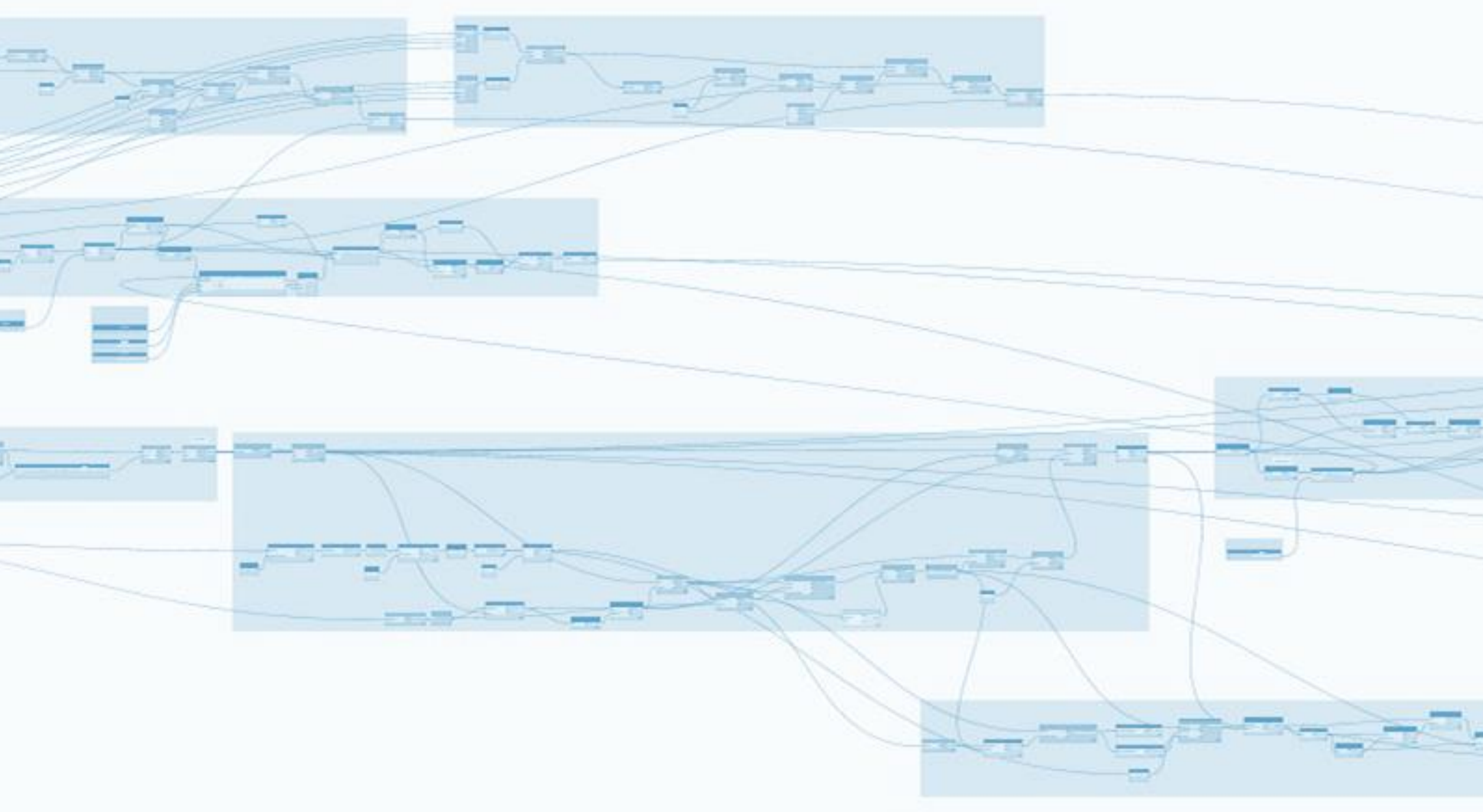
## Metrics / Objectives

- Explicit in the code name if the objective is to be maximized or minimized
- Use normalized values (% or 0-1) so the study is valid for different use cases and options are easy to compare
- Some users like to combine all outputs into a value weighting each of them with a coefficient

## Study Settings

- Balance between population size and number of generations
- Seed introduces randomness, it can be left at its default value





Name	Date modified	Type	Size
GD - How To Park Your Car.Dependencies	21/09/2020 23:31	File folder	
GD - Toilet Arrangement -1-2.Dependencies	04/10/2020 23:25	File folder	
GD - Toilet Arrangement.Dependencies	03/10/2020 00:56	File folder	
Grid Object Placement.Dependencies	31/08/2020 14:51	File folder	
Maximize Window Views.Dependencies	31/08/2020 14:51	File folder	
OfficeLayout_COVID19.Dependencies	26/05/2020 23:23	File folder	
OfficeLayout_COVID19_C.Dependencies	28/05/2020 07:32	File folder	
Randomize Object Placement.Dependencies	31/08/2020 14:51	File folder	
Stepped Grid Object Placement.Dependencies	31/08/2020 14:51	File folder	
Three Box Massing.Dependencies	31/08/2020 14:51	File folder	
Workspace Layout.Dependencies	31/08/2020 14:51	File folder	
GD - Floor Tile Arrangement.dyn	12/10/2020 22:15	Dynamo Studio W...	202 KB
GD - How To Park Your Car.dyn	22/09/2020 11:42	Dynamo Studio W...	234 KB
GD - Toilet Arrangement -1-2.dyn	04/10/2020 23:25	Dynamo Studio W...	451 KB
GD - Toilet Arrangement.dyn	04/10/2020 15:44	Dynamo Studio W...	430 KB
Grid Object Placement.dyn	22/06/2020 14:40	Dynamo Studio W...	270 KB
Maximize Window Views.dyn	22/06/2020 14:40	Dynamo Studio W...	224 KB
OfficeLayout_COVID19.dyn	28/05/2020 08:03	Dynamo Studio W...	229 KB
OfficeLayout_COVID19_C.dyn	01/07/2020 15:50	Dynamo Studio W...	189 KB

## Graph

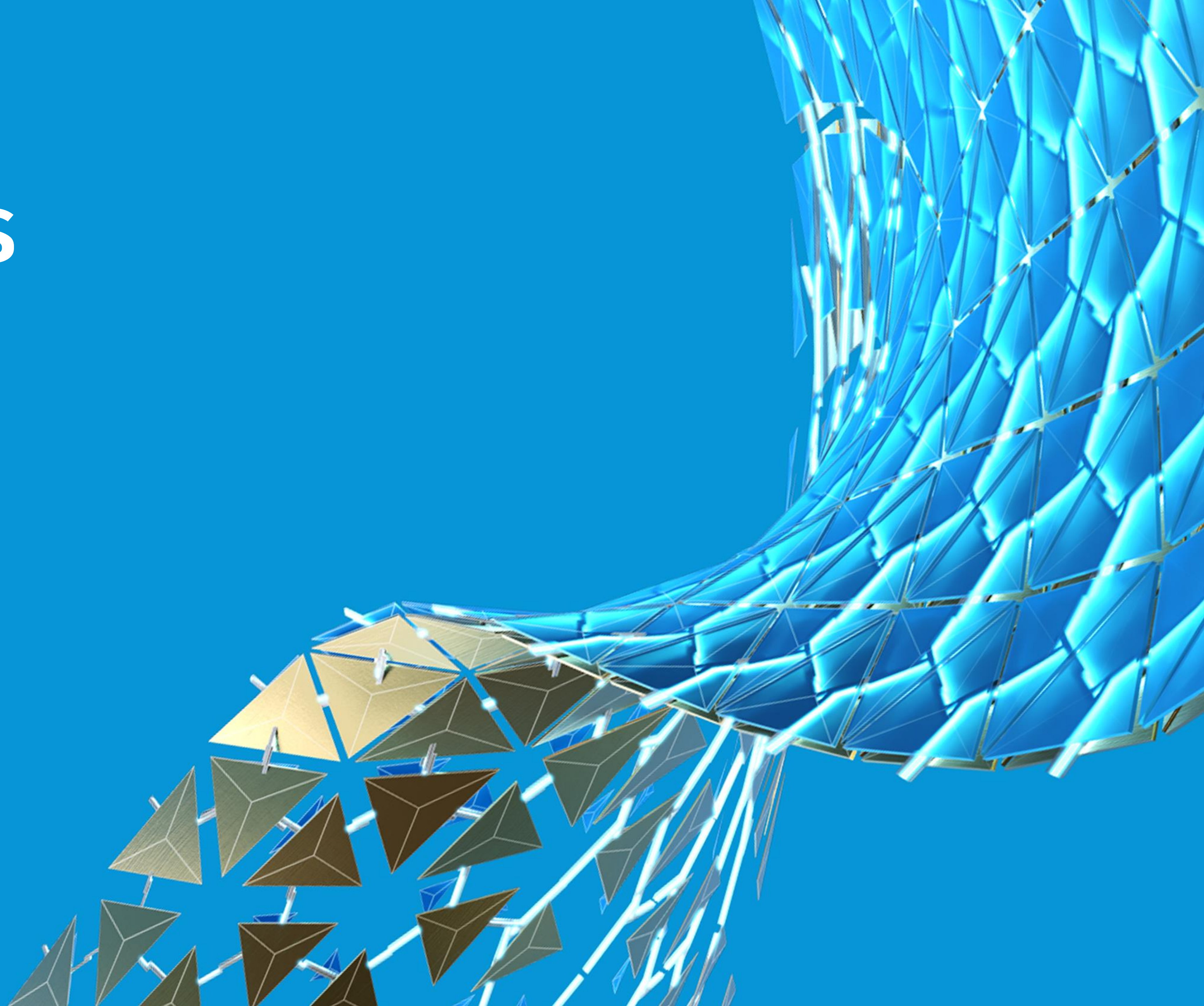
- Use grouping and colouring to explain the process
- Identify the portions of the graph used for Inputs, Variables, Objectives and Visualization

## Documentation & Sharing

- For others to run the GD study, share the DYN file and Dependencies folder created in the AEC Generative Design folder in your Documents folder
- Highly recommended to add a video, process diagram and instructions



# Resources





# Resources

## GENERATIVE DESIGN PRIMER

<https://www.generativedesign.org>

## DYNAMO FORUM & BLOG

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

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

## AUTODESK UNIVERSITY 2020

- Generative Design in Revit for Workspace Layout - Tomasz Fudala
- 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

## PRODUCT HELP

[Product help](#)

[Release notes](#)







