Evolutionary Design

DM II Week 12

DES 212| Winter Term 2 | 2026 | 3 Credits
Instructor: Xun Liu

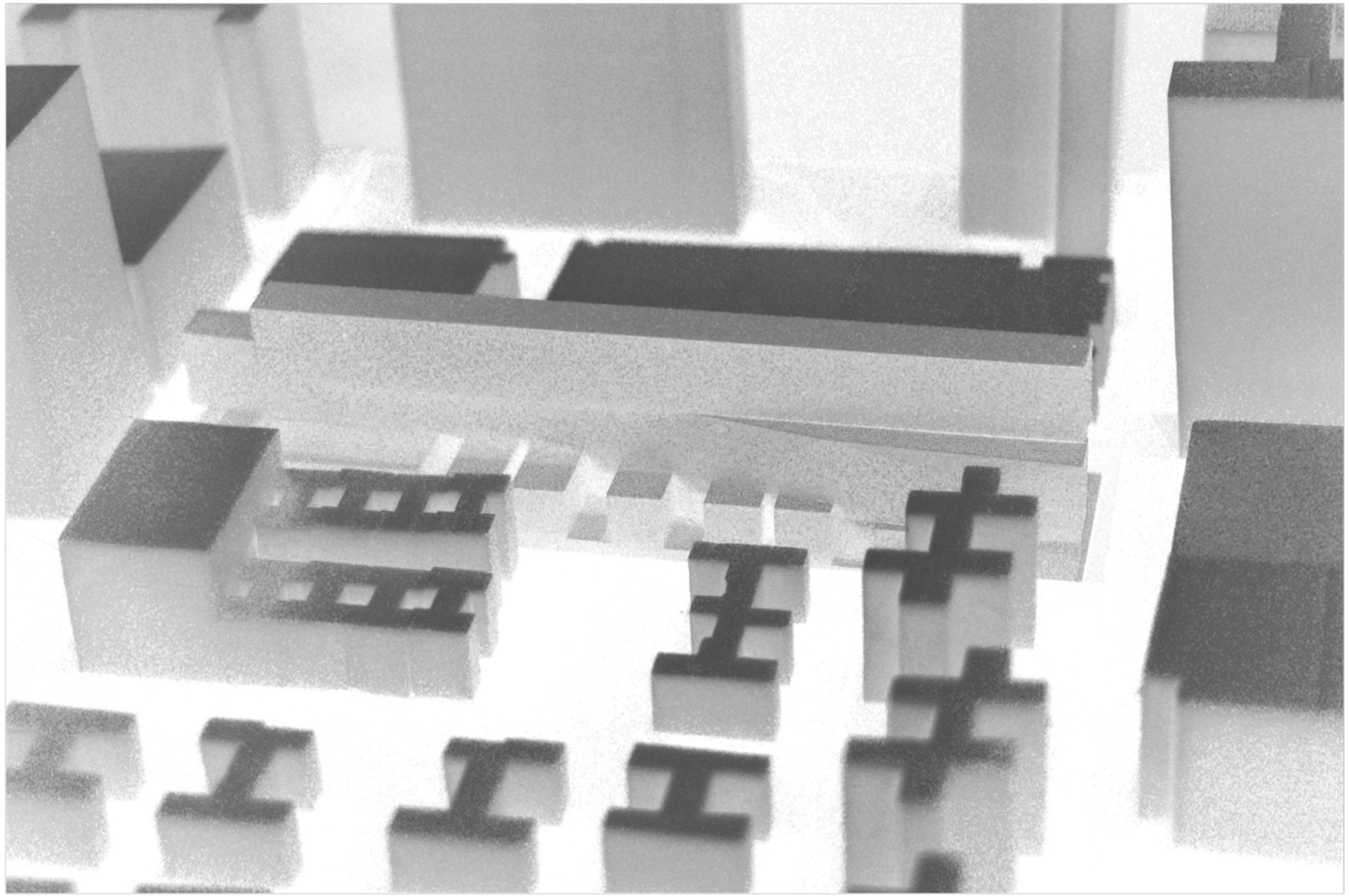
Content

1. The Generative Design Loop
2. Case Studies of ”Optimization”
3. Looking Forward

The Generative Design Loop

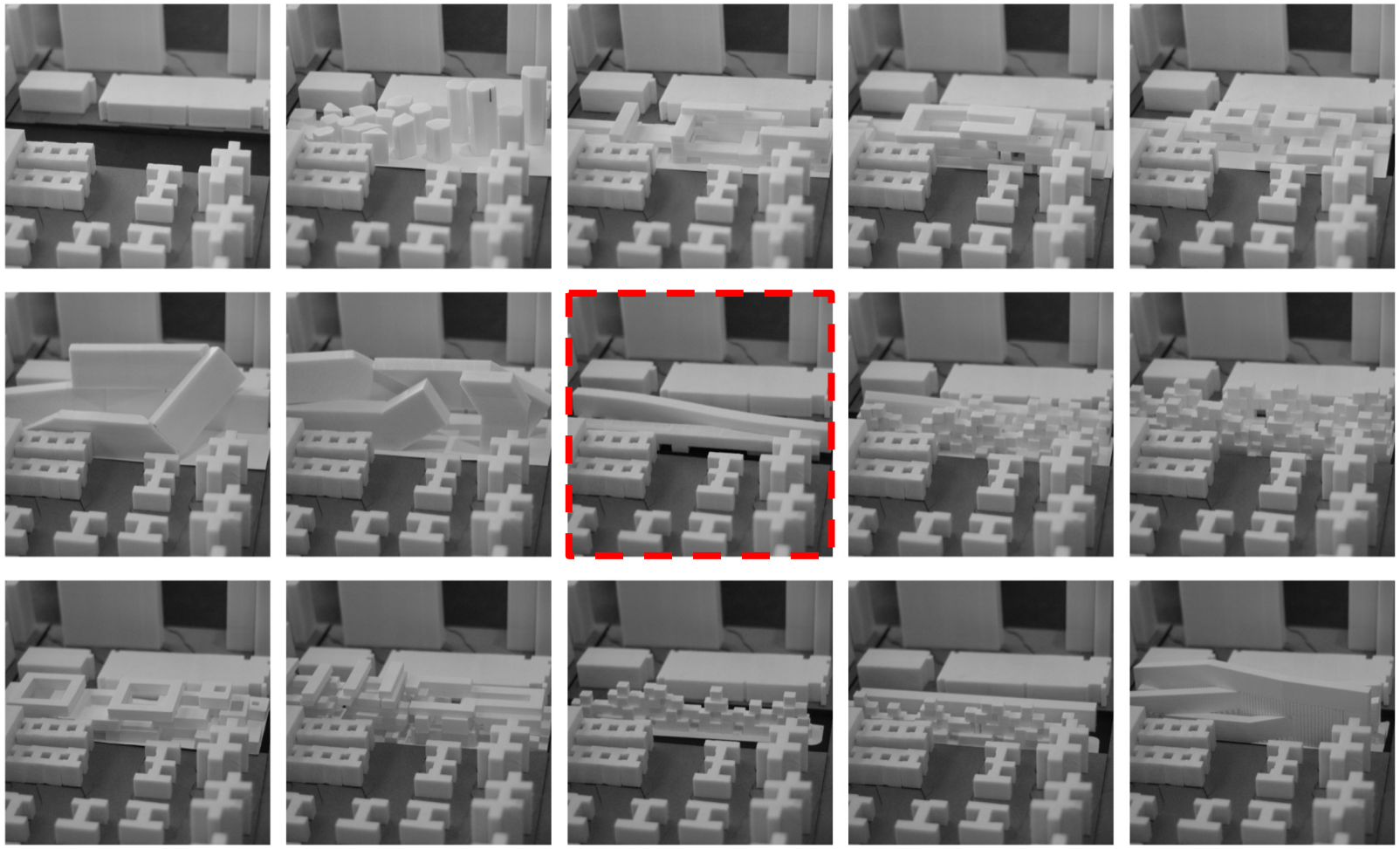
Iteration Is Not New

- Design has always been iterative
- Studio critique = feedback loop
- Computers accelerate the loop



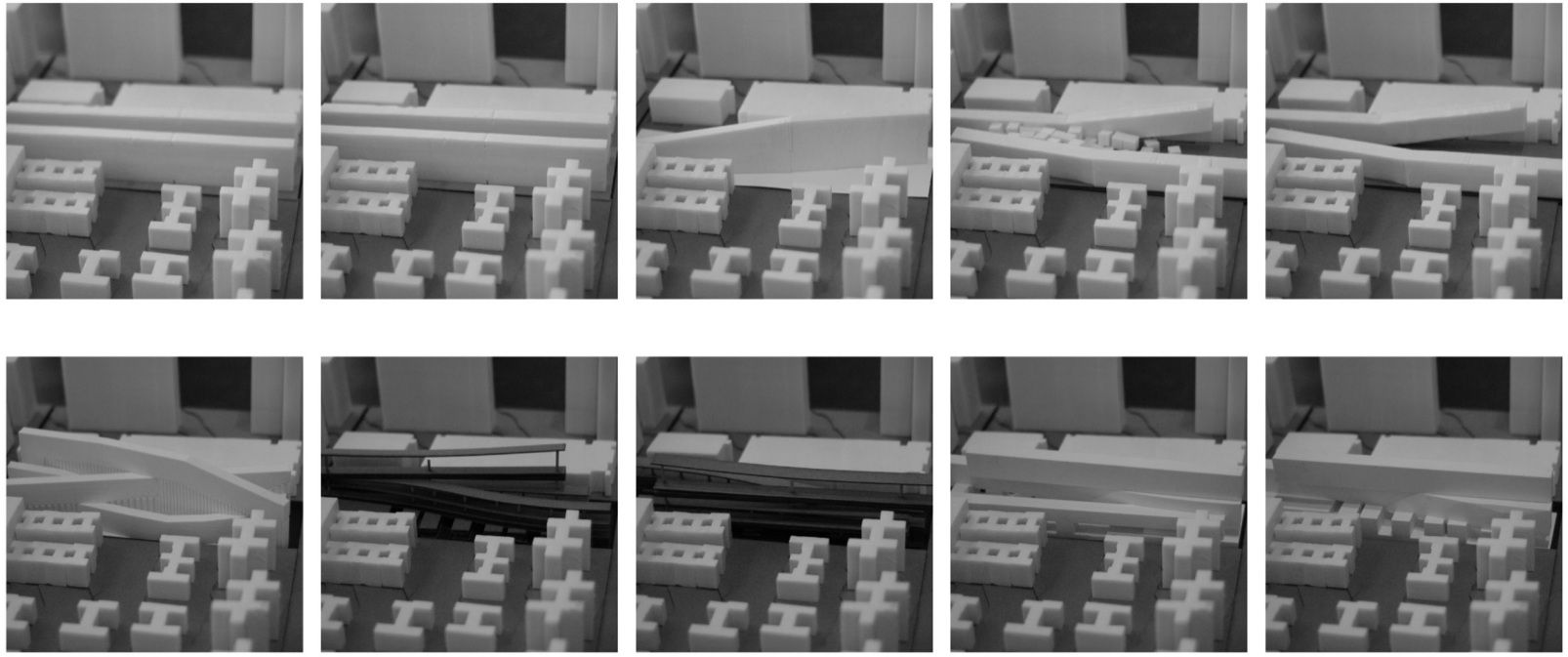
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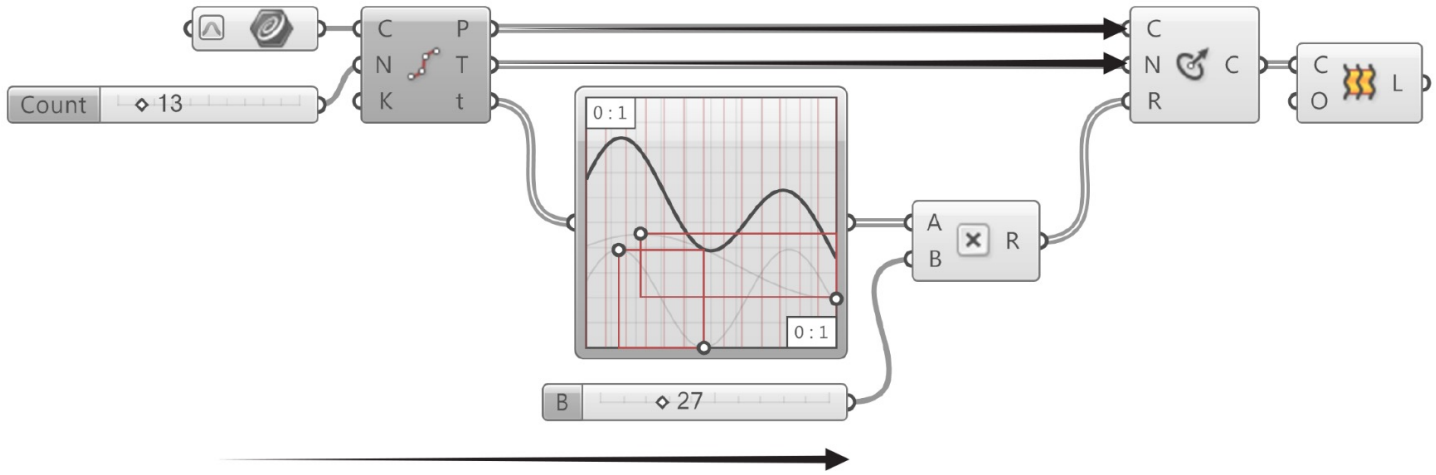


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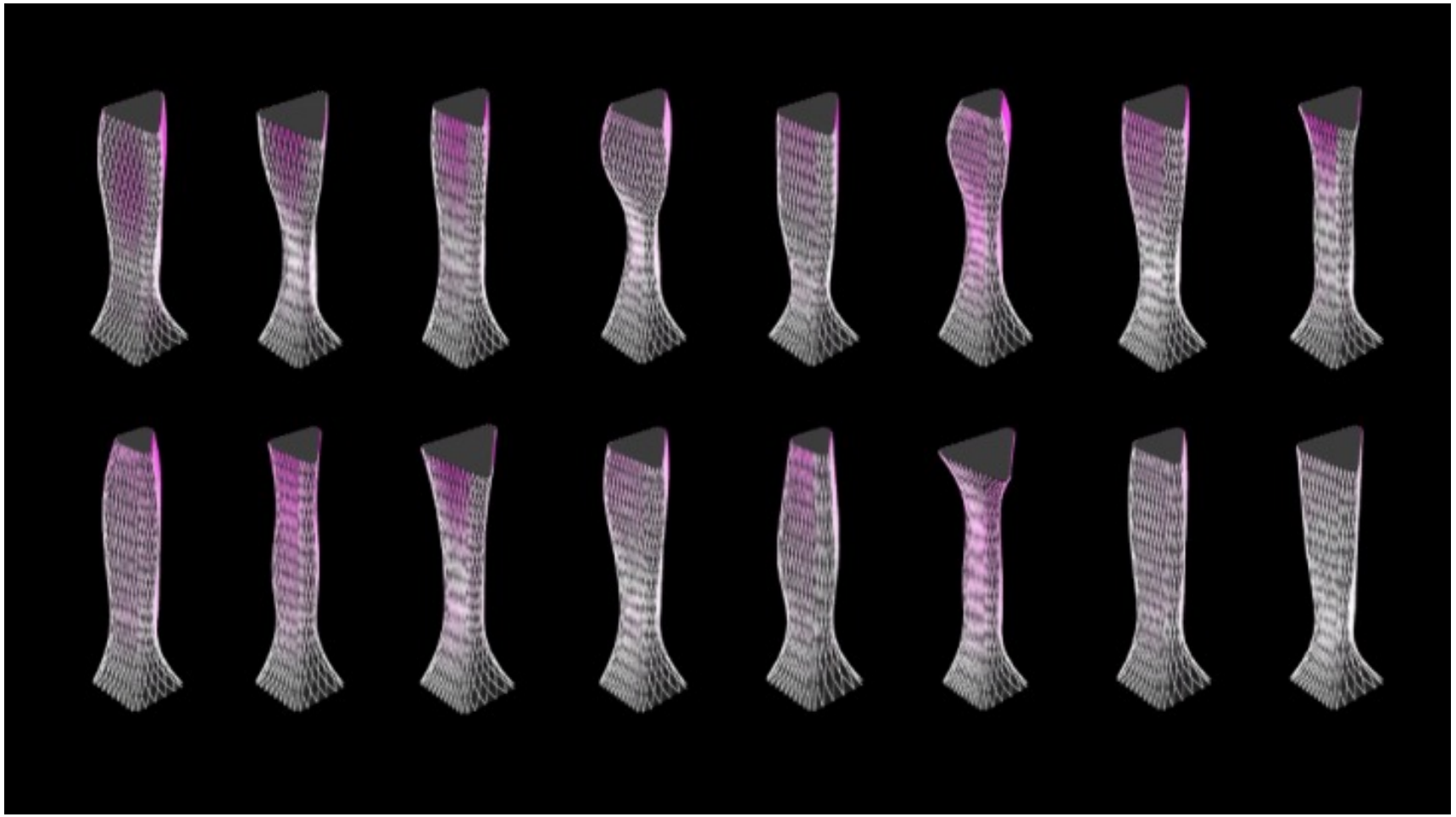
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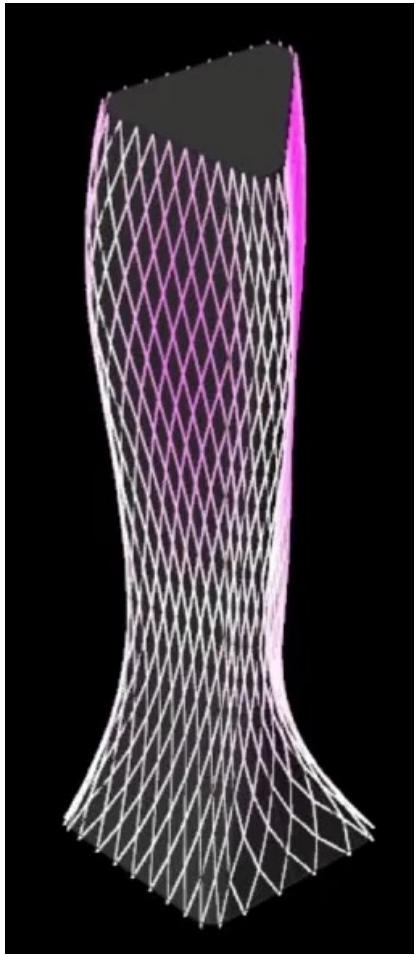


Linear Logic to Generative Logic

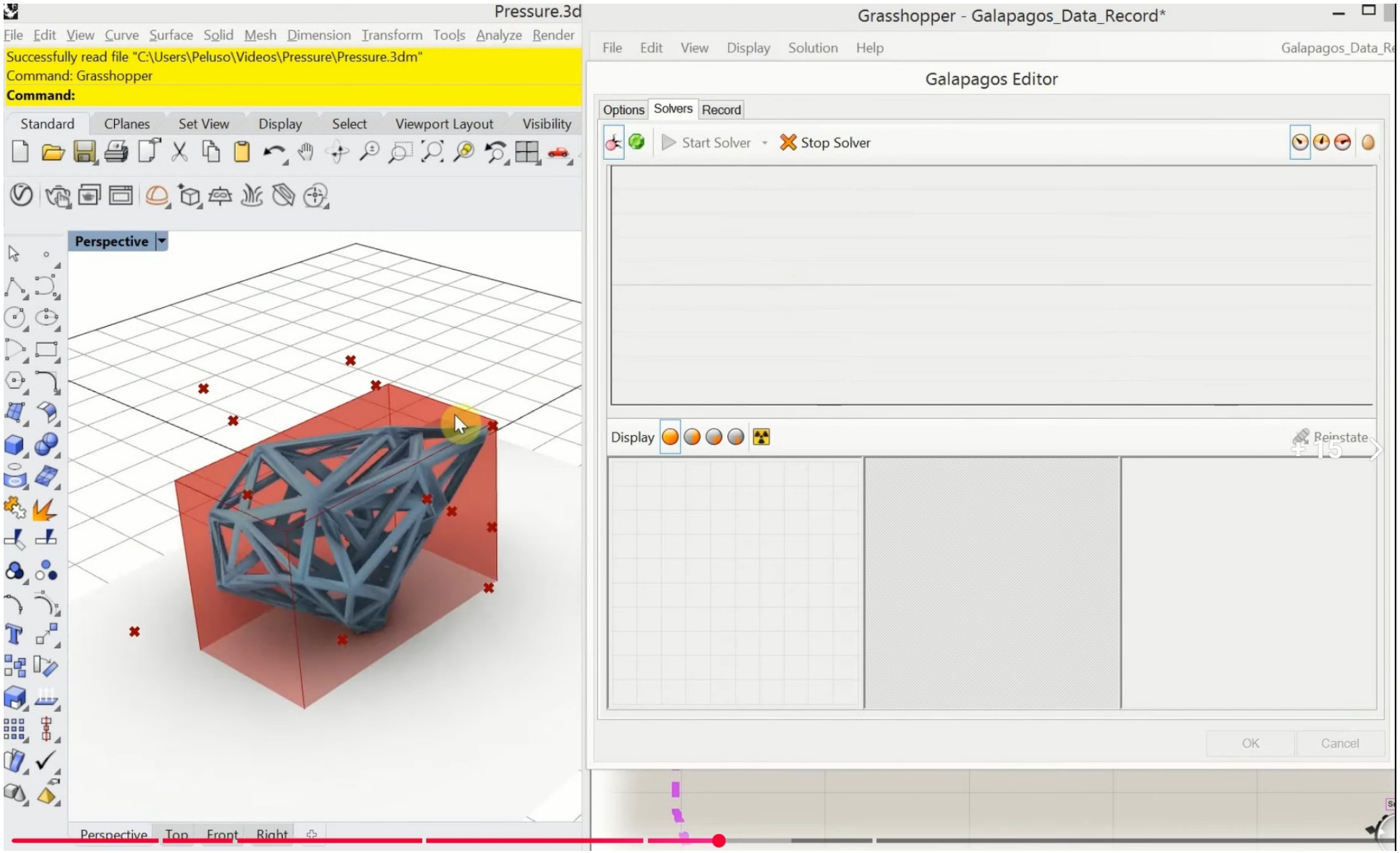


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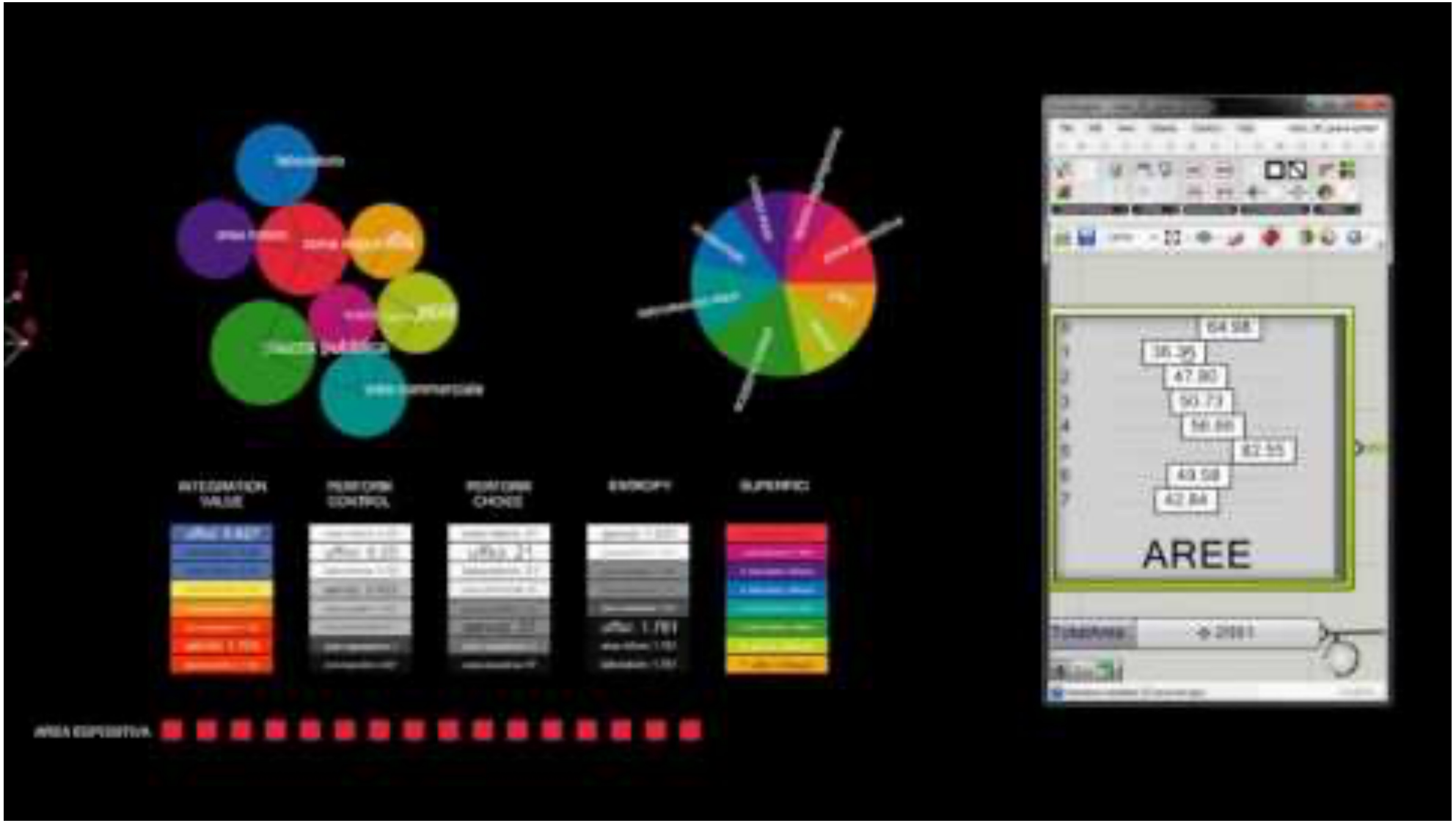




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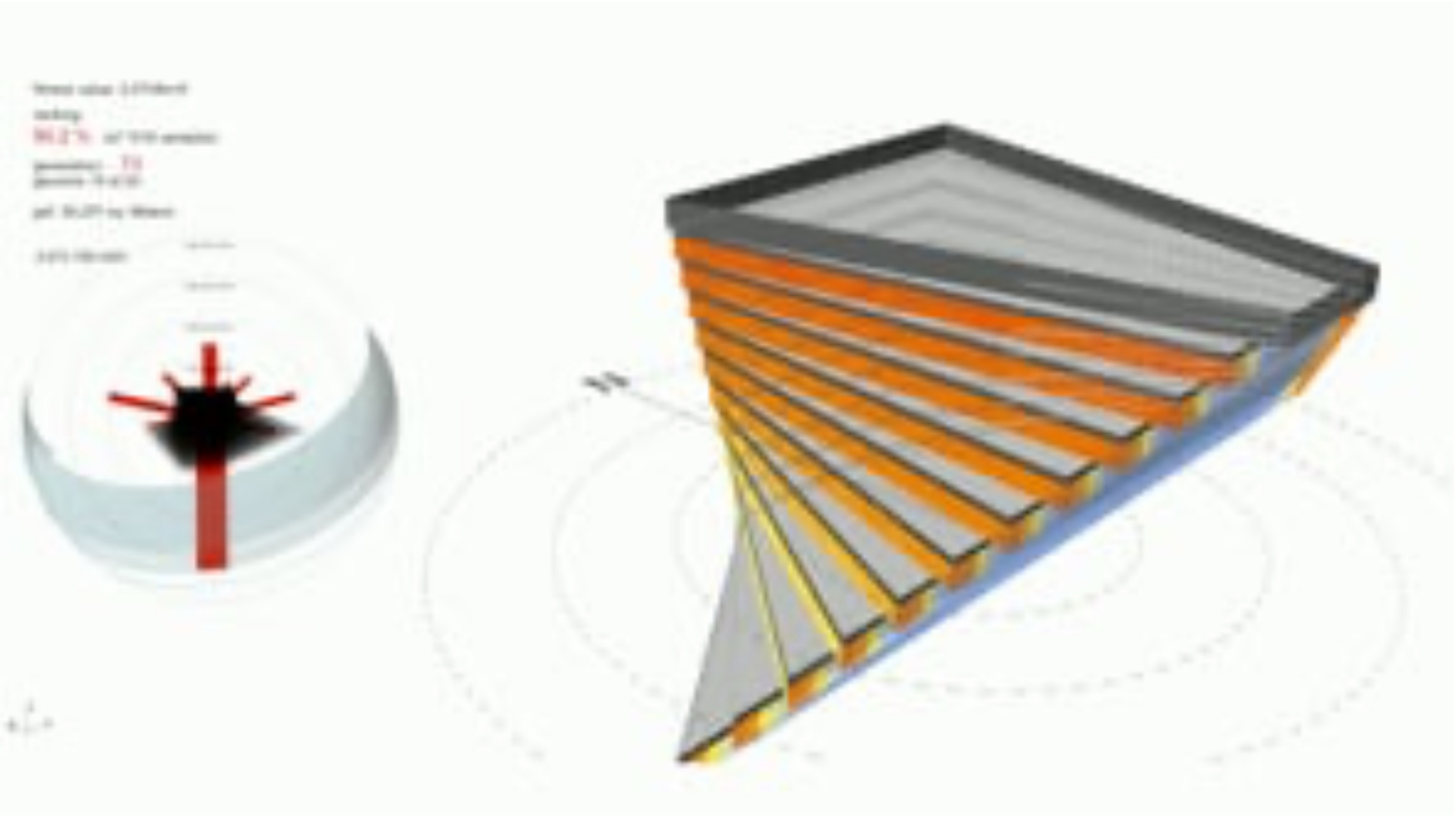


Linear Logic to Generative Logic



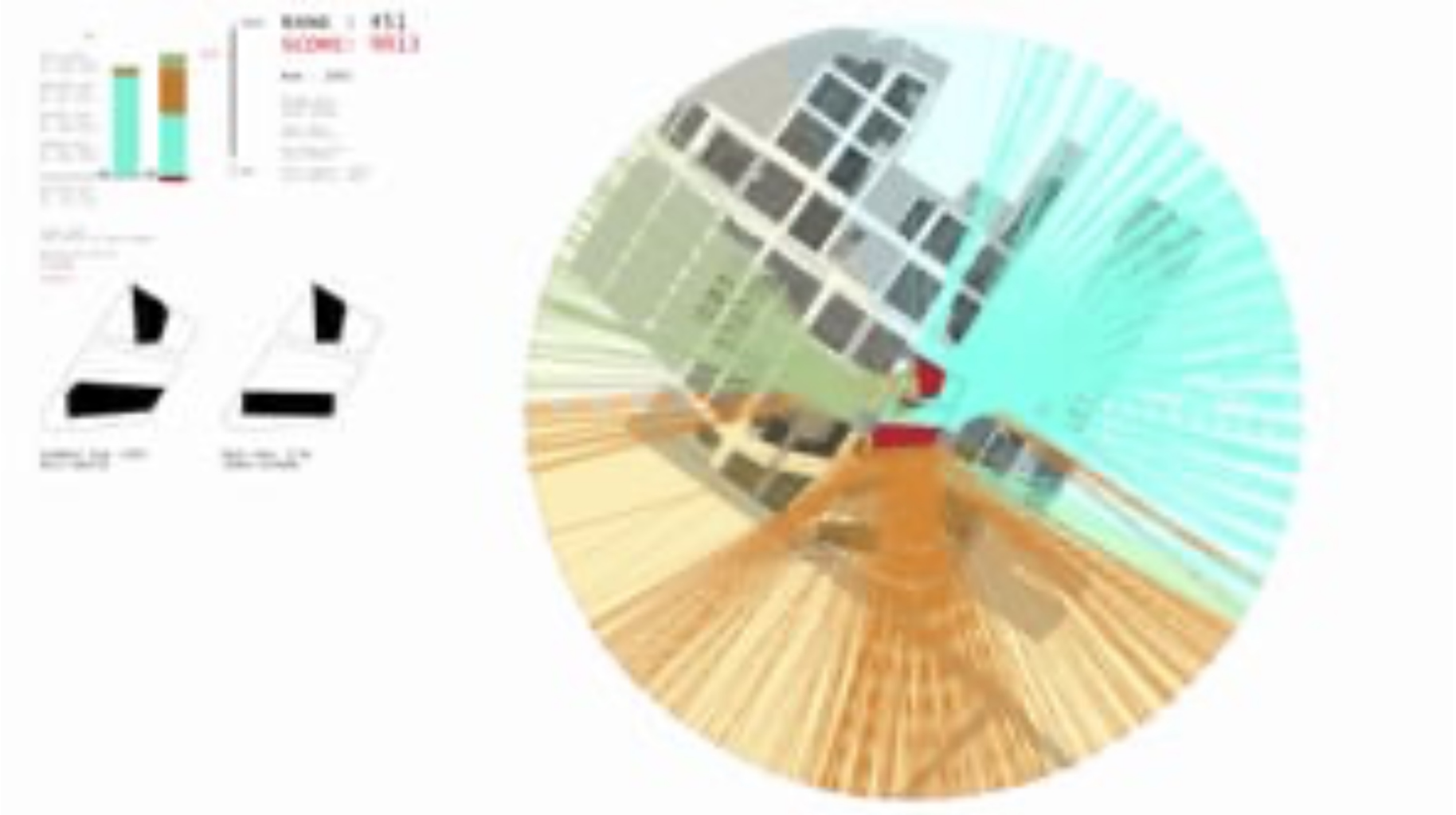
Resource: https://www.youtube.com/watch?v=7P2frKOJZ0k

Linear Logic to Generative Logic



Resource: https://vimeo.com/118756126?fl=pl&fe=vl

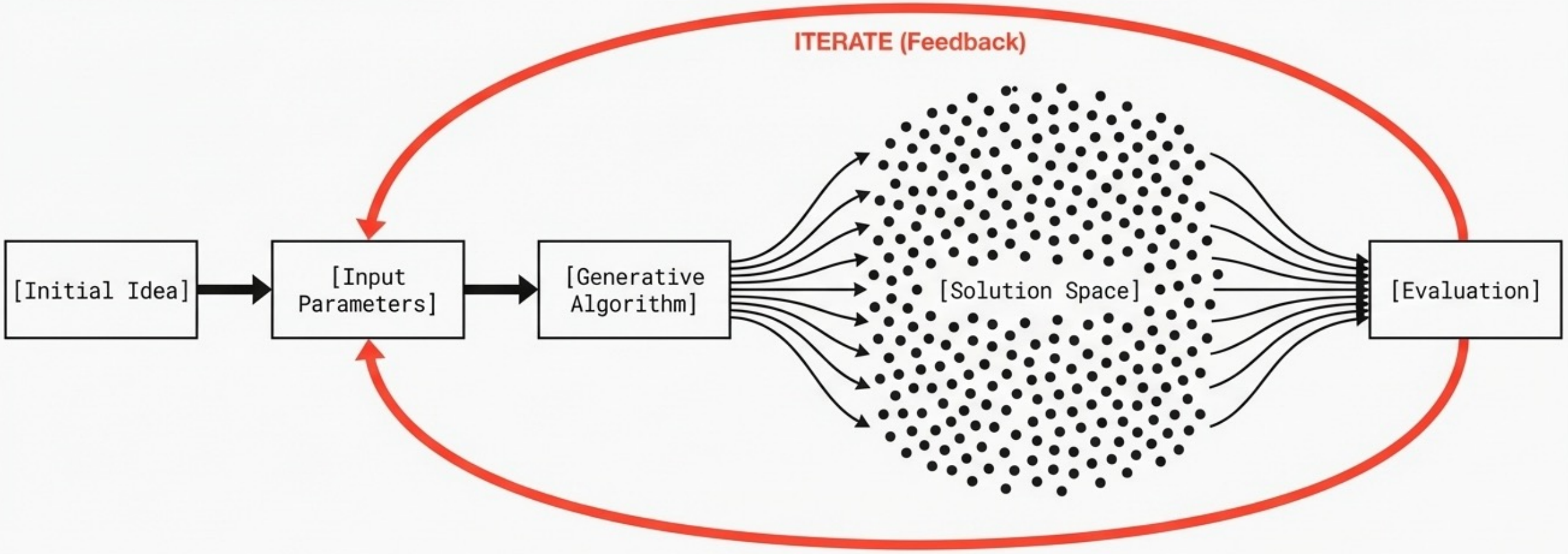
Linear Logic to Generative Logic



Resource: https://vimeo.com/114298250

The Generative Engine

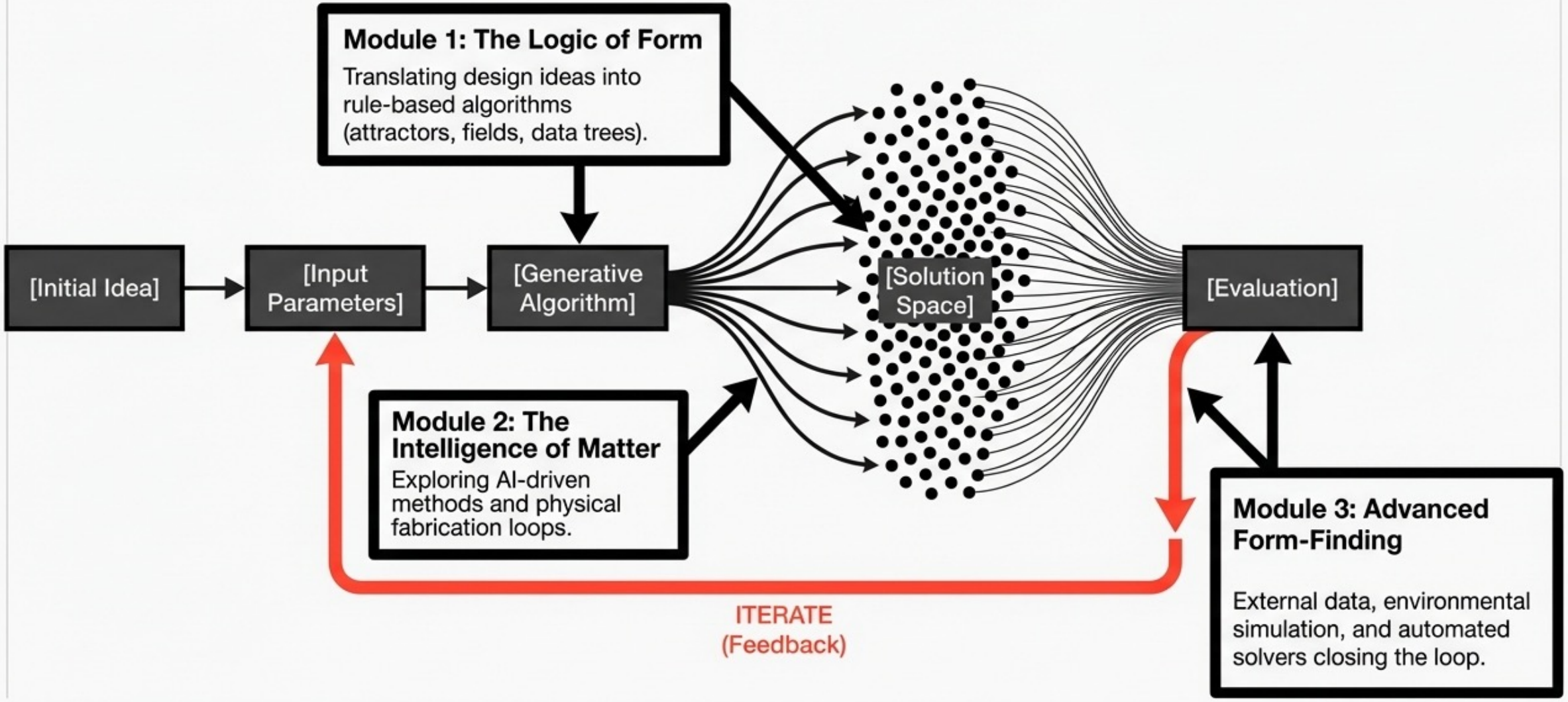
The Master Loop Explanatory Visual



Generate: A parametric model produces variations by altering inputs.	**Evaluate:** A simulation scores each variation against defined goals.	**Iterate:** Results feed back to adjust parameters, manually or automatically.

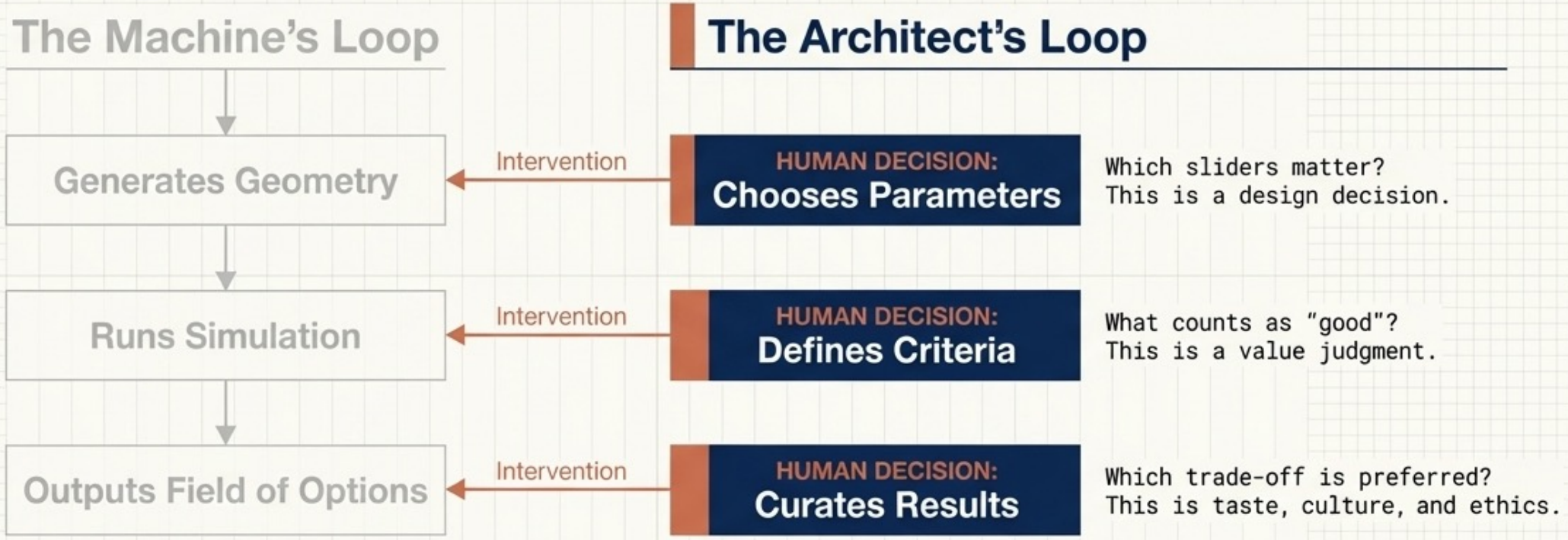
NotebookLM

The Semester in One Loop



NotebookLM

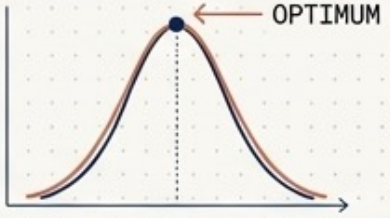
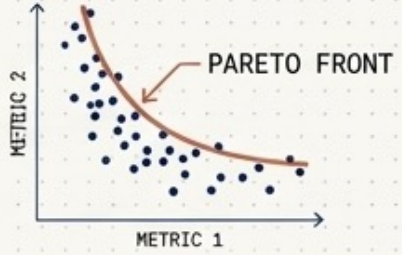
Computation does not replace design; it shifts effort from drafting solutions to defining values.



The key question in generative design is always: who decides what 'better' means?

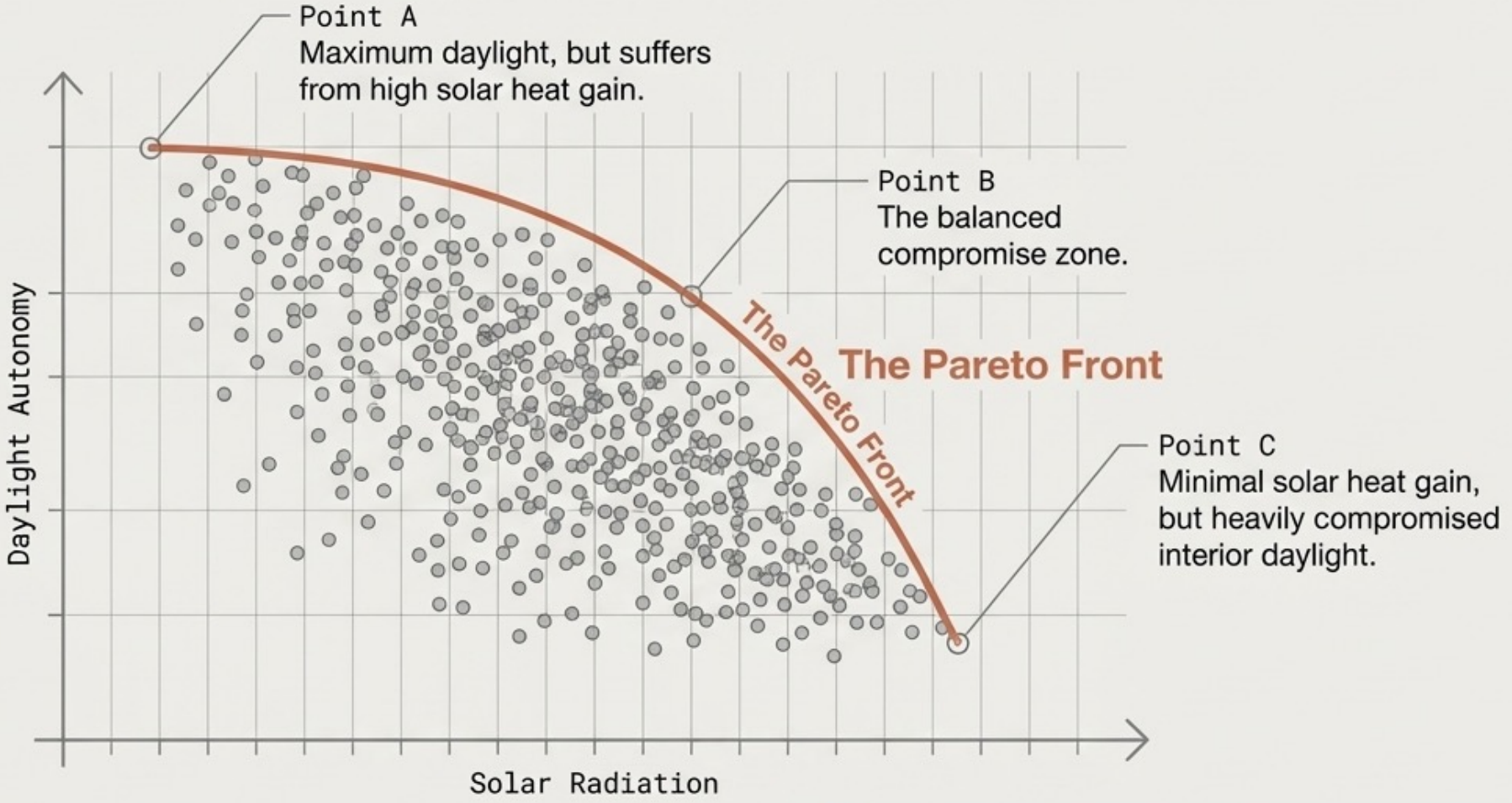
NotebookLM

Optimization strategies scale to match the complexity of the architectural problem.

Single-Objective Optimization			
Goal: Find the absolute best value for one isolated metric.	**Trade-offs:** None. Adjusts one ‘dial’ for maximum signal.	**Output Shape:** The Mountain 	**Ecosystem:** Galapagos.
Multi-Objective Optimization			
Goal: Balance two or more competing metrics simultaneously (e.g., maximize solar gain vs. minimize cooling load).	**Trade-offs:** High. Improving one metric degrades another.	**Output Shape:** The Pareto Front 	**Ecosystem:** Wallacei, Octopus.

NotebookLM

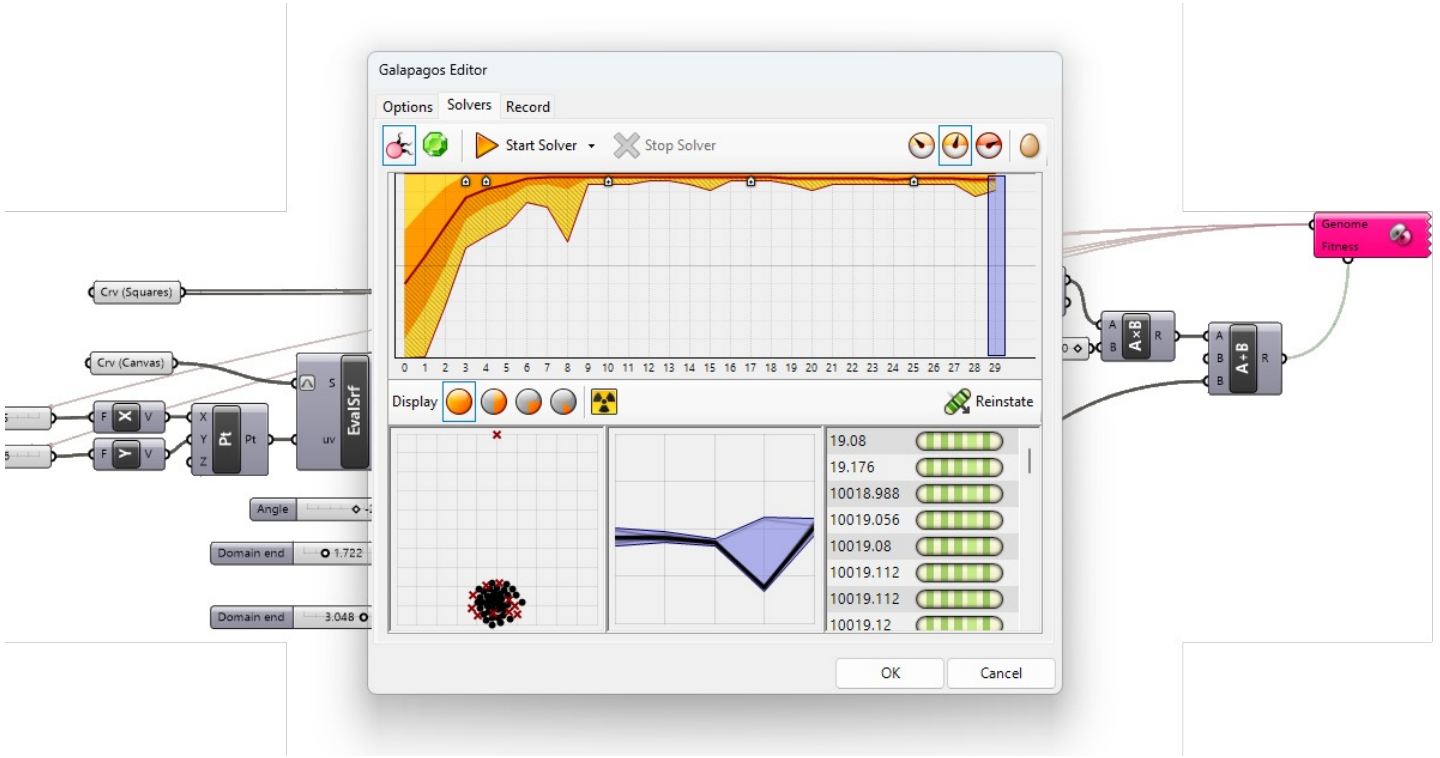
The Pareto Front visualizes the landscape of optimal compromises.



The solver reveals the boundaries of physics.
The designer selects the position on the curve.

NotebookLM

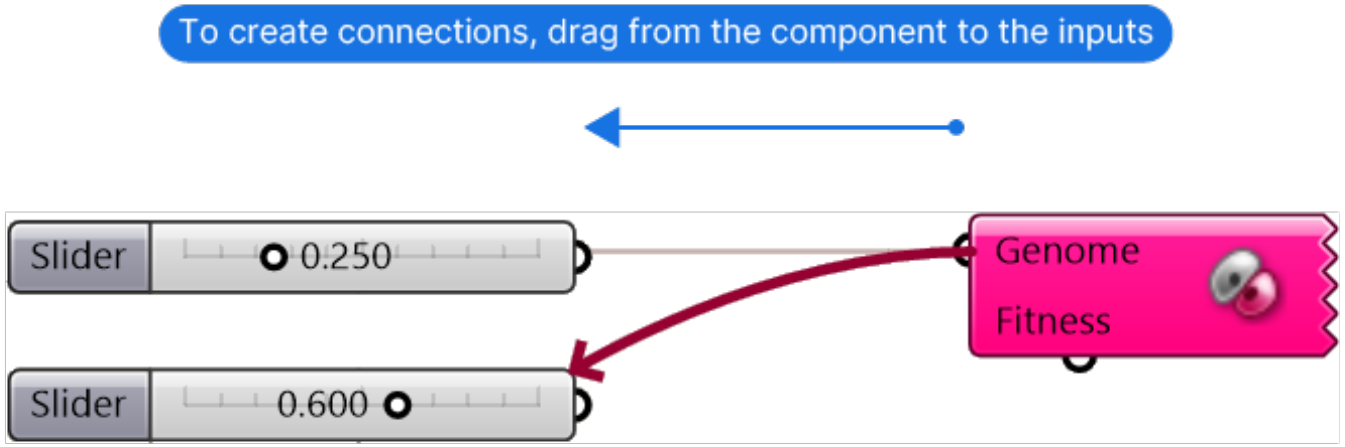
Evolutionary Solver





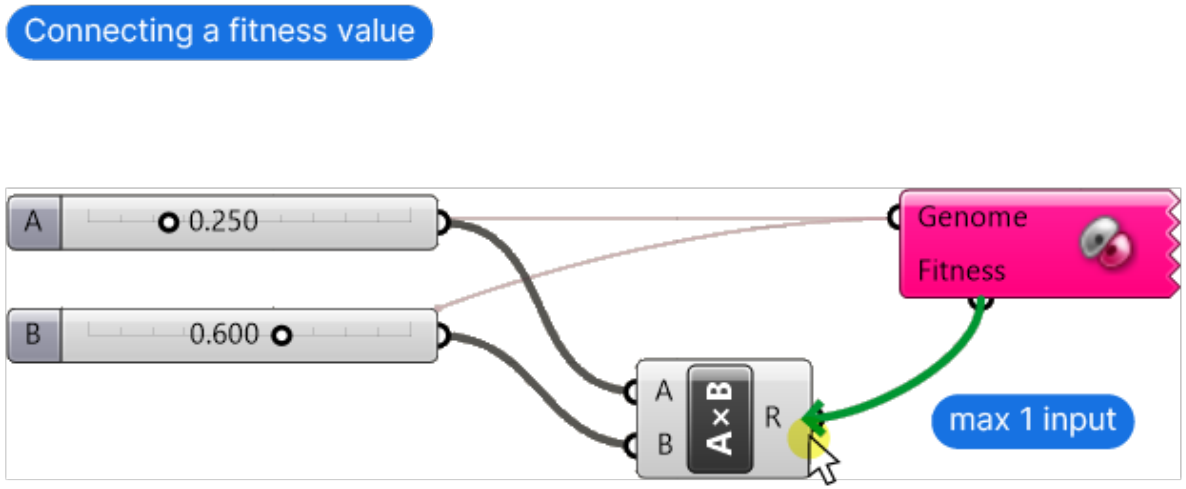
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Evolutionary Solver



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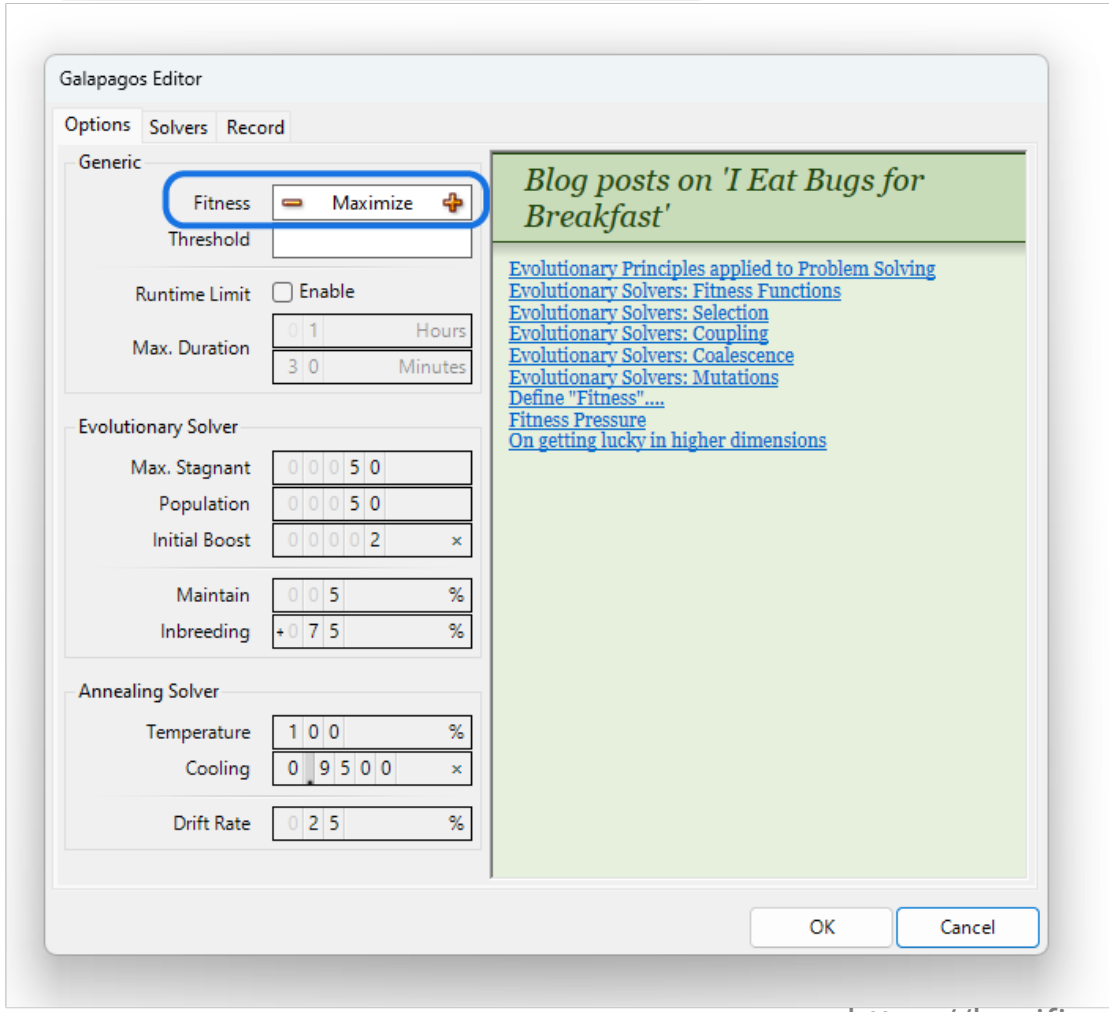
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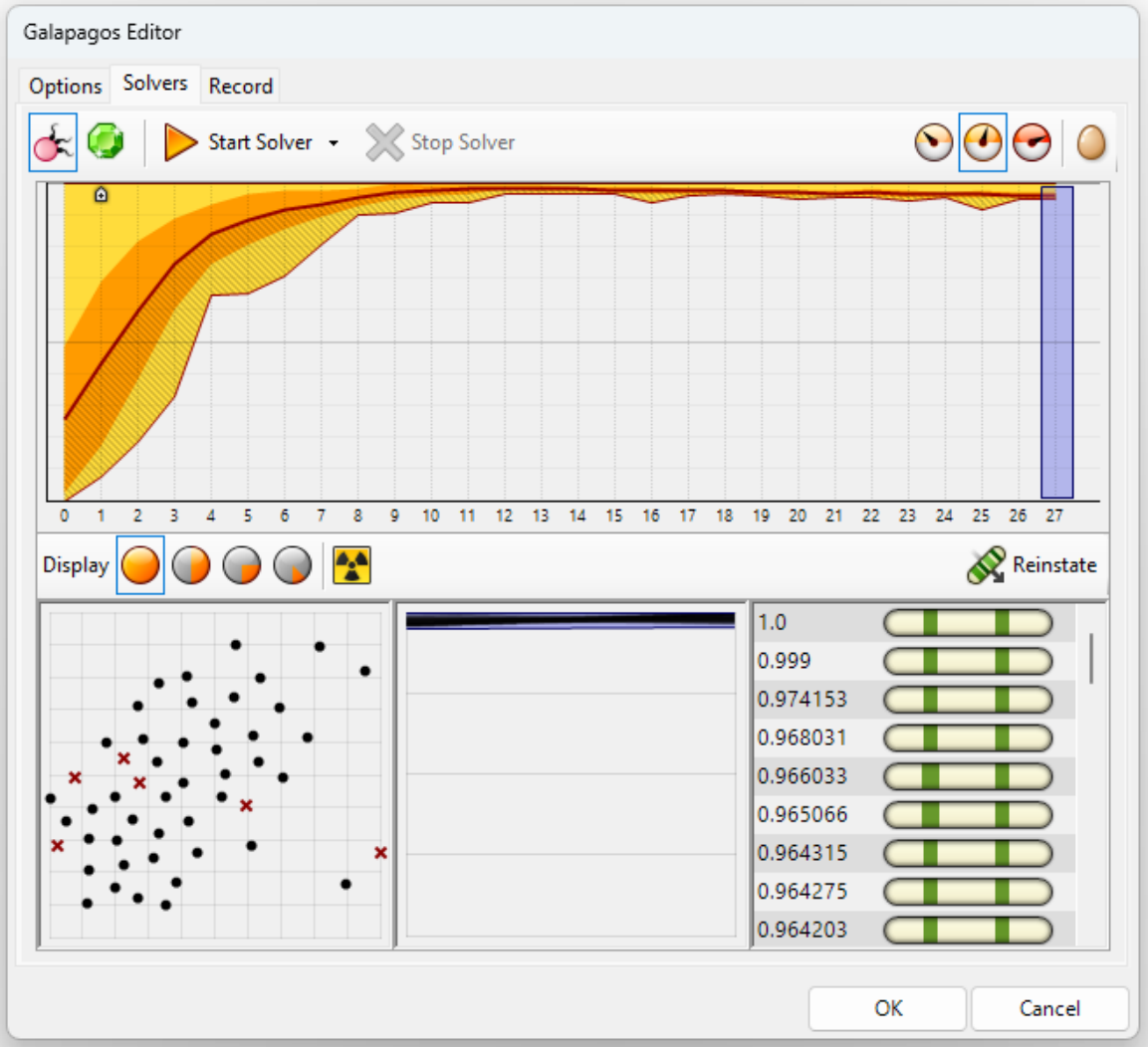
Evolutionary Solver

Define whether to optimize for minimum or maximum



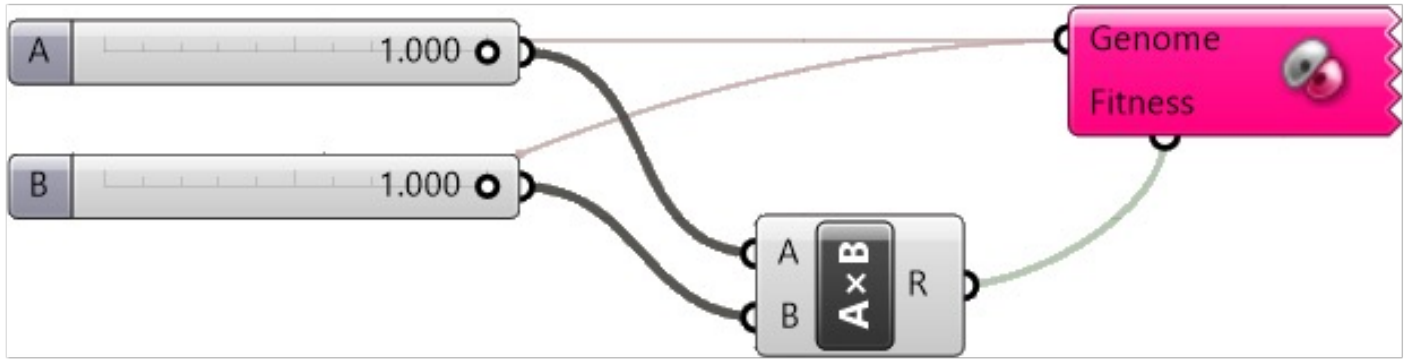
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Evolutionary Solver



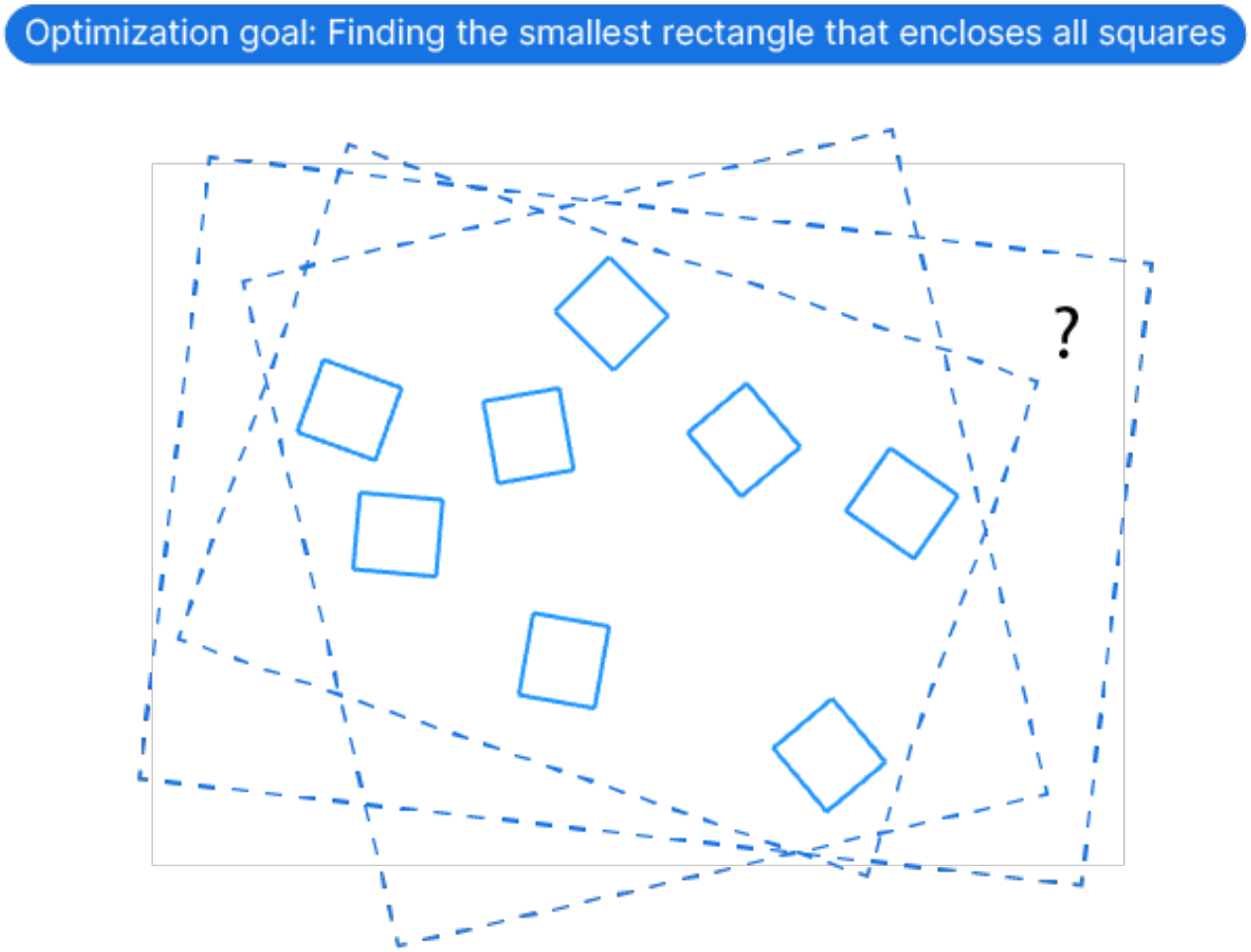
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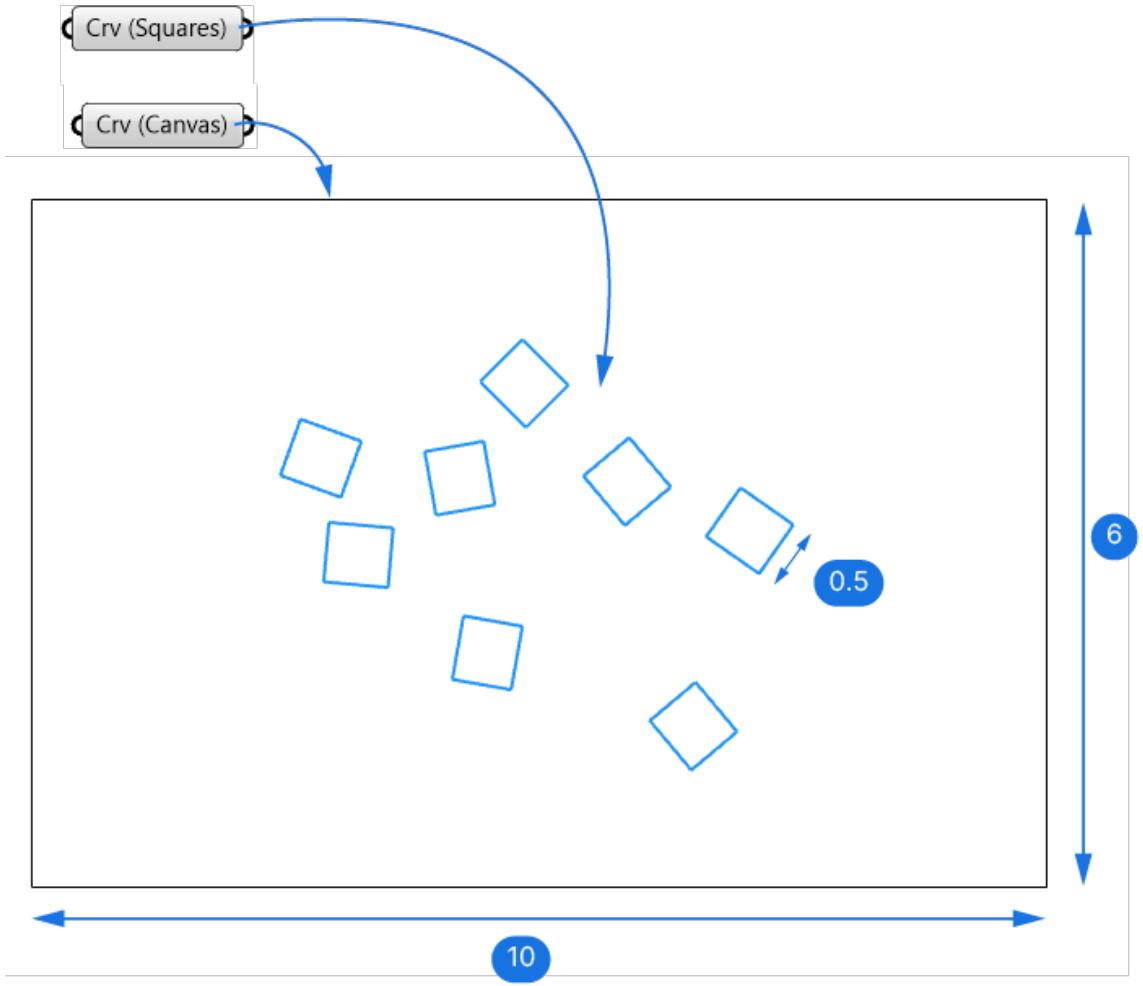
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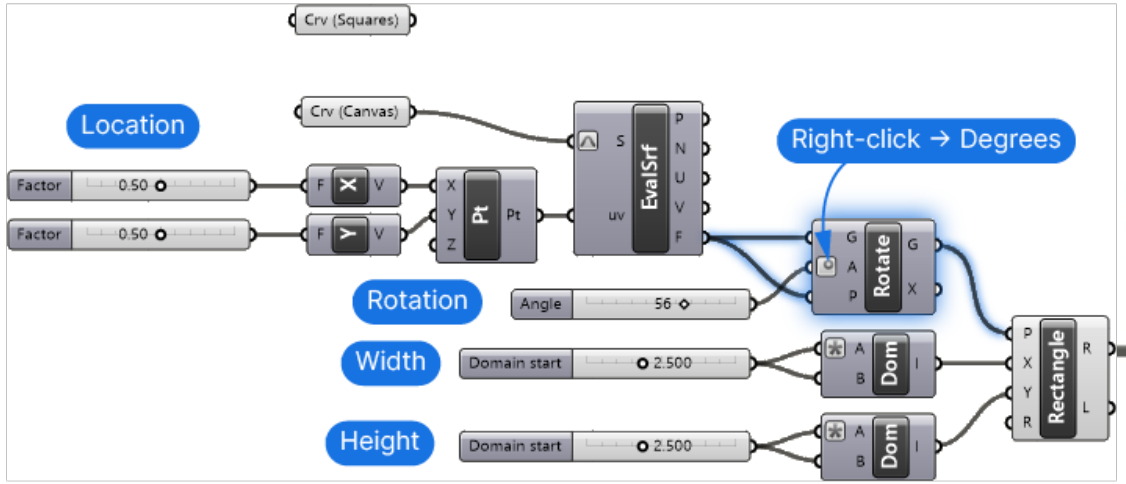
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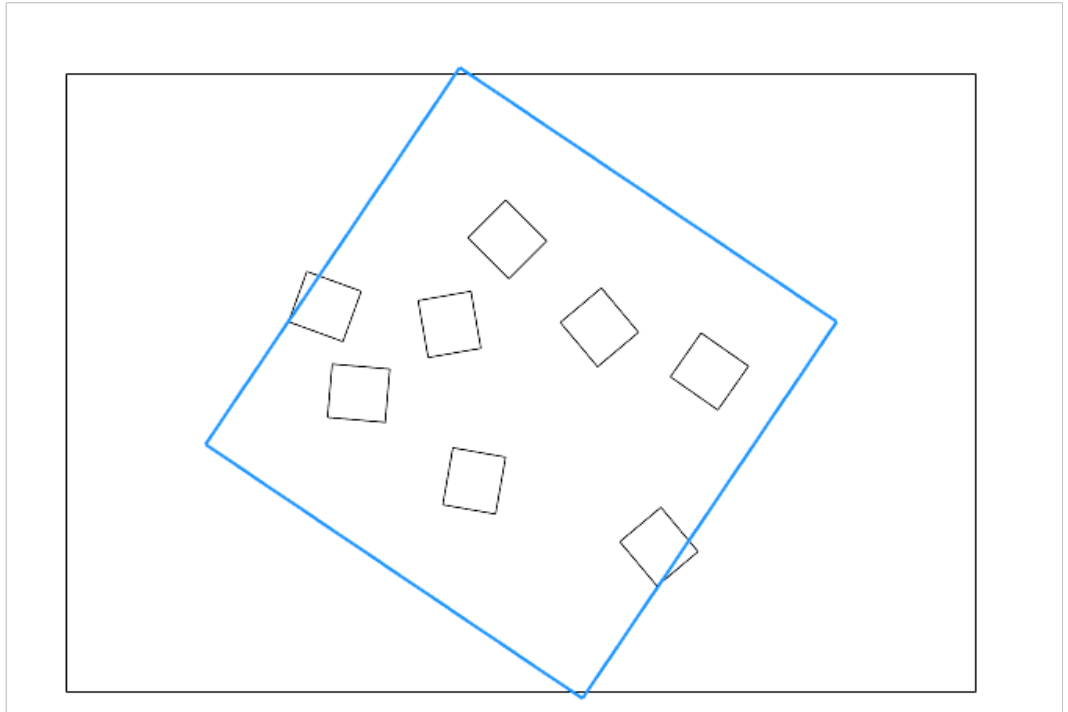
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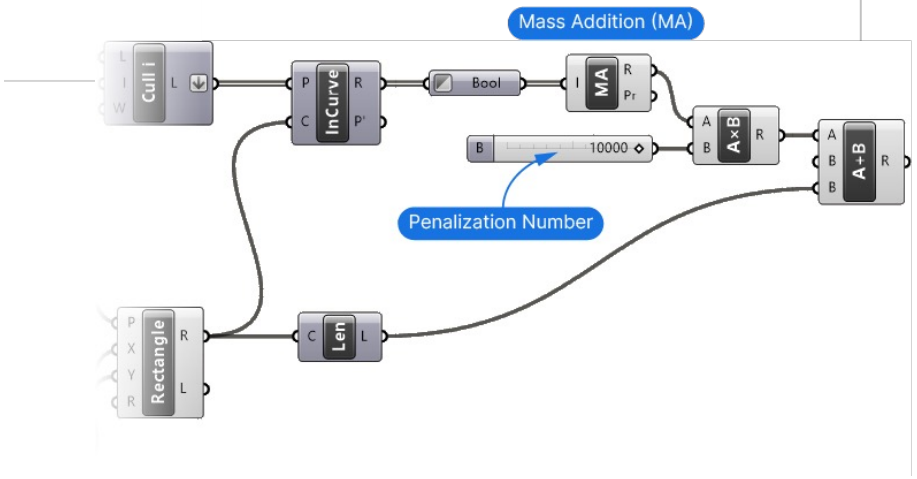


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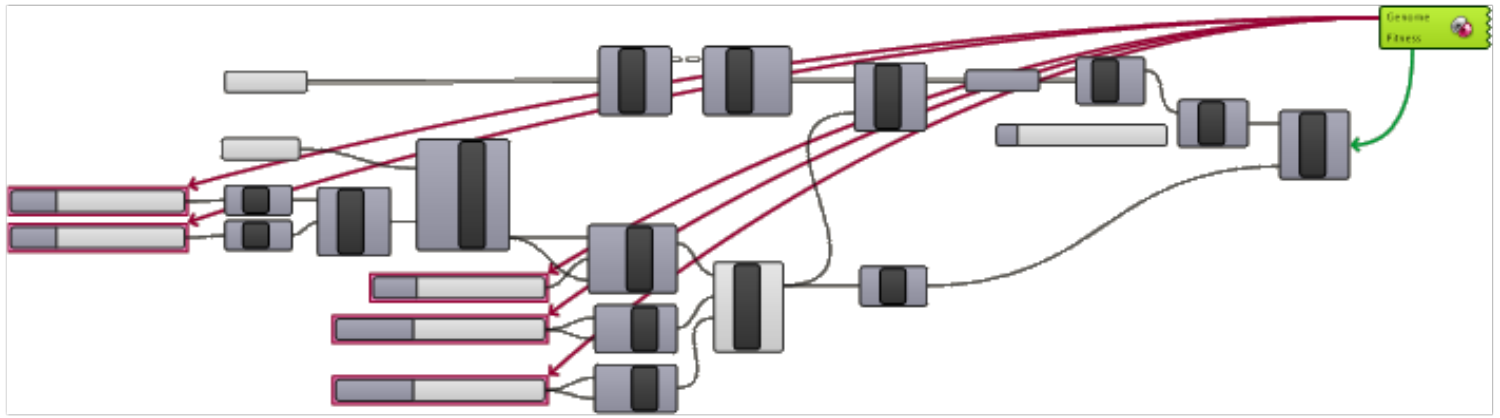


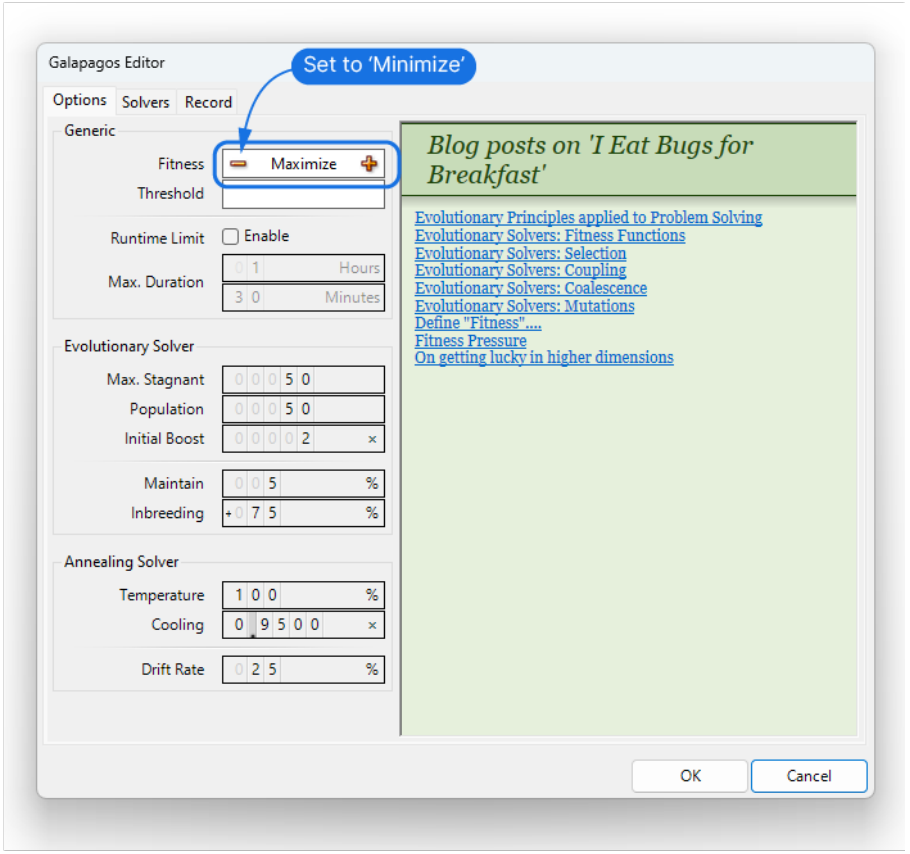




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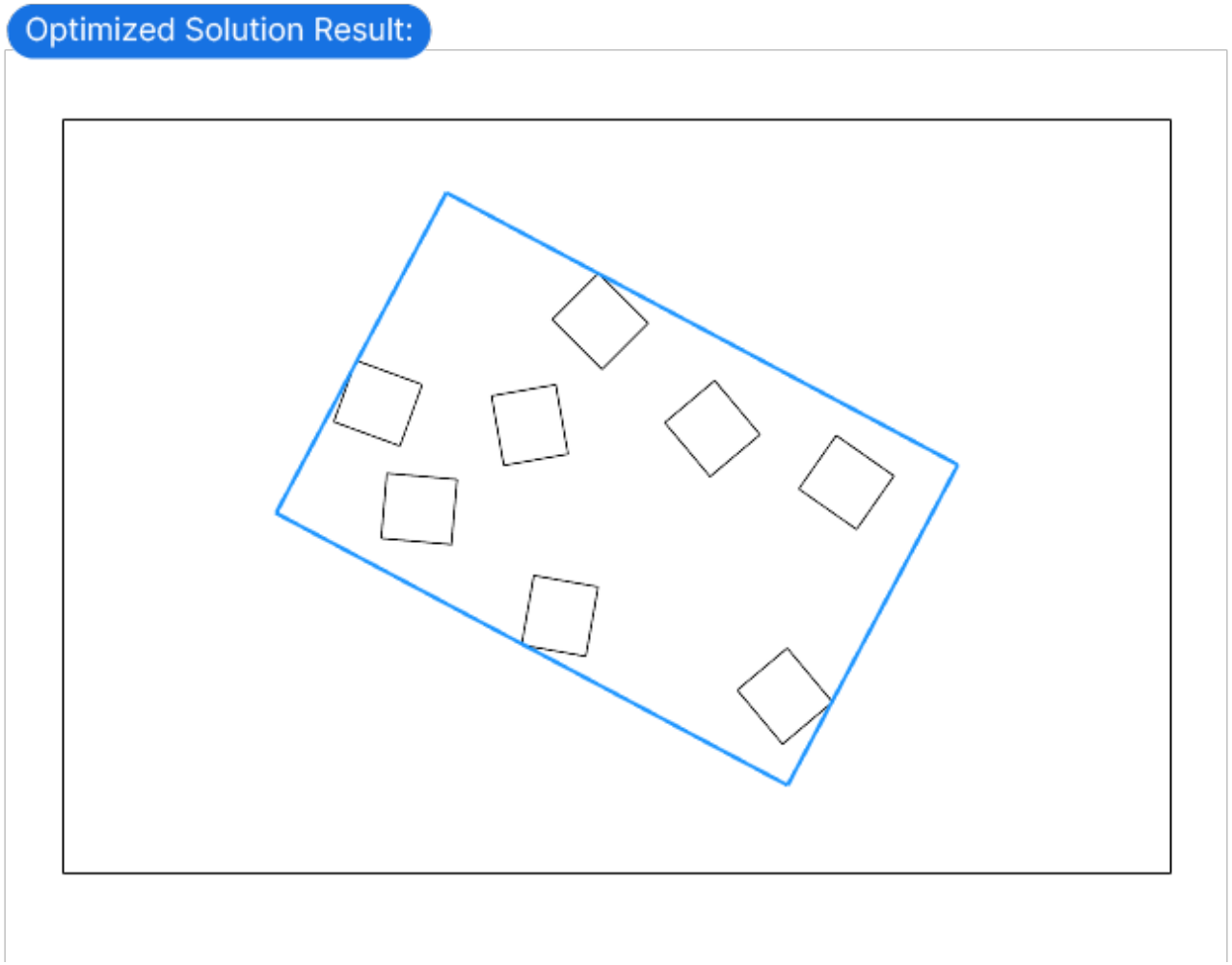
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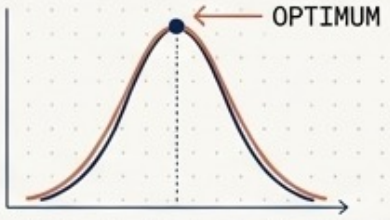
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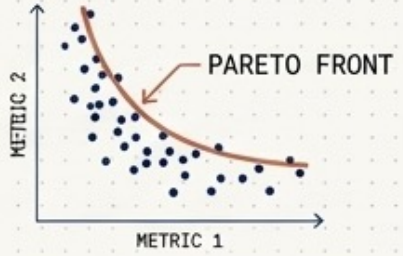
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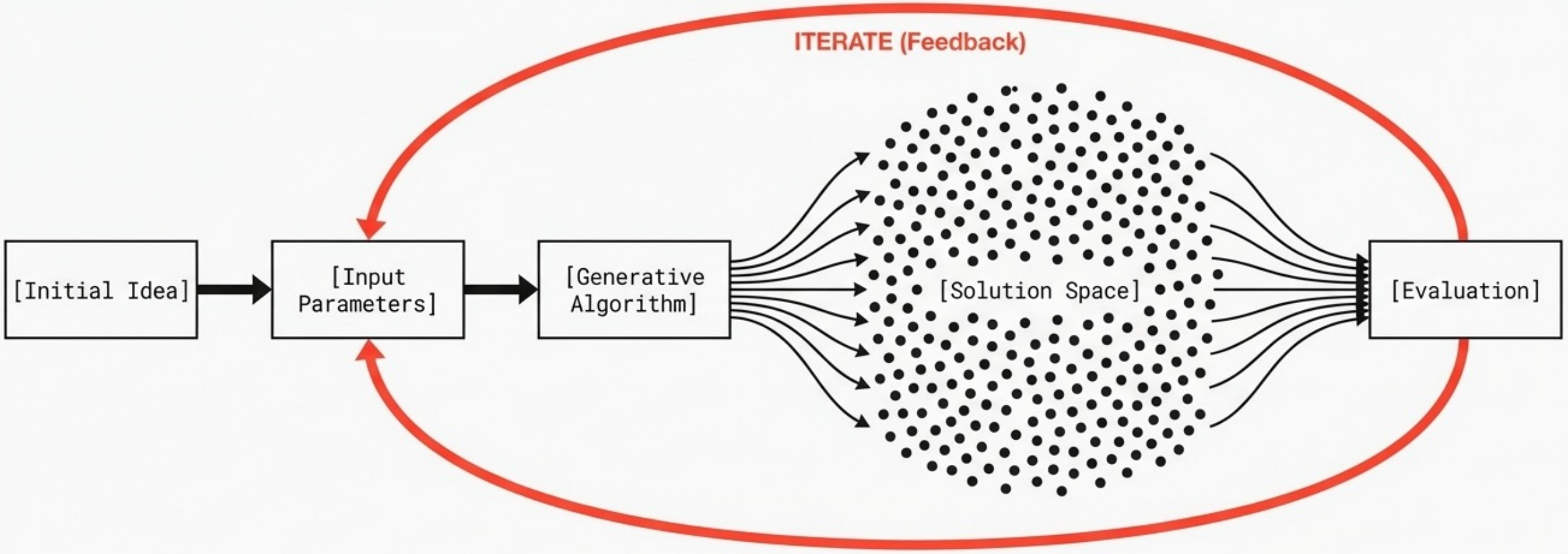
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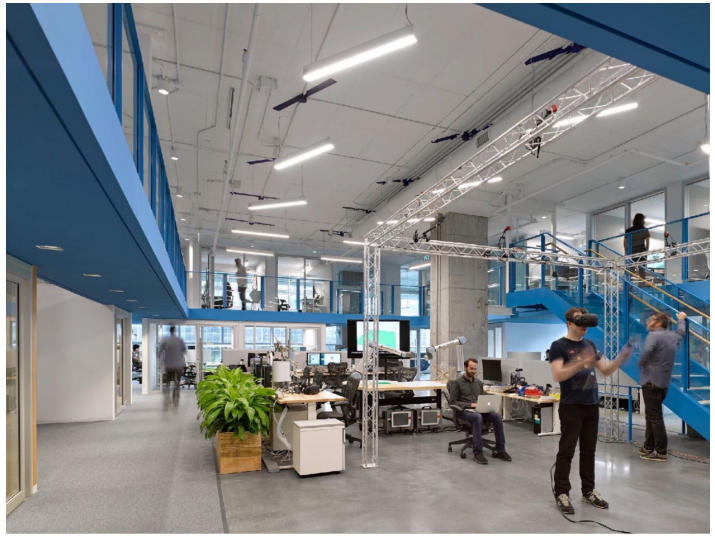
Case Studies

Case Studies

Layout Optimization

60,000 sq ft office. 300 employees surveyed.
6 goals. 10,000 options generated.
10 finalists presented with data.



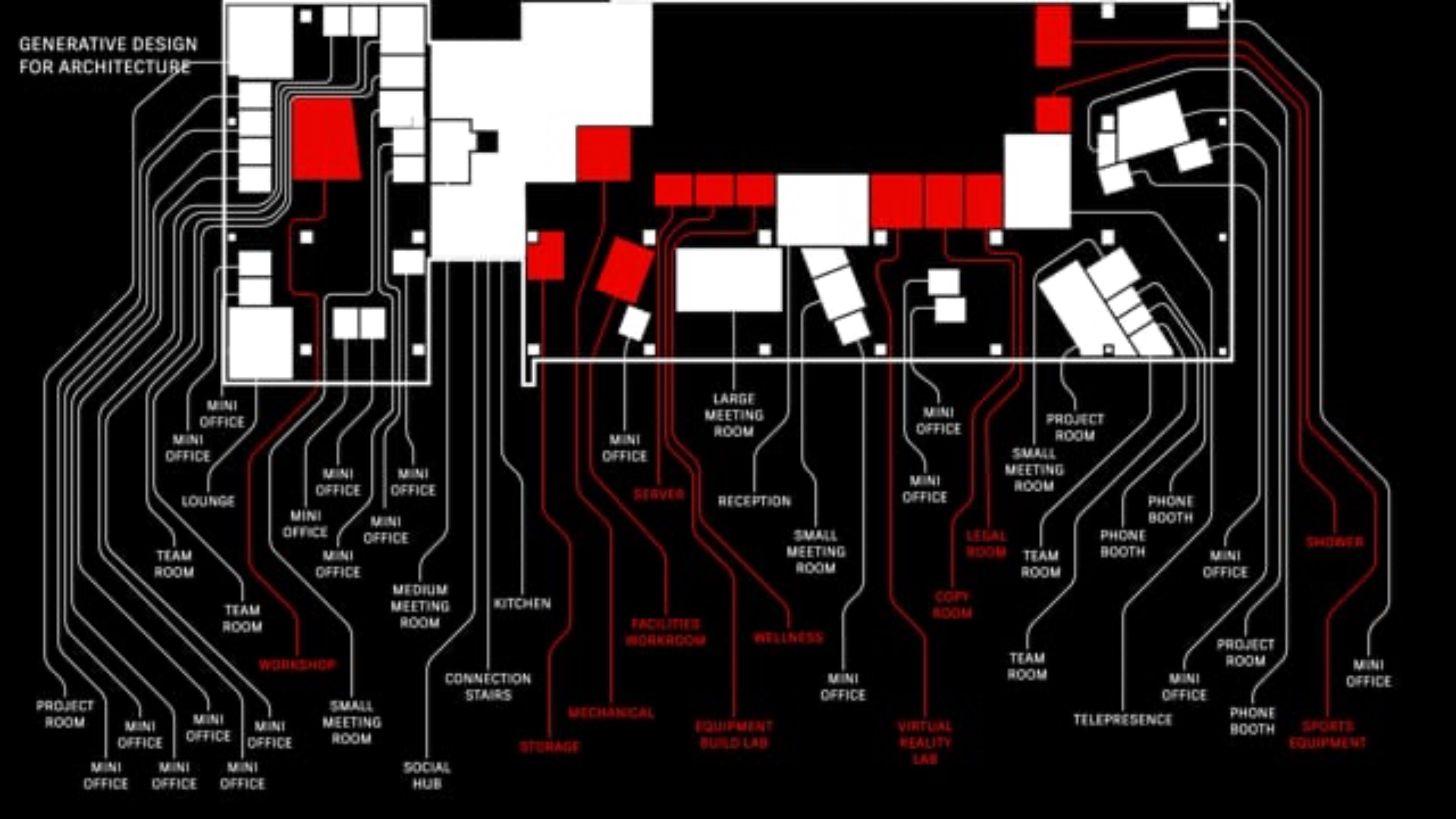




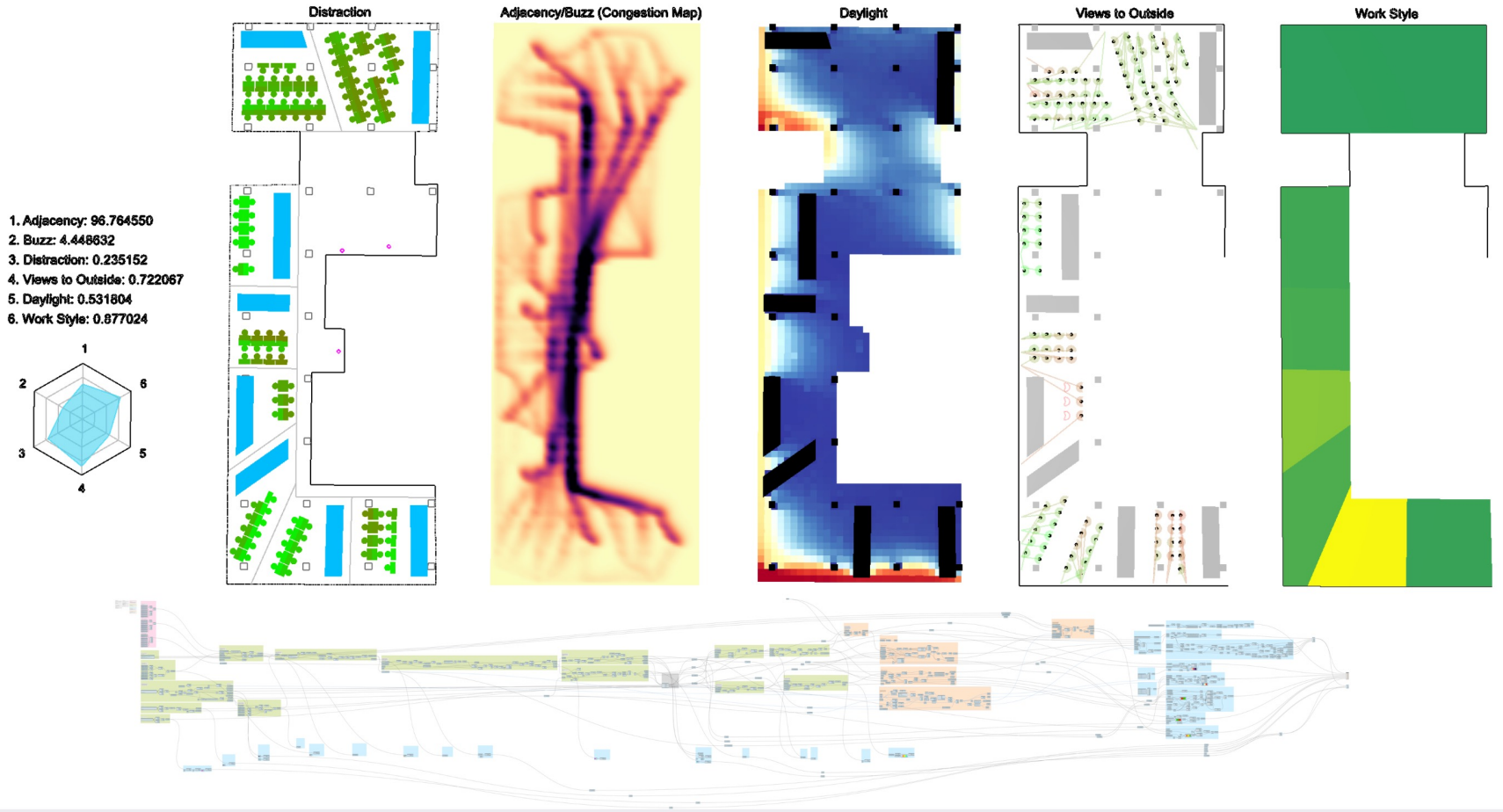


Autodesk MaRS Office
The Living, 2017

Resource: https://www.autodesk.com/autodesk-university/class/Hands-Project-Rediscover-generatively-designing-Autodesk-Torontos-office-2019


GENERATIVE DESIGN FOR ARCHITECTURE
MINI OFFICE
MINI OFFICE
LOUNGE
TEAM ROOM
TEAM ROOM
WORKSHOP
PROJECT ROOM
MINI OFFICE
MINI OFFICE
MINI OFFICE
MINI OFFICE
MINI OFFICE
MINI OFFICE
MINI OFFICE
MINI OFFICE
MINI OFFICE
MINI OFFICE
MINI OFFICE
SMALL MEETING ROOM
MEDIUM MEETING ROOM
SOCIAL HUB
CONNECTION STAIRS
KITCHEN
STORAGE
MECHANICAL
MINI OFFICE
FACILITIES WORKROOM
SERVER
EQUIPMENT BUILD LAB
LARGE MEETING ROOM
RECEPTION
WELLNESS
SMALL MEETING ROOM
MINI OFFICE
VIRTUAL REALITY LAB
MINI OFFICE
MINI OFFICE
COPY ROOM
LEGAL ROOM
SMALL MEETING ROOM
PROJECT ROOM
TEAM ROOM
TEAM ROOM
PHONE BOOTH
PHONE BOOTH
TELEPRESENCE
MINI OFFICE
MINI OFFICE
PROJECT ROOM
PHONE BOOTH
SHOWER
SPORTS EQUIPMENT
MINI OFFICE

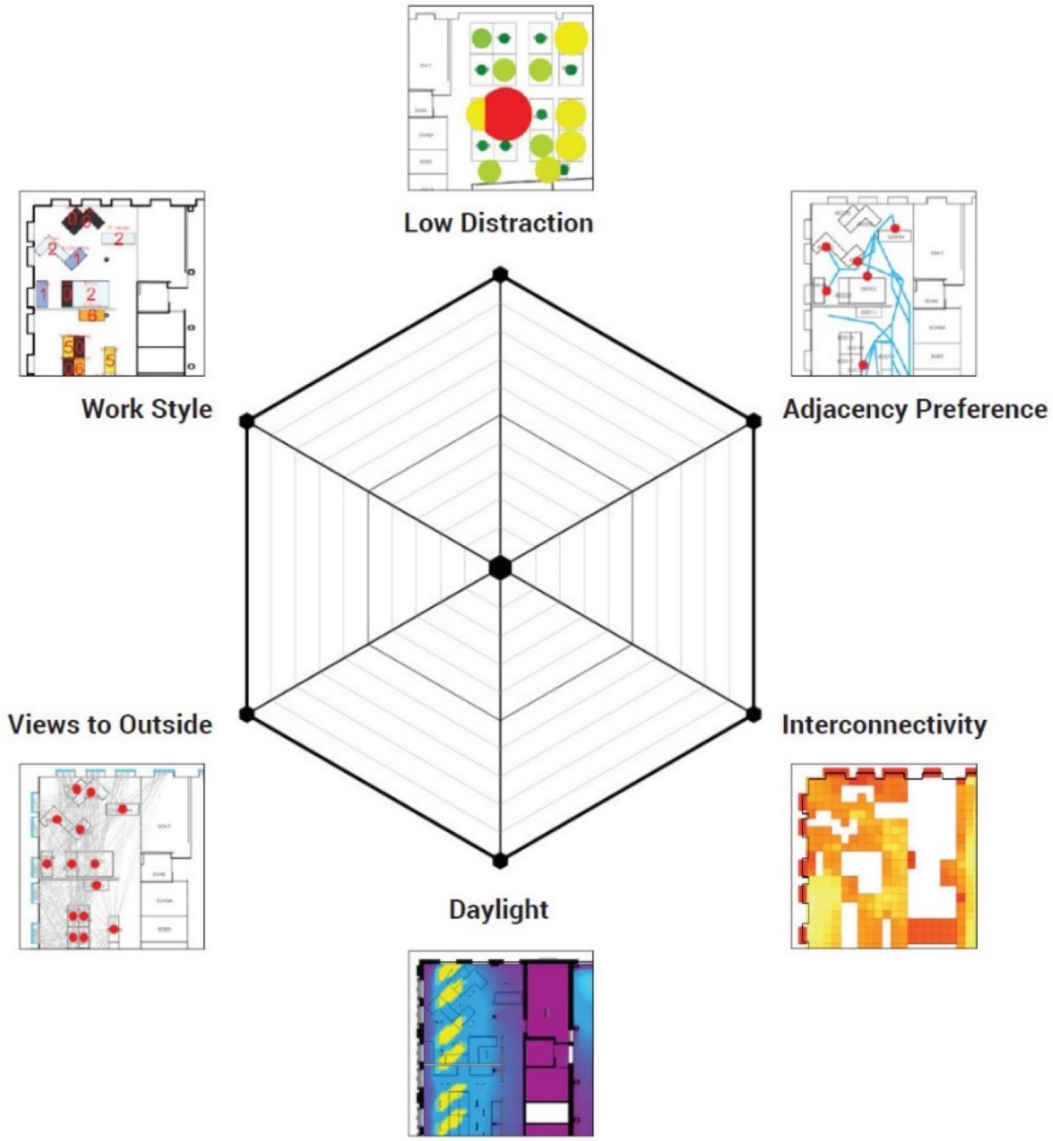
Layout Optimization



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Layout Optimization



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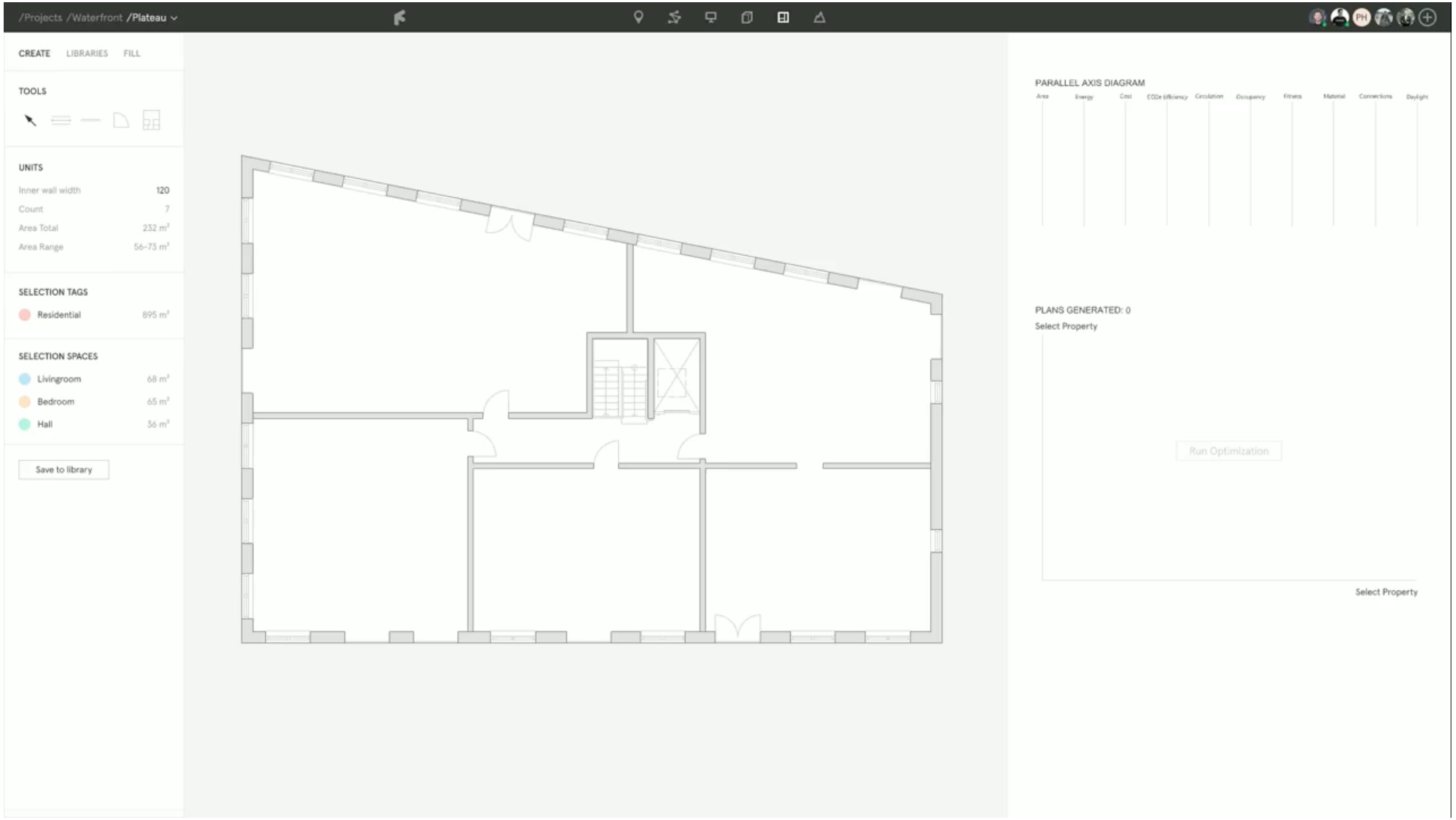
Layout Optimization

1	**Multi-Objective Optimization**	Real design problems have competing goals — generative design explores trade-offs across all of them simultaneously
2	**Parametric Geometry System**	The layout is encoded as ~25 numeric parameters that define neighborhoods, spines, and desk placement — making it machine-searchable
3	**Evaluation is Key**	Six quantifiable metrics (distraction, adjacency, buzz, daylight, views, work style) turn subjective preferences into computable fitness functions
4	**Accessible Tools**	Dynamo + Refinery bring generative design from bespoke research code to tools any designer can use

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Case Studies

Layout Optimization

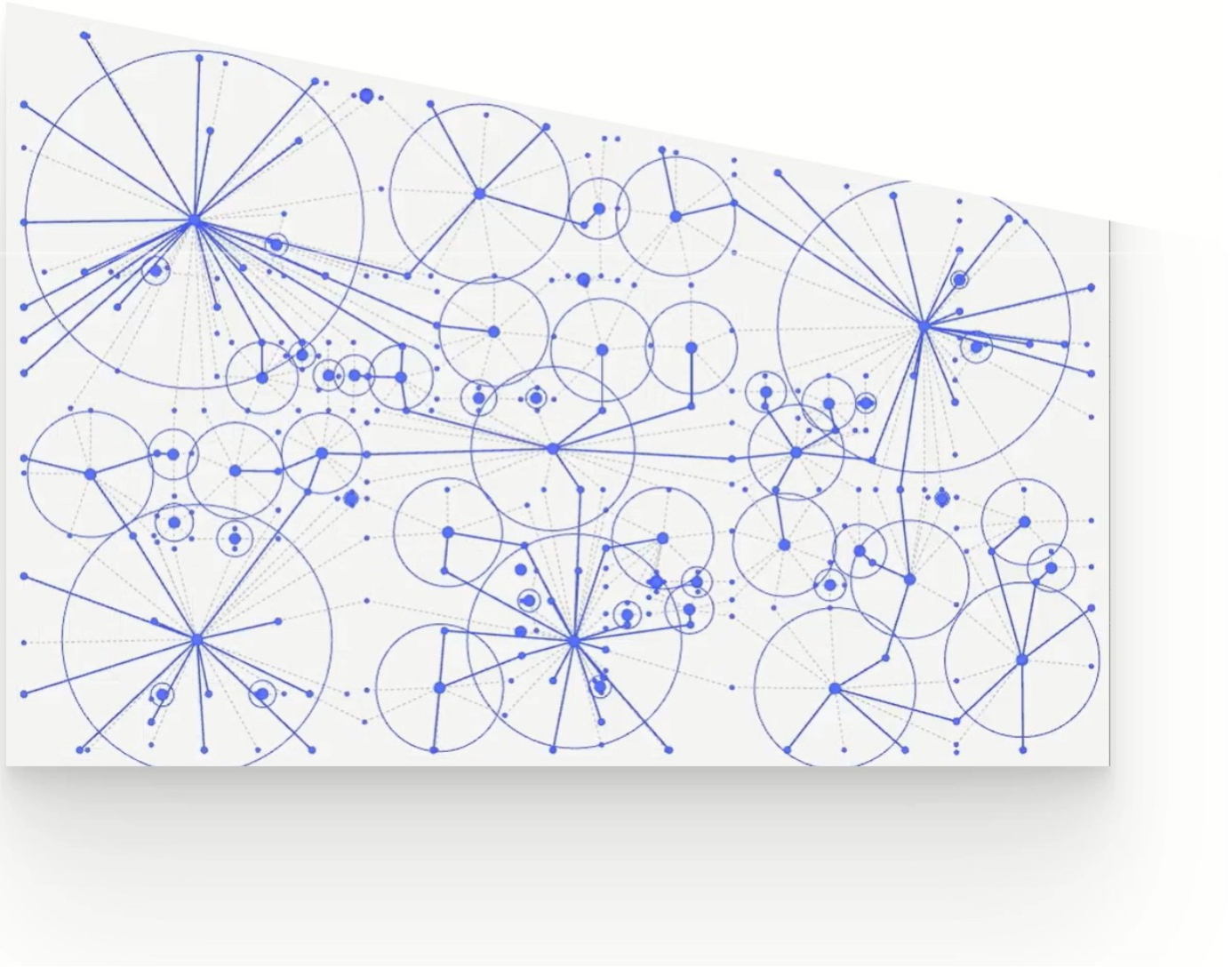


Finch

Resource: https://www.finch3d.com

Case Studies

Layout Optimization

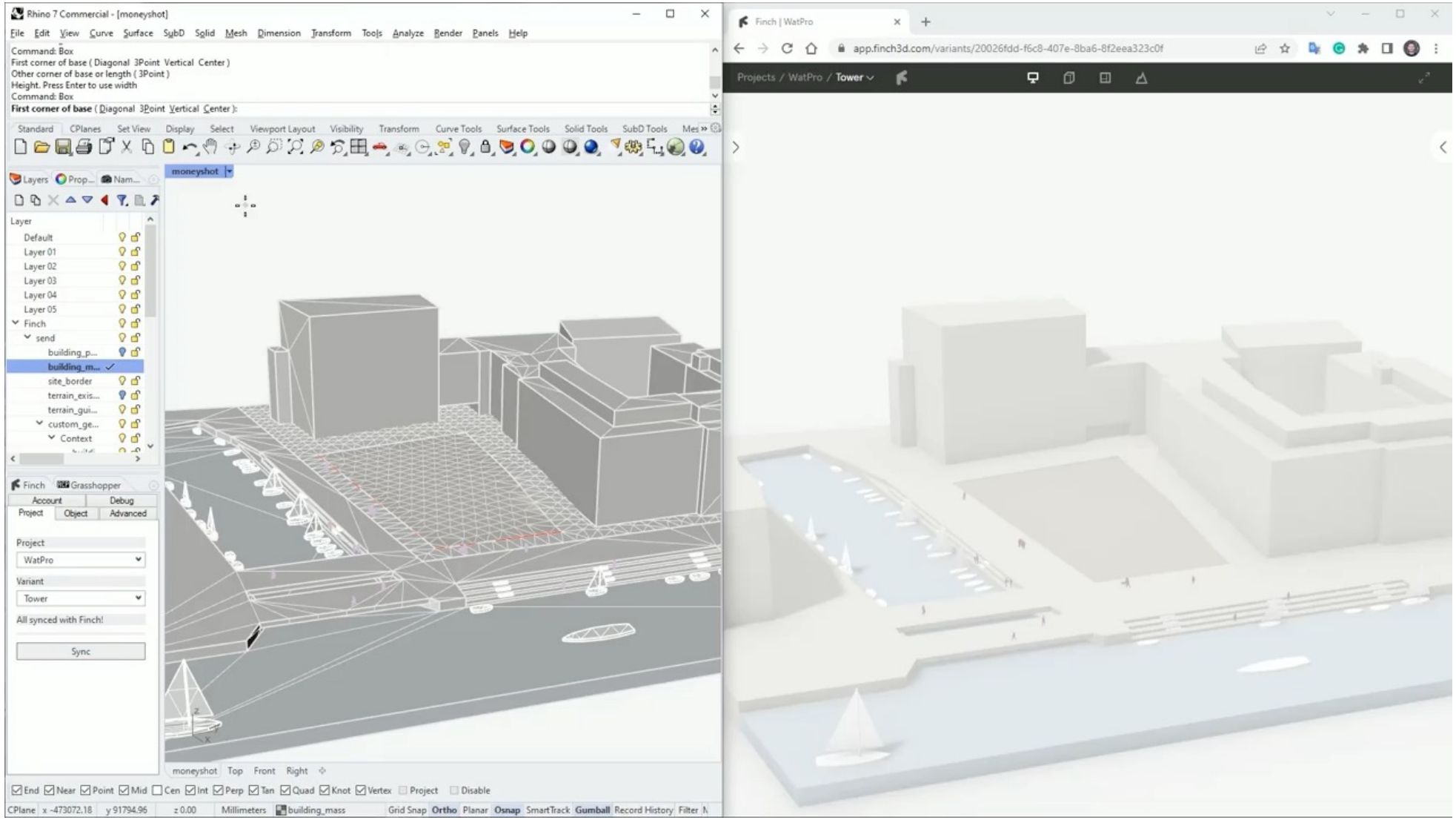


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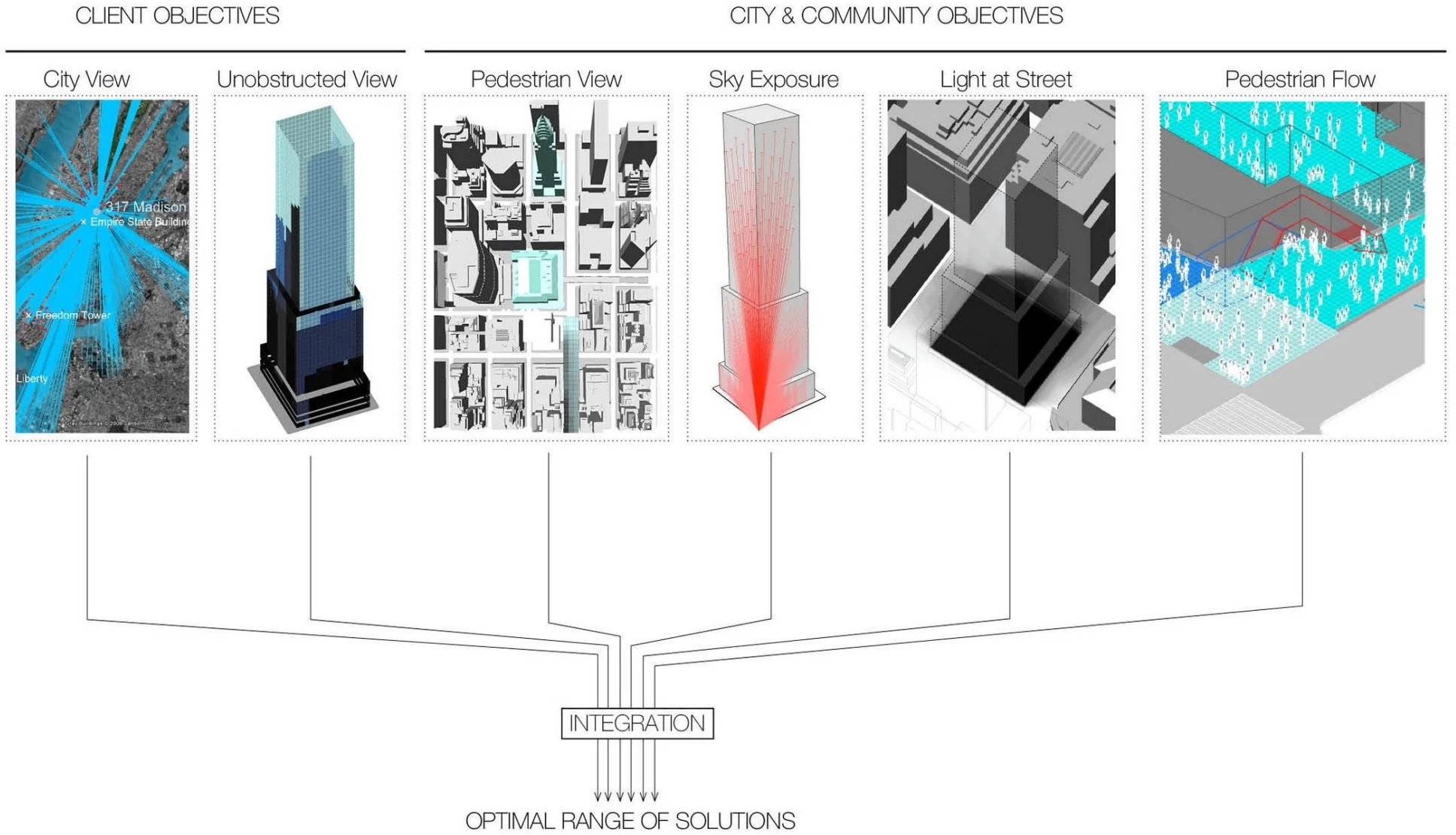
Layout Optimization

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Massing Optimization

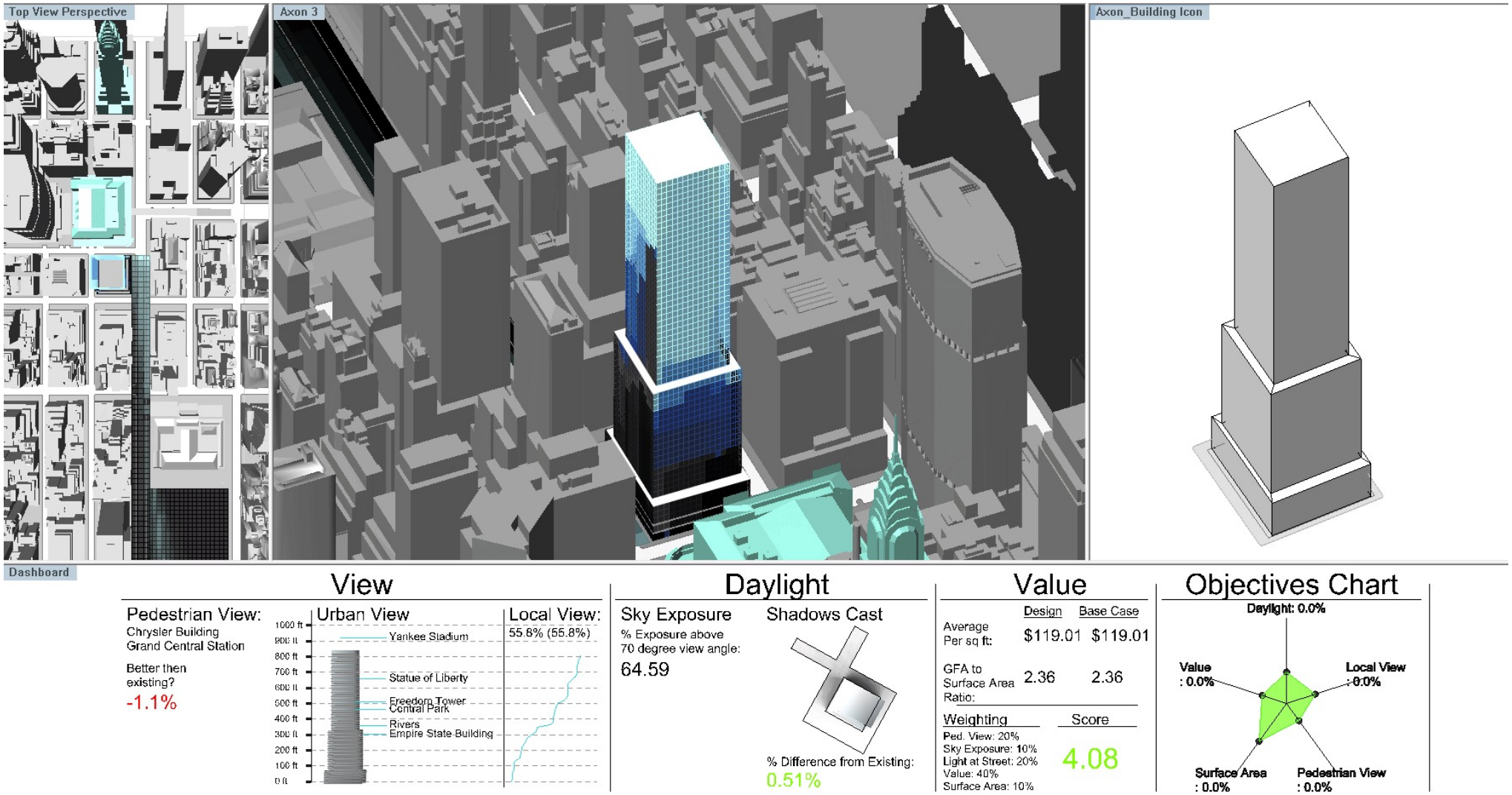


One Vanderbilt
KPF 2016

Resource: https://ui.kpf.com/one-vanderbilt

Massing Optimization

One Vanderbilt
KPF 2016



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Case Studies

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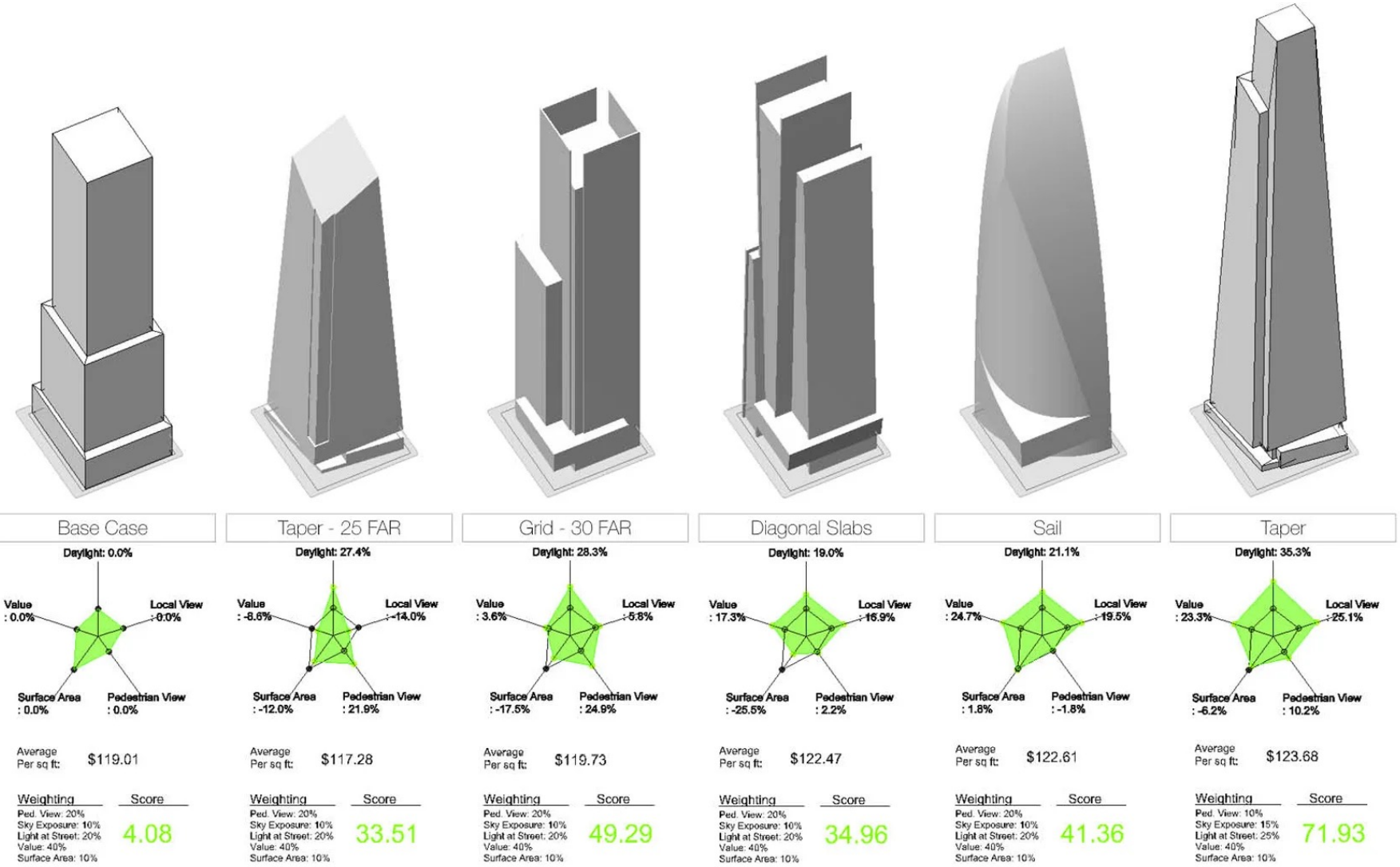
ONE VANDERBILT

One Vanderbilt
KPF 2016



Massing Optimization

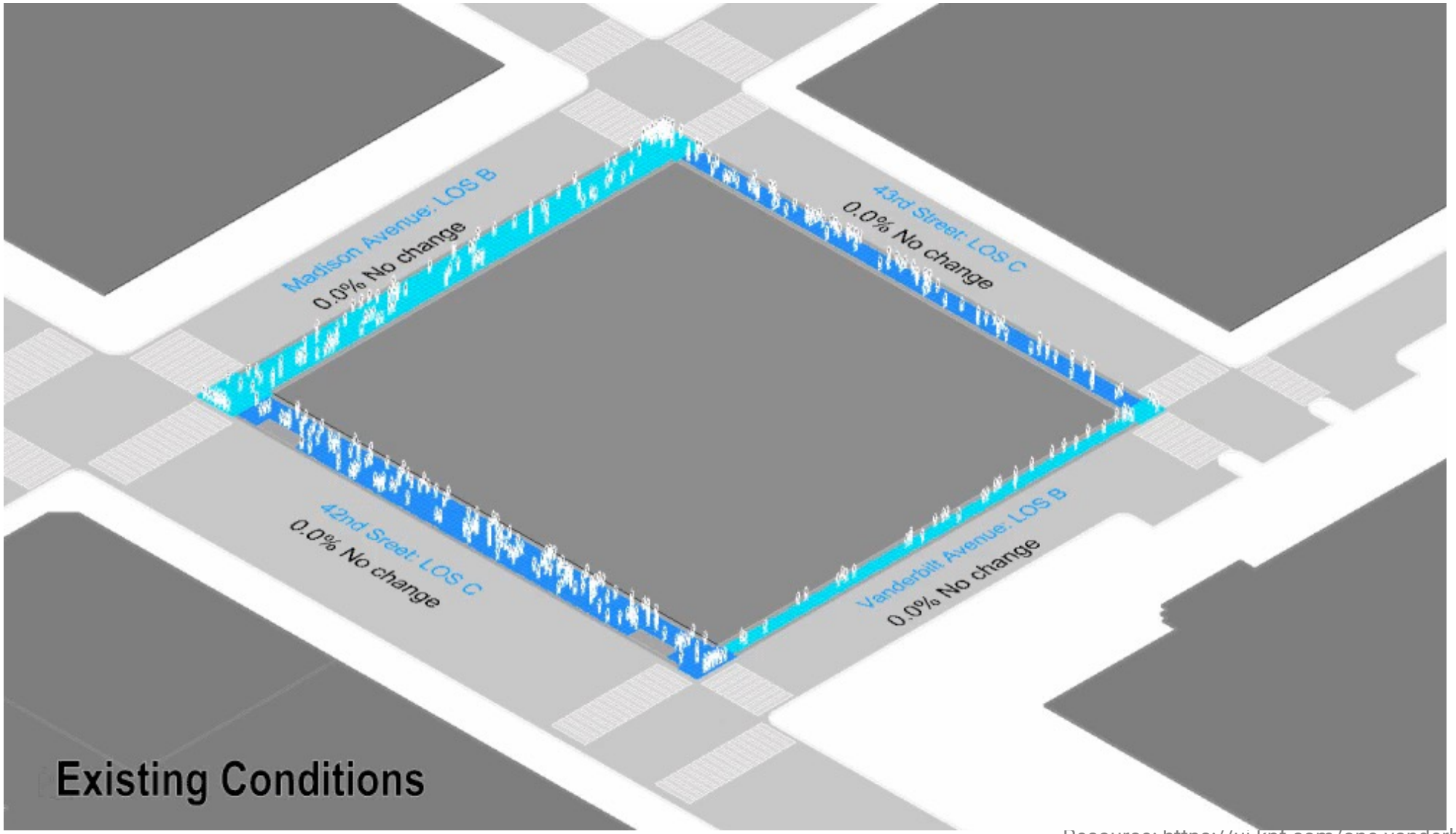
One Vanderbilt
KPF 2016



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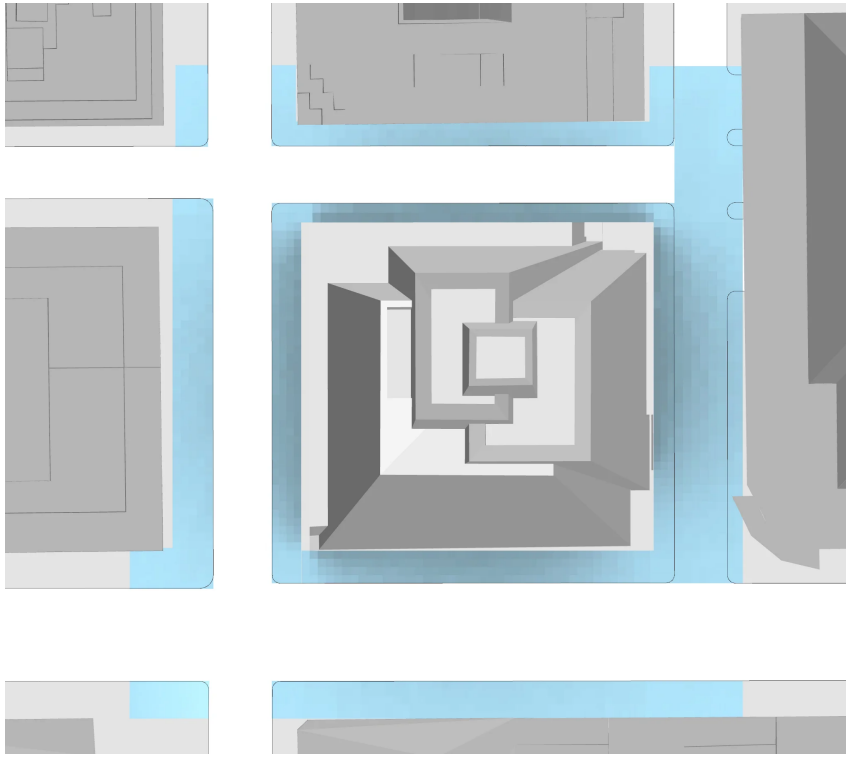
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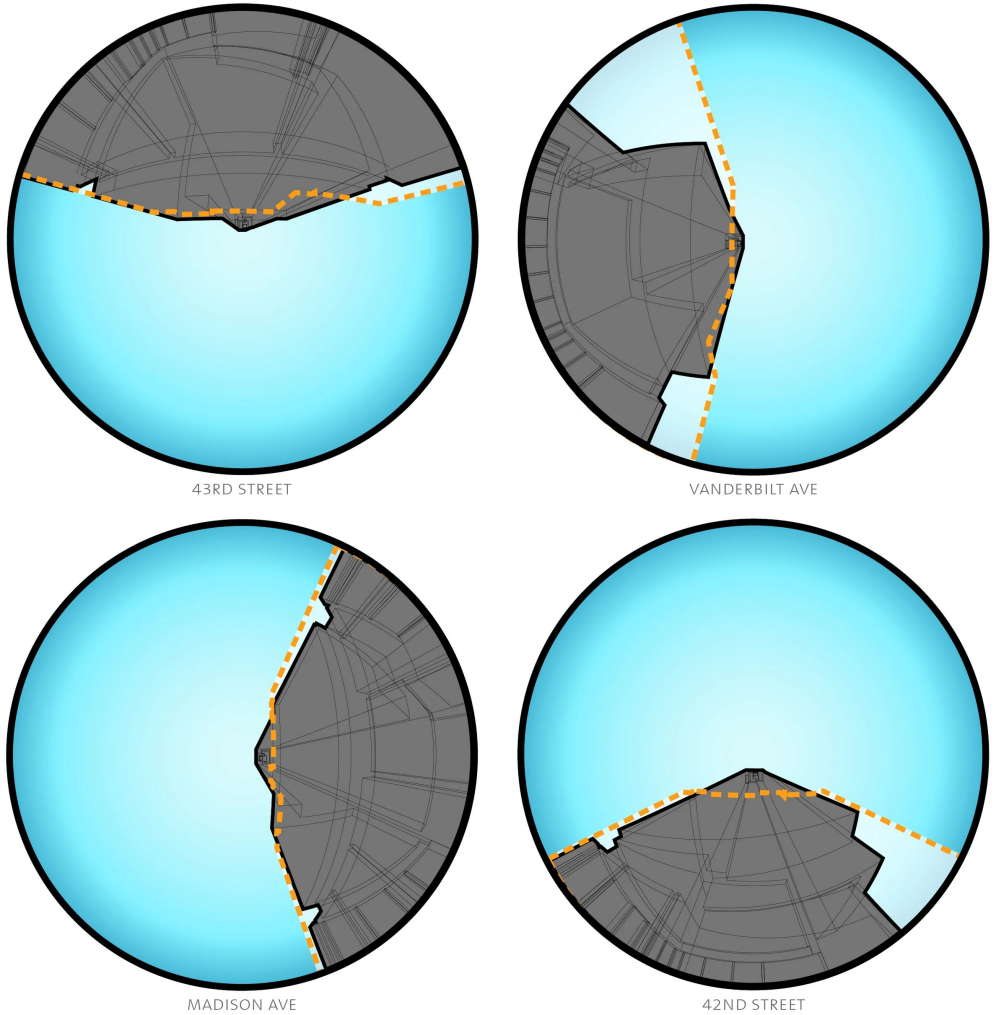


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One Vanderbilt
KPF 2016



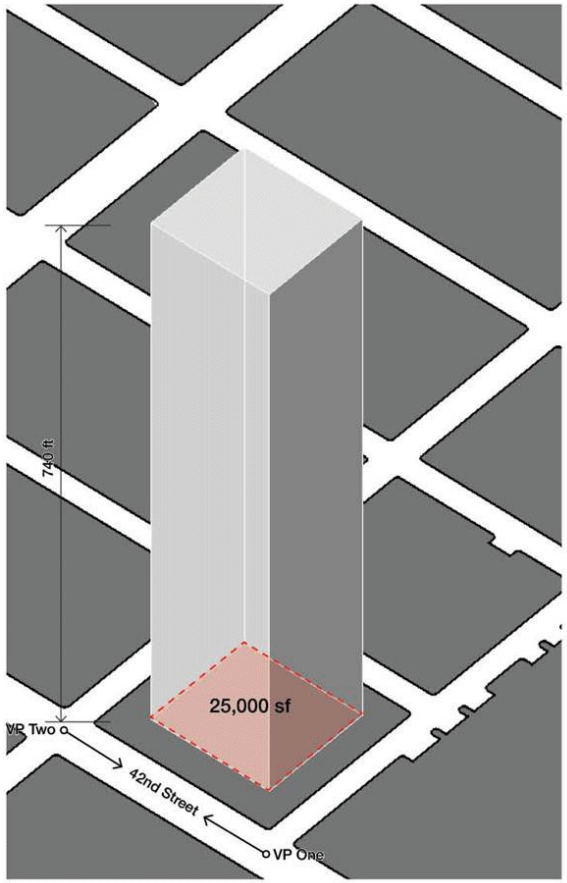
Resource: https://ui.kpf.com/one-vanderbilt

Massing Optimization

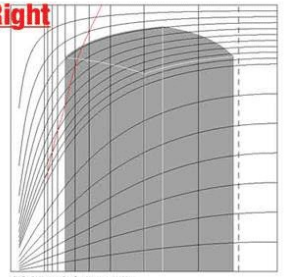
One Vanderbilt
KPF 2016

Testing Iterations_ Simple Extrusion **Not As of Right**

Height : 740 feet Stacking Diagram 1
Gross Floor Area : 1,206,390 sf
FAR : 24
Overall Daylight Score : **59%**
(Midtown)

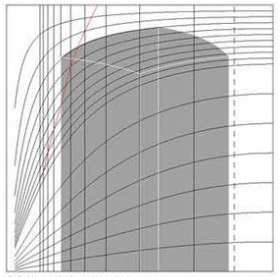


Mass Axonometric



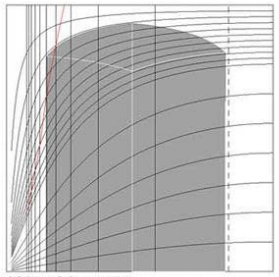
SCORING SUMMARY
(42nd Street, Vantage Point One)

SECTION		SCORE
81-274 (b)	Squares above 70deg. blocked	-41.2
81-274 (c)	Squares below 70deg. open	6.3
81-274 (d)	Profile enchroachment penalty 000.00 000.00	-16.3
	Total Blockage	-51.2
81-274 (e)	Available daylight squares	96.0
81-274 (f)	Remaining daylight	44.8
81-274 (g)	DAYLIGHT SCORE	46.7%



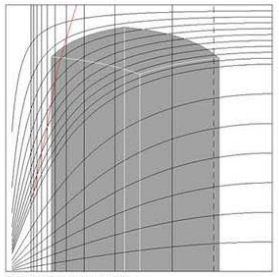
SCORING SUMMARY
(42nd Street, Vantage Point Two)

SECTION		SCORE
81-274 (b)	Squares above 70deg. blocked	-41.2
81-274 (c)	Squares below 70deg. open	6.3
81-274 (d)	Profile enchroachment penalty 000.00 000.00	-16.3
	Total Blockage	-51.2
81-274 (e)	Available daylight squares	96.0
81-274 (f)	Remaining daylight	44.8
81-274 (g)	DAYLIGHT SCORE	46.7%



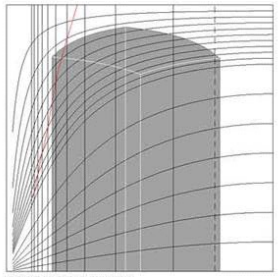
SCORING SUMMARY
(43rd Street, Vantage Point One)

SECTION		SCORE
81-274 (b)	Squares above 70deg. blocked	-36.7
81-274 (c)	Squares below 70deg. open	10.5
81-274 (d)	Profile enchroachment penalty 000.00 000.00	-5.6
	Total Blockage	-31.8
81-274 (e)	Available daylight squares	98.0
81-274 (f)	Remaining daylight	66.2
81-274 (g)	DAYLIGHT SCORE	67.6%



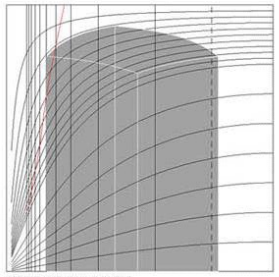
SCORING SUMMARY
(Madison Avenue, Vantage Point One)

SECTION		SCORE
81-274 (b)	Squares above 70deg. blocked	-39.0
81-274 (c)	Squares below 70deg. open	8.4
81-274 (d)	Profile enchroachment penalty 000.00 000.00	-12.65
	Total Blockage	-43.25
81-274 (e)	Available daylight squares	96.0
81-274 (f)	Remaining daylight	52.75
81-274 (g)	DAYLIGHT SCORE	54.9%



SCORING SUMMARY
(Madison Avenue, Vantage Point Two)

SECTION		SCORE
81-274 (b)	Squares above 70deg. blocked	-39.0
81-274 (c)	Squares below 70deg. open	8.4
81-274 (d)	Profile enchroachment penalty 000.00 000.00	-12.65
	Total Blockage	-43.25
81-274 (e)	Available daylight squares	96.0
81-274 (f)	Remaining daylight	52.75
81-274 (g)	DAYLIGHT SCORE	54.9%

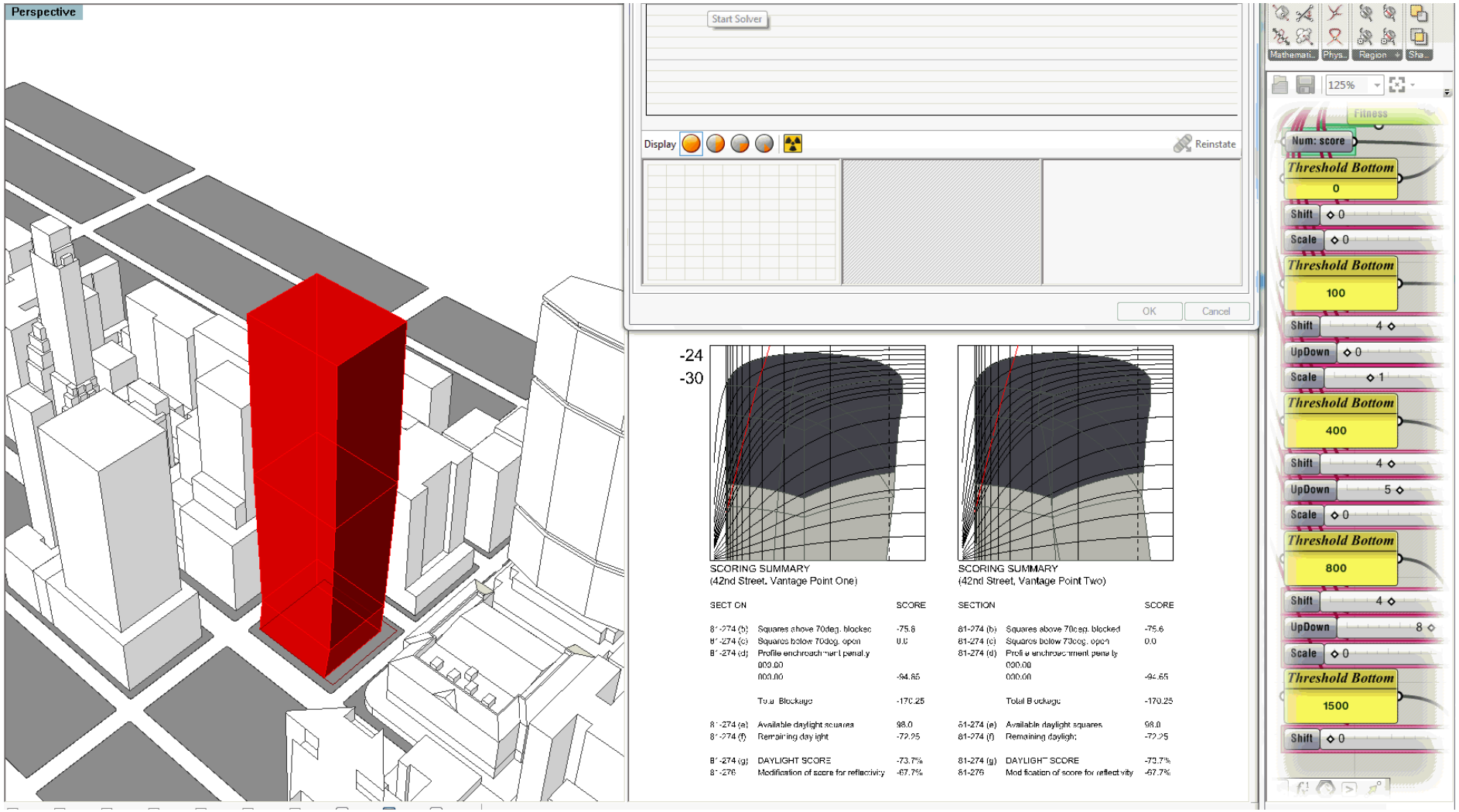


SCORING SUMMARY
(Vanderbilt Avenue, Vantage Point One)

SECTION		SCORE
81-274 (b)	Squares above 70deg. blocked	-35.4
81-274 (c)	Squares below 70deg. open	10.5
81-274 (d)	Profile enchroachment penalty 000.00 000.00	-5.6
	Total Blockage	-30.5
81-274 (e)	Available daylight squares	96.0
81-274 (f)	Remaining daylight	65.5
81-274 (g)	DAYLIGHT SCORE	68.2%

Massing Optimization

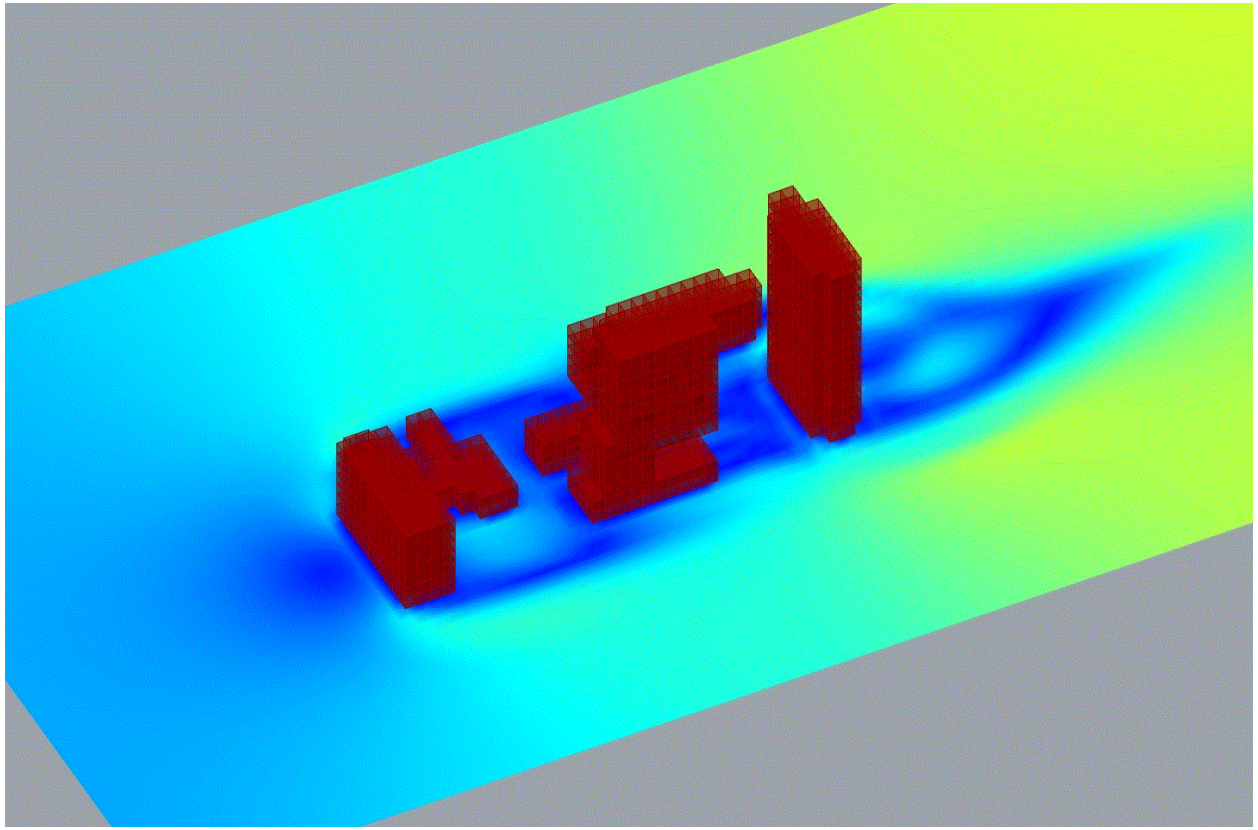
One Vanderbilt
KPF 2016

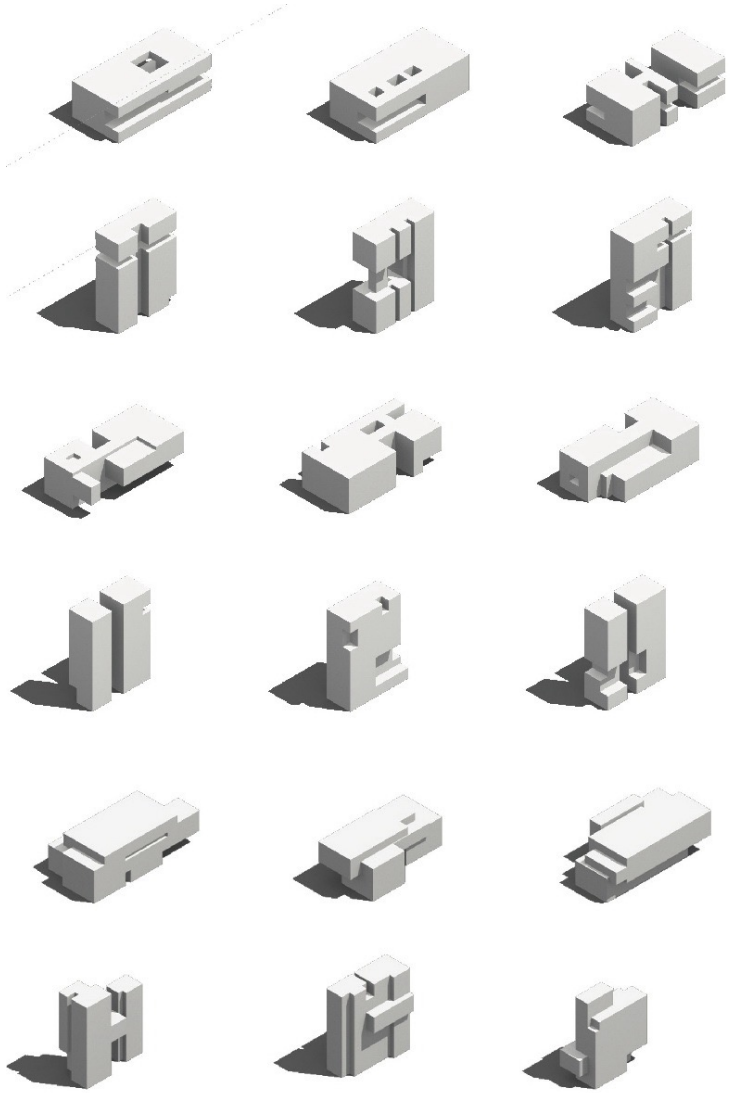


Resource: https://ui.kpf.com/one-vanderbilt

Massing Optimization

EvoMass

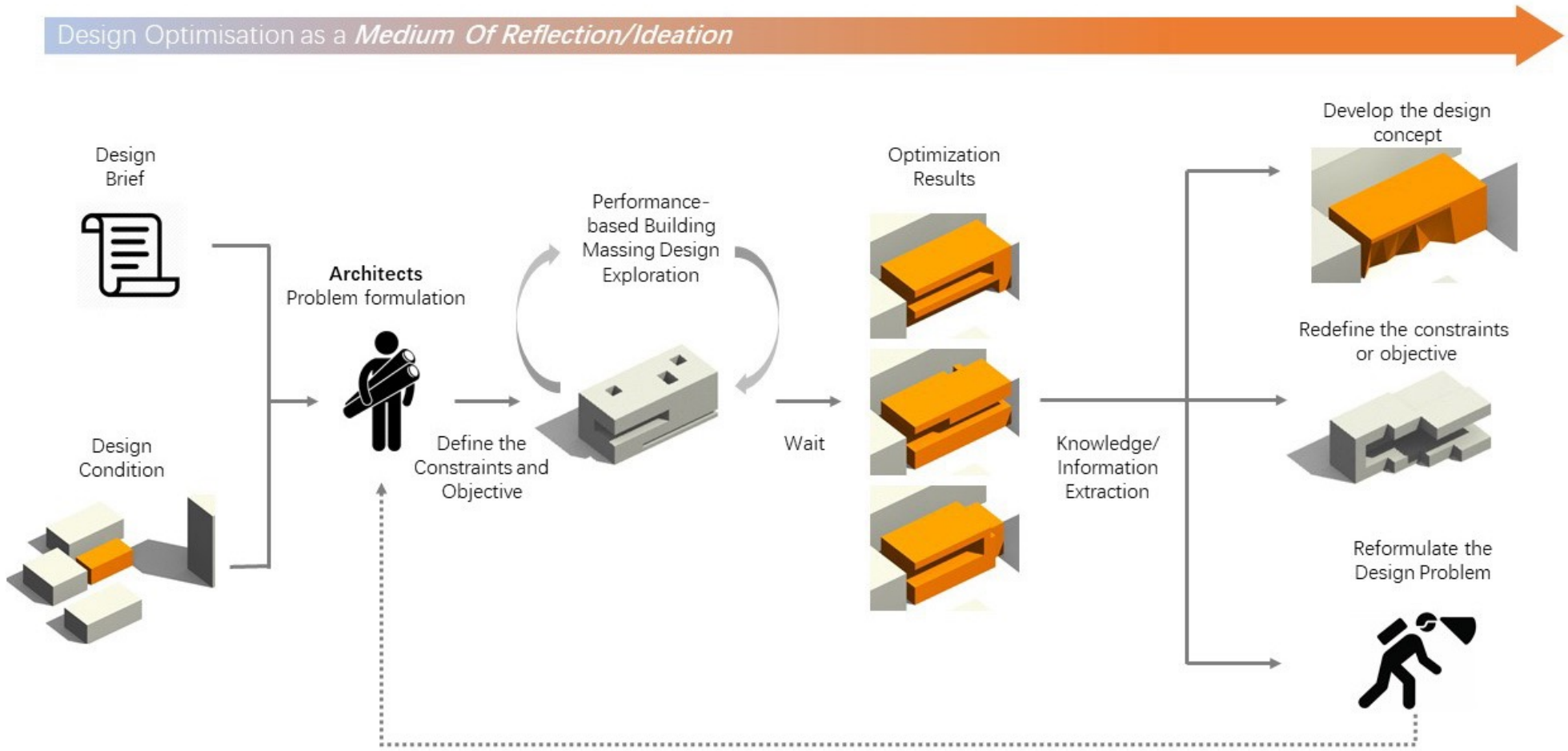




Resource: https://www.food4rhino.com/en/app/evomass

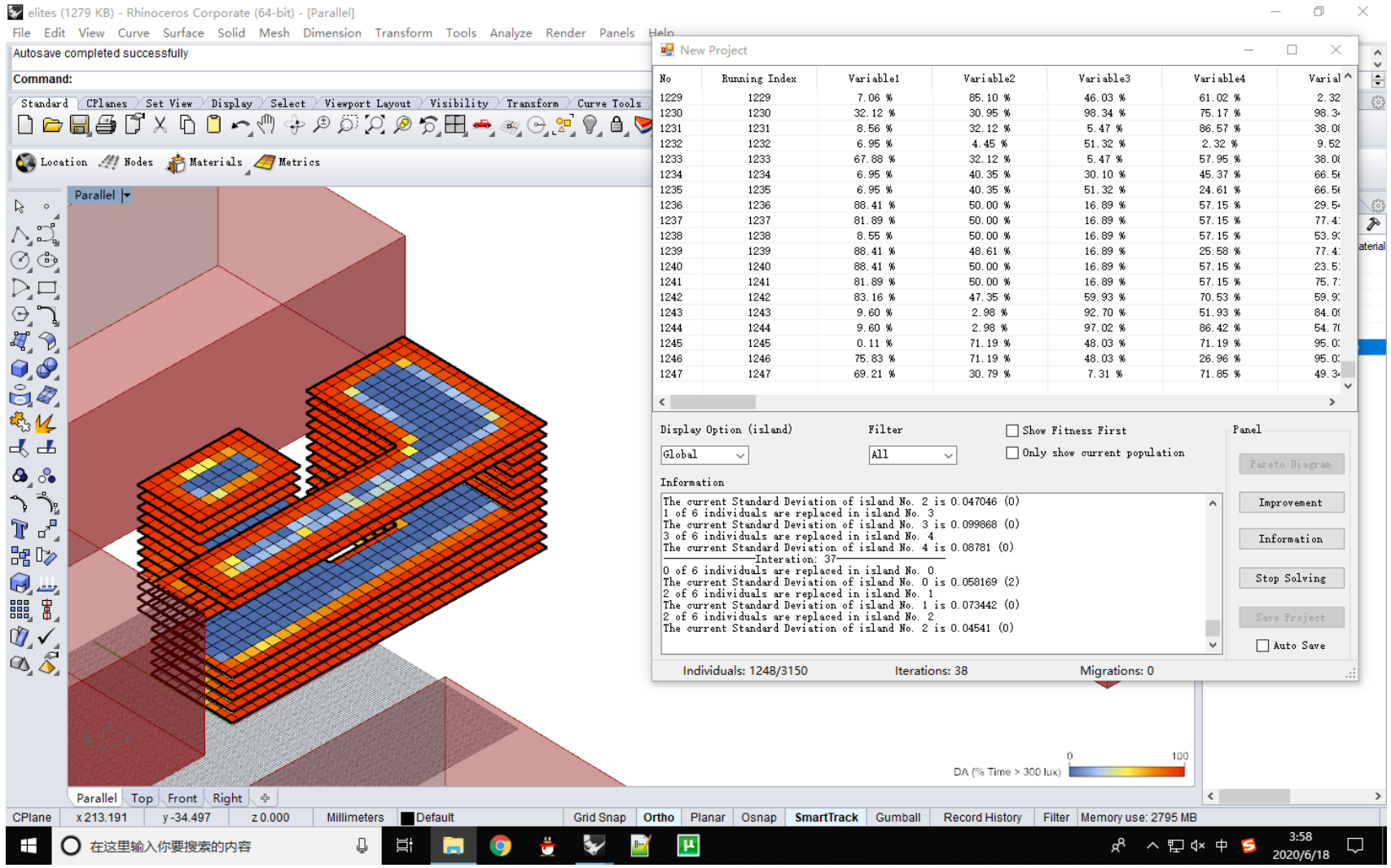
Massing Optimization

EvoMass



Resource: https://www.food4rhino.com/en/app/evomass

Massing Optimization

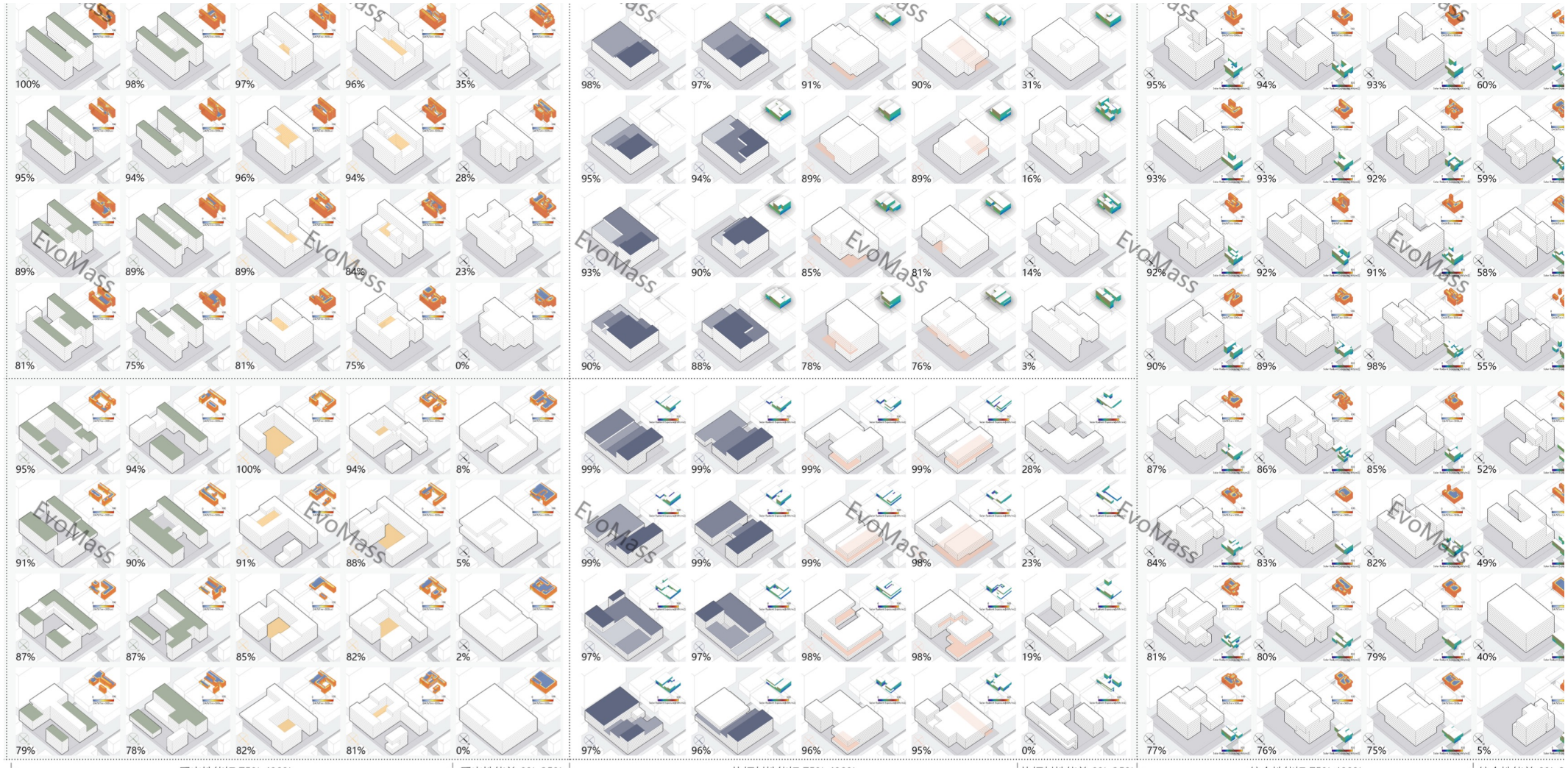


EvoMass

Resource: https://www.food4rhino.com/en/app/evomass

Massing Optimization

EvoMass



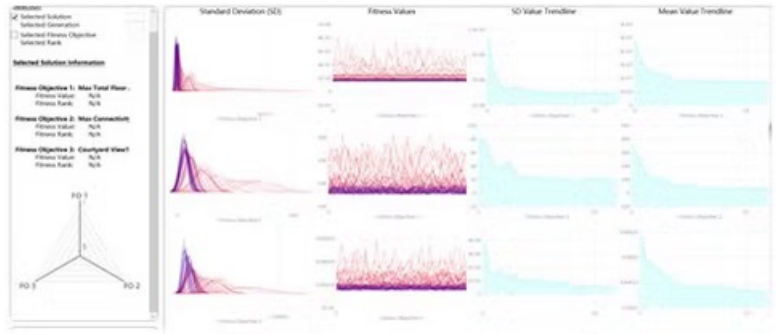
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Massing Optimization

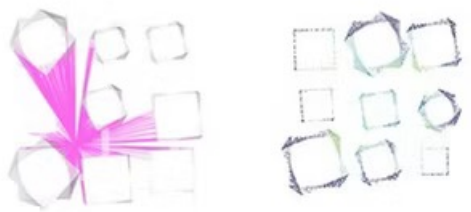
Wallacei

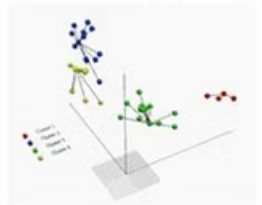
Solution Geometry

Previous Works



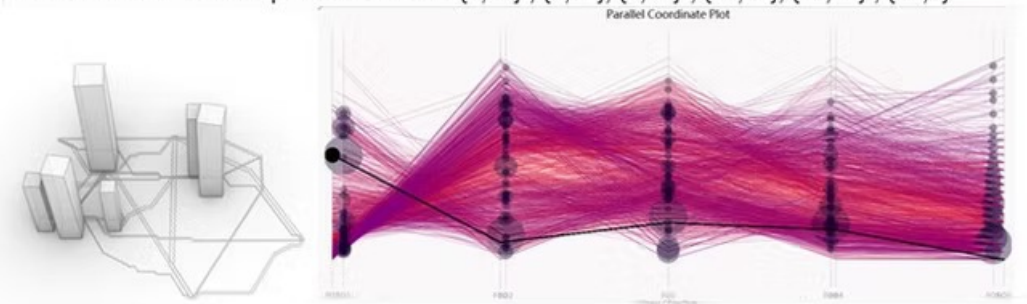




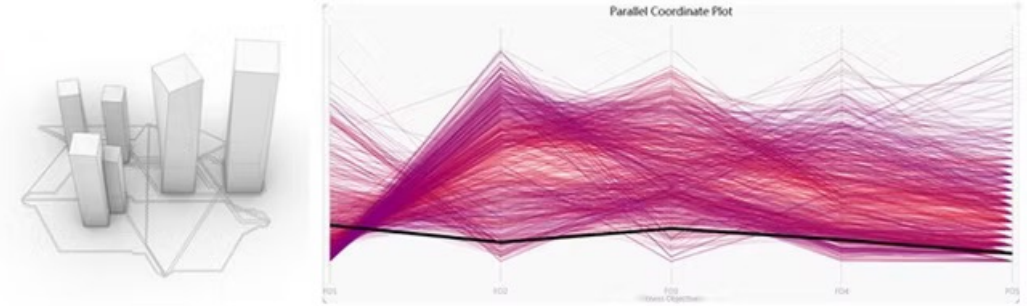


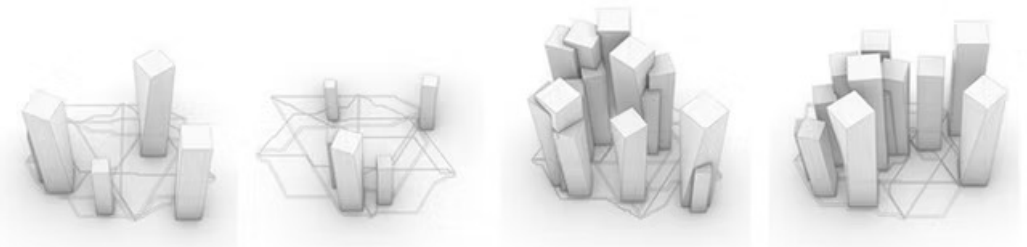
4 clusters of the last generation

The same solution that repeated the most: {4,28} ; {6,26}; {9,19} ; {11,24}; {11,25} ; {13,5}



{16,11}: the least relative difference between fitness ranks = the average of fitness rank





{20,5} {20,11} {20,12} {20,13}

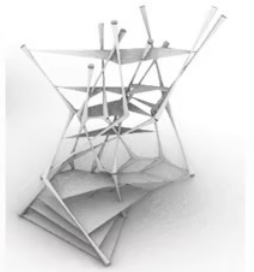
Resource: wallacei.com/research

Massing Optimization

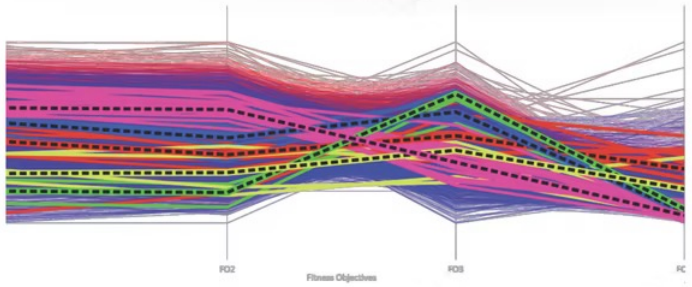
Wallacei



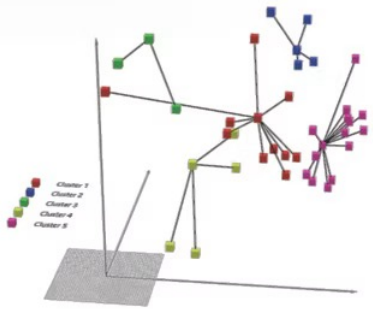
Generation Cluster



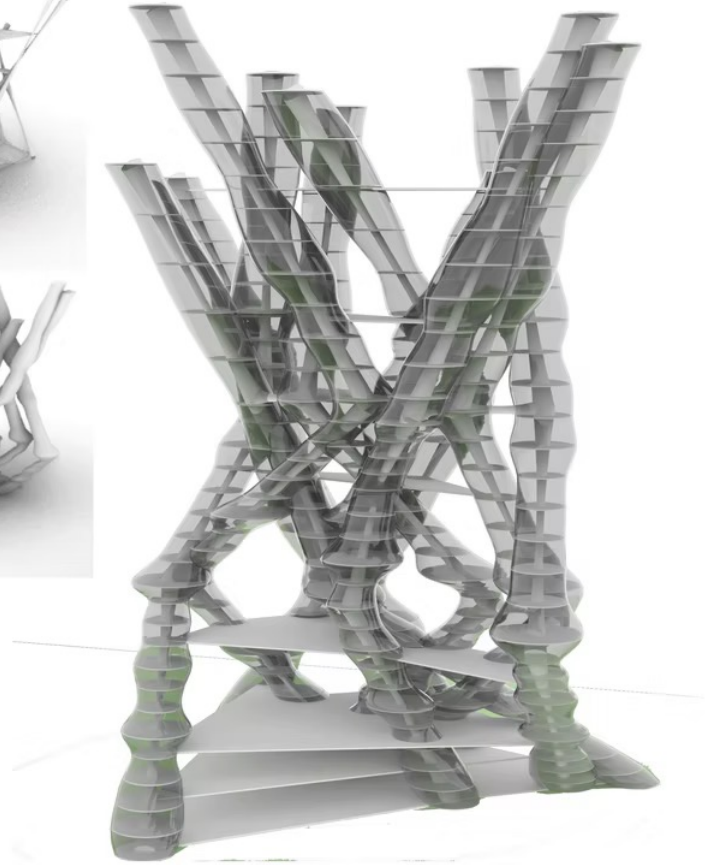




Parallel Coordinate Plot



K-Means Clustering Algorithm



Gen.77 Ind.3

Resource: wallacei.com/research

Case Studies

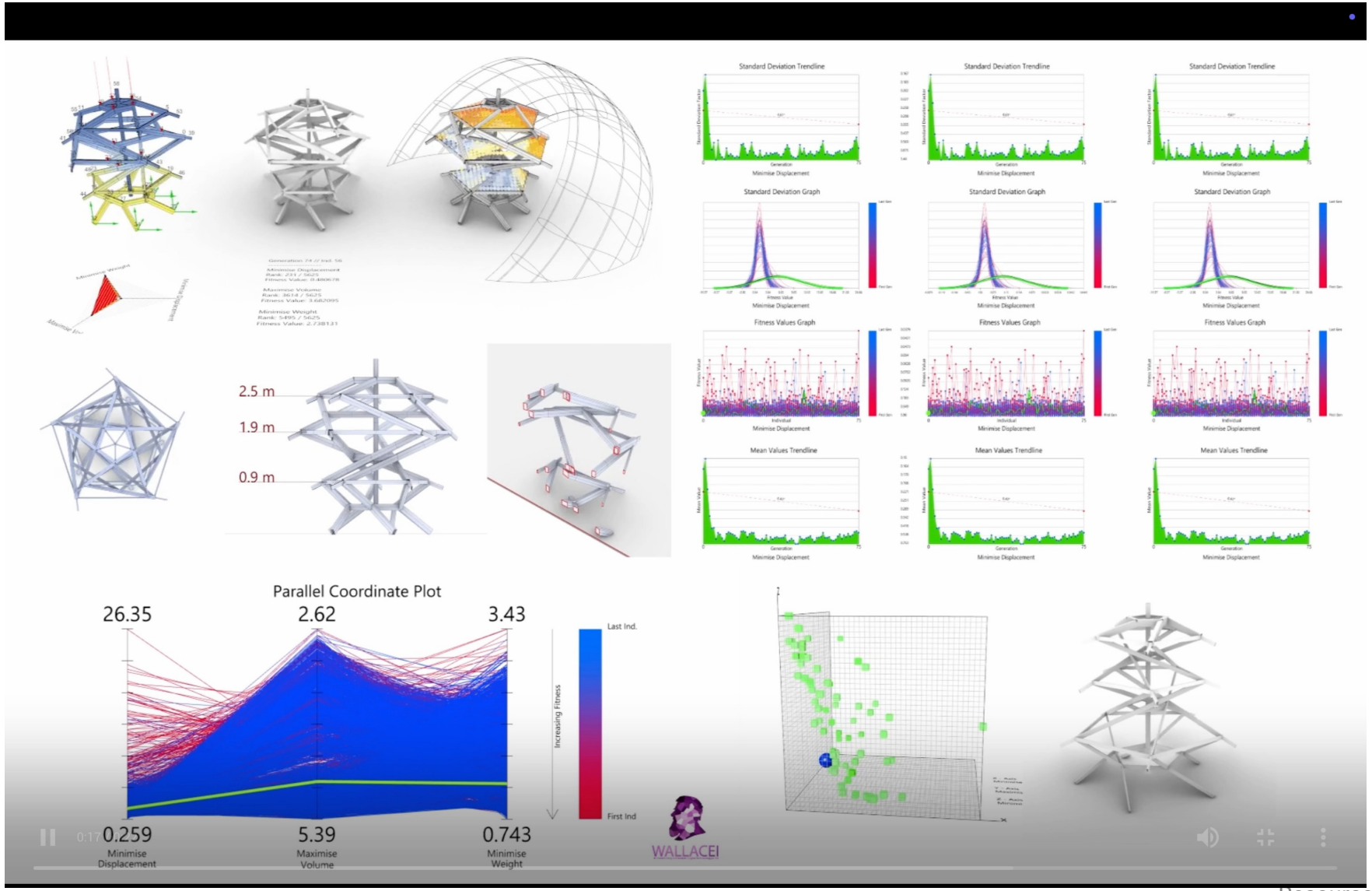
Massing Optimization



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Resource: wallacei.com/research

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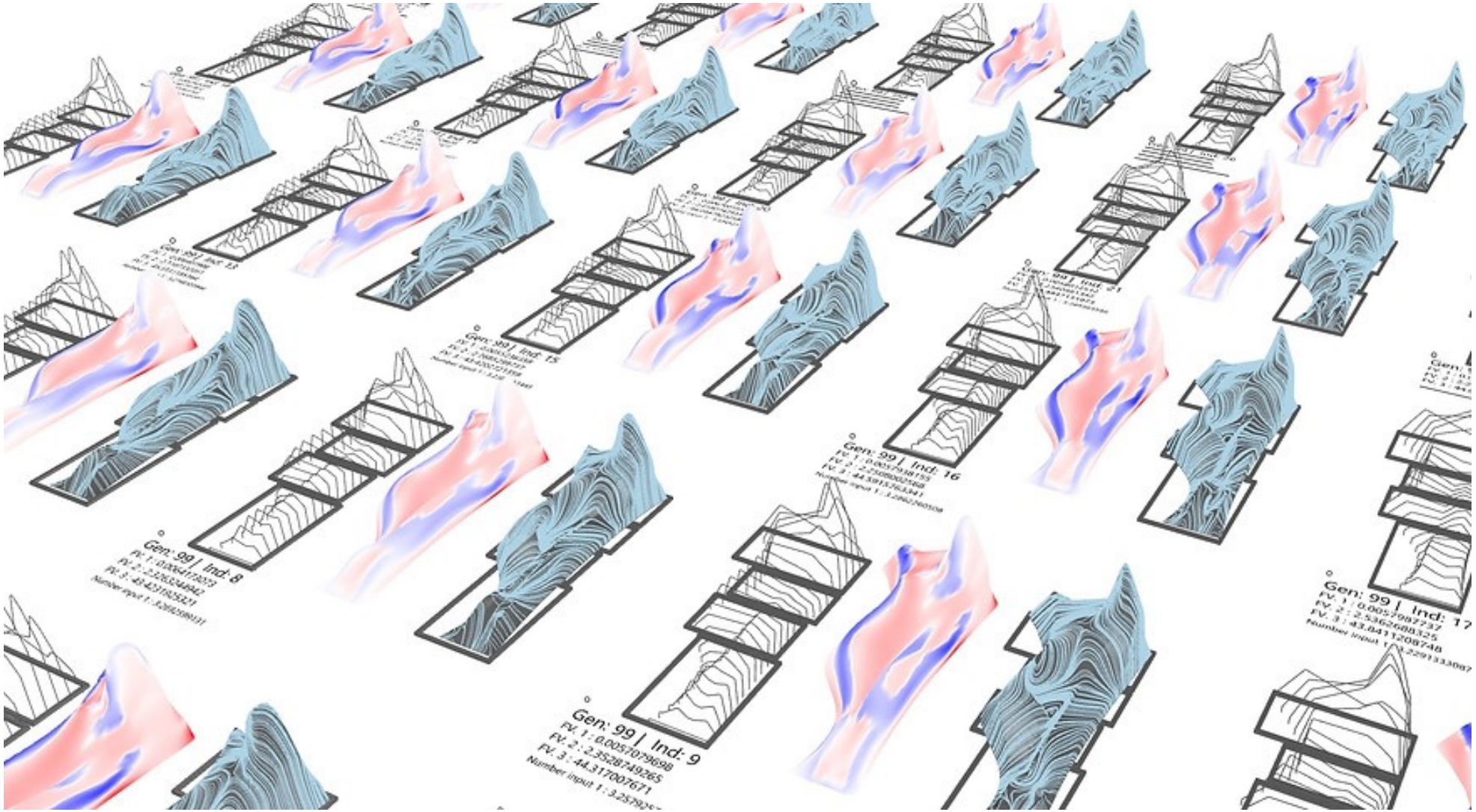


Wallacei

Resource: wallacei.com/research

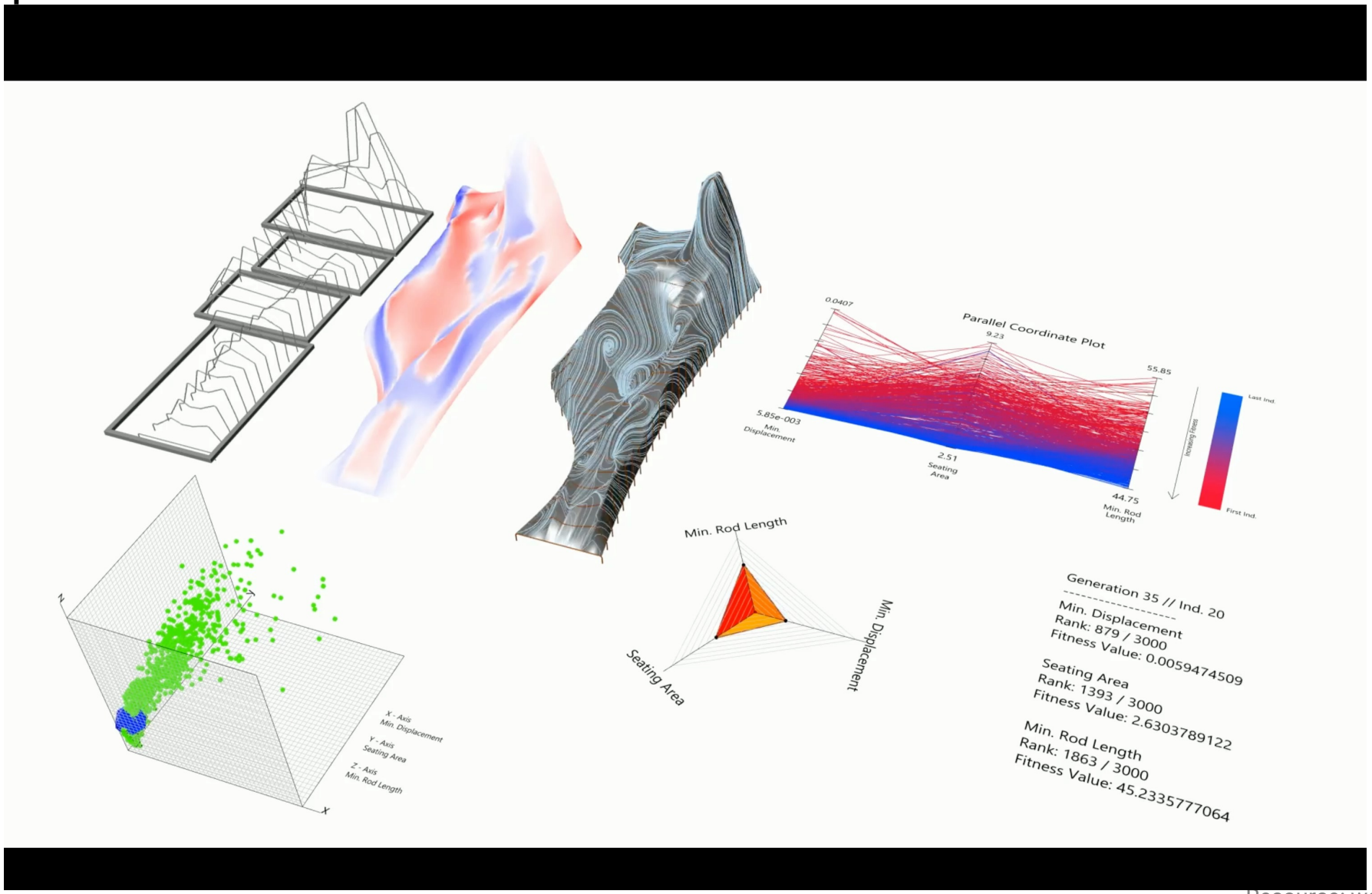
Massing Optimization

Wallacei



Resource: wallacei.com/research

Massing Optimization



Wallacei

Resource: wallacei.com/research

AI Agent in the Loop

AI Agent Definition

Non-agentic workflow (zero-shot):

Please type out an essay on topic X from start to finish in one go, without using backspace.



Agentic workflow:

Write an essay outline on topic X

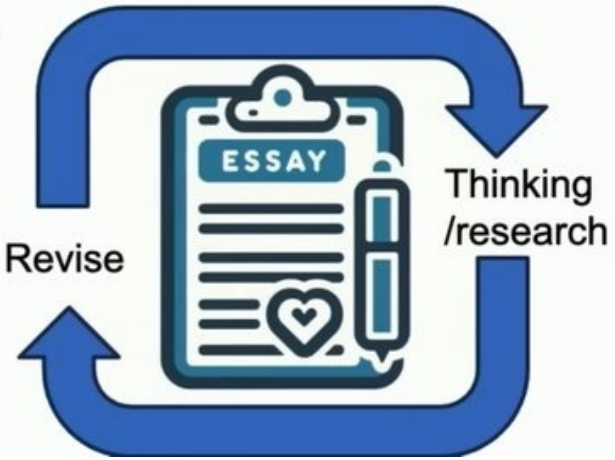
Do you need any web research?

Write a first draft.

Consider what parts need revision or more research.

Revise your draft.

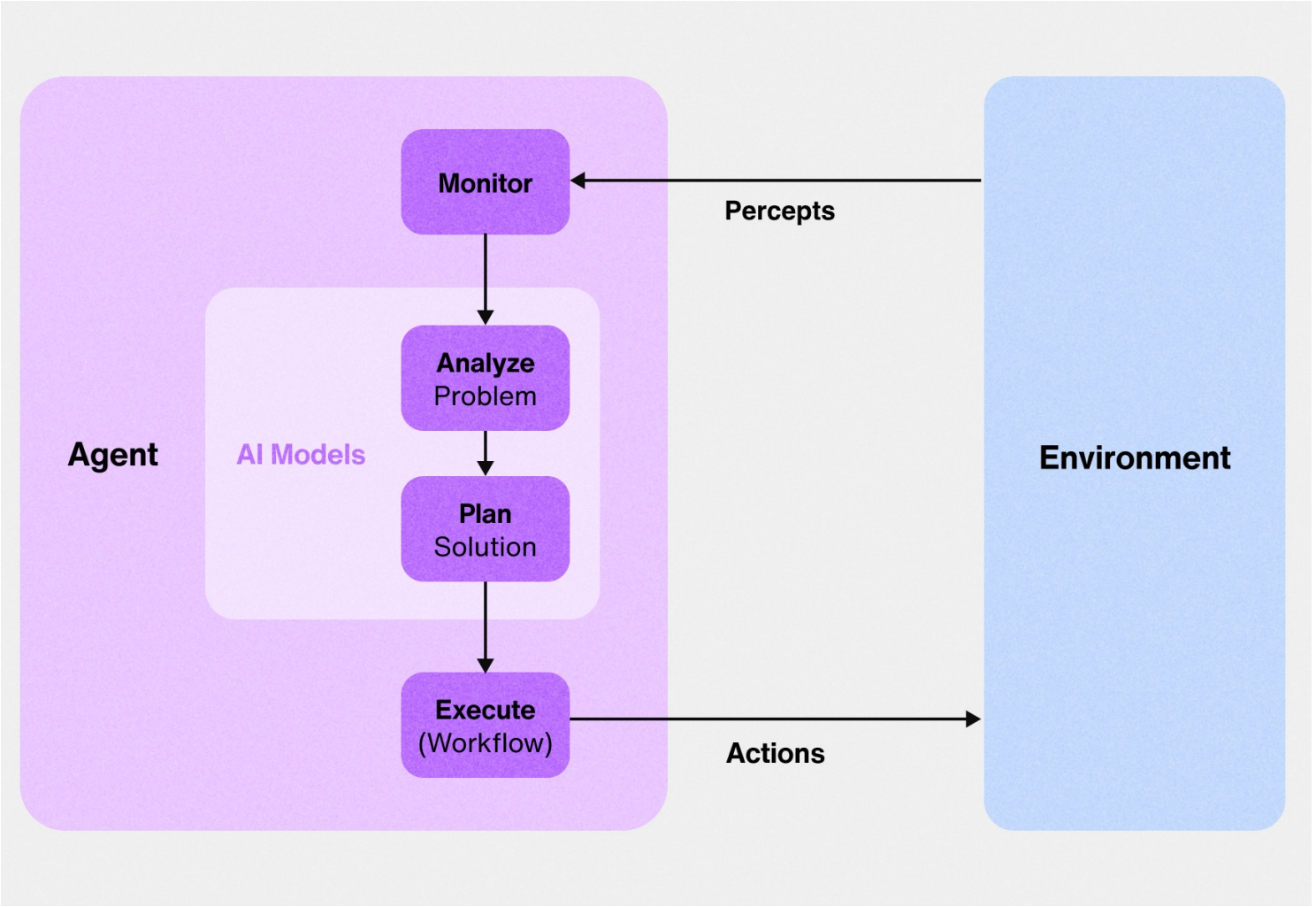
....



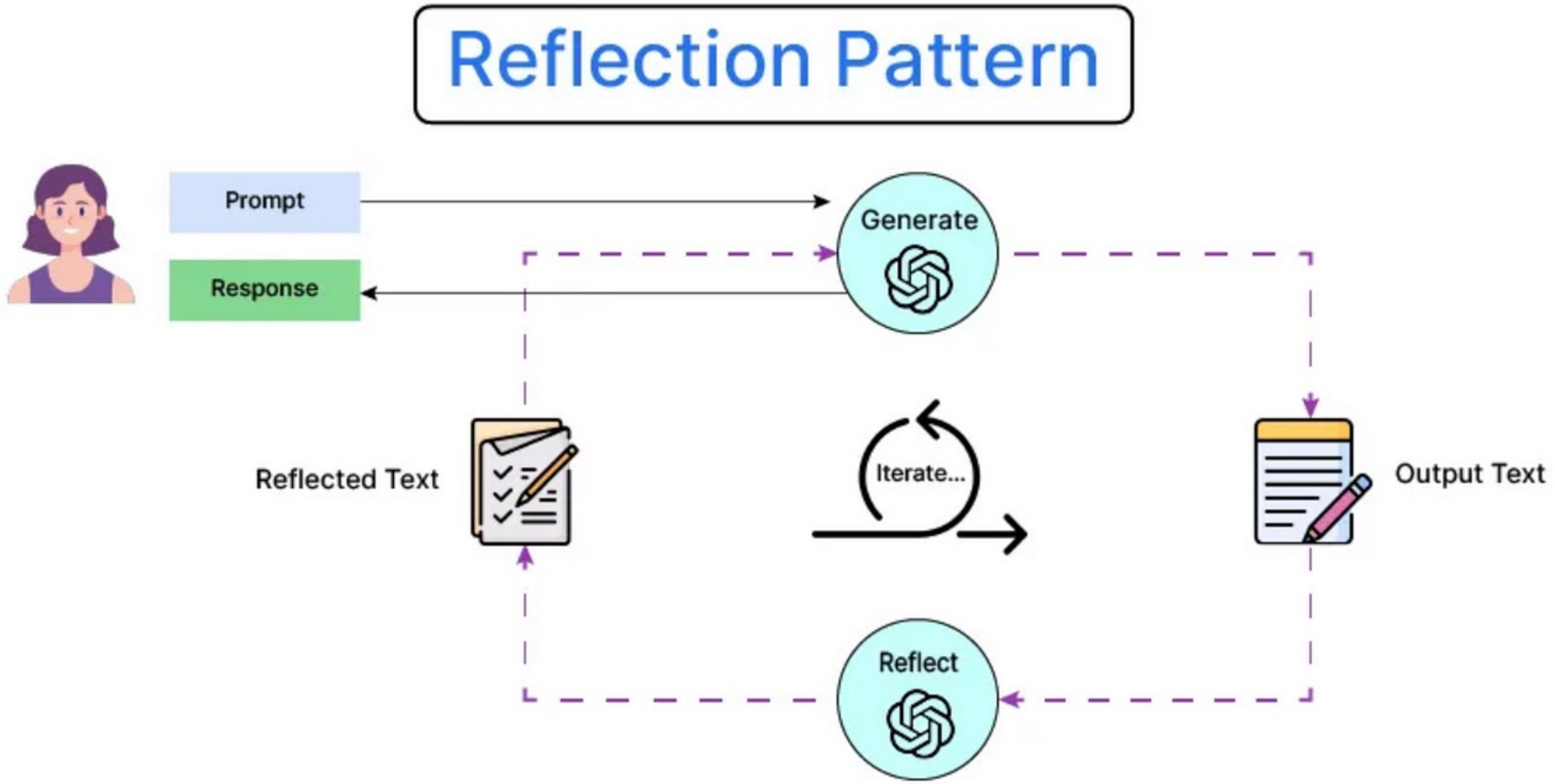
AI Agent Definition



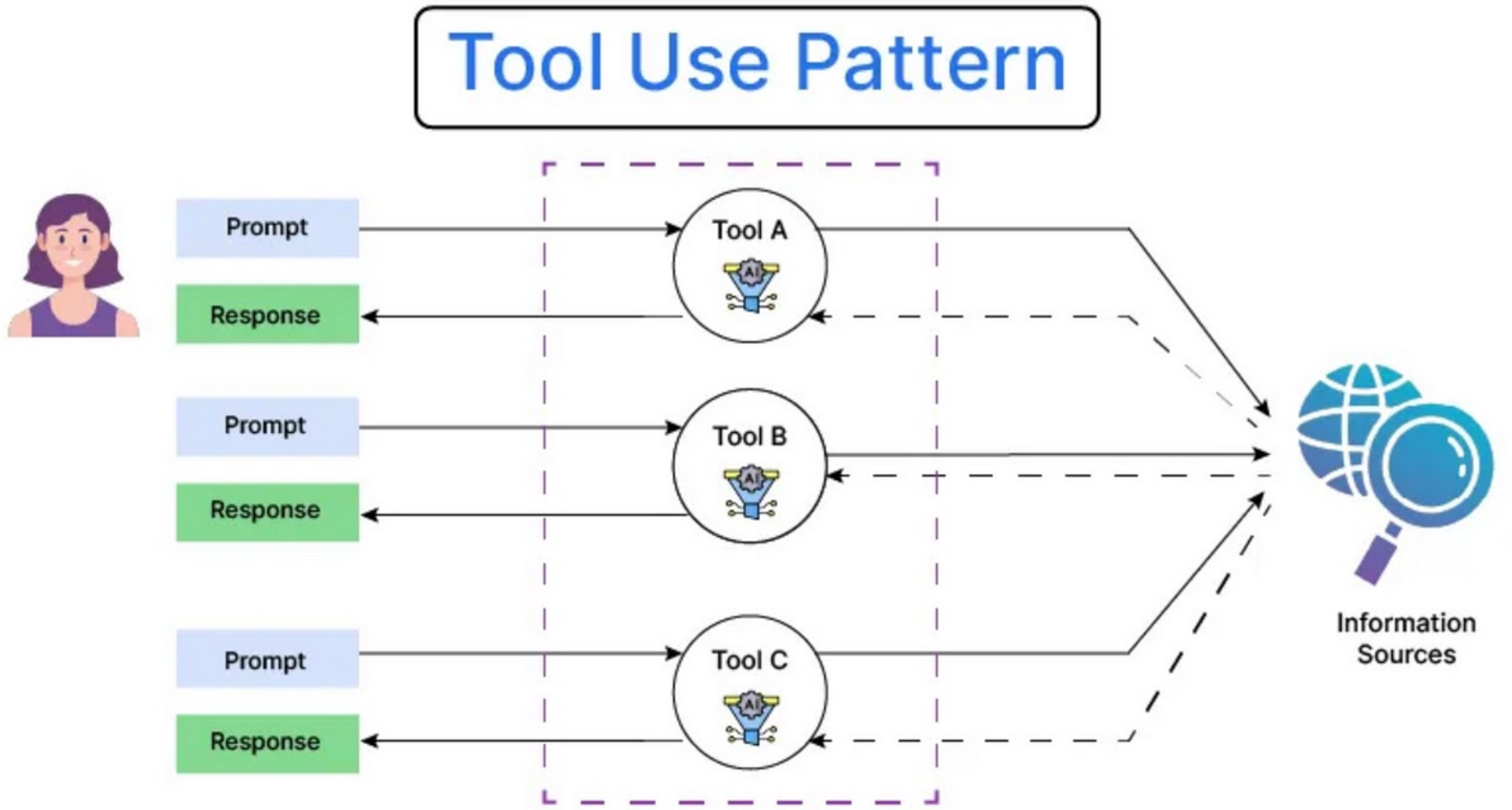
AI Agentic Workflow



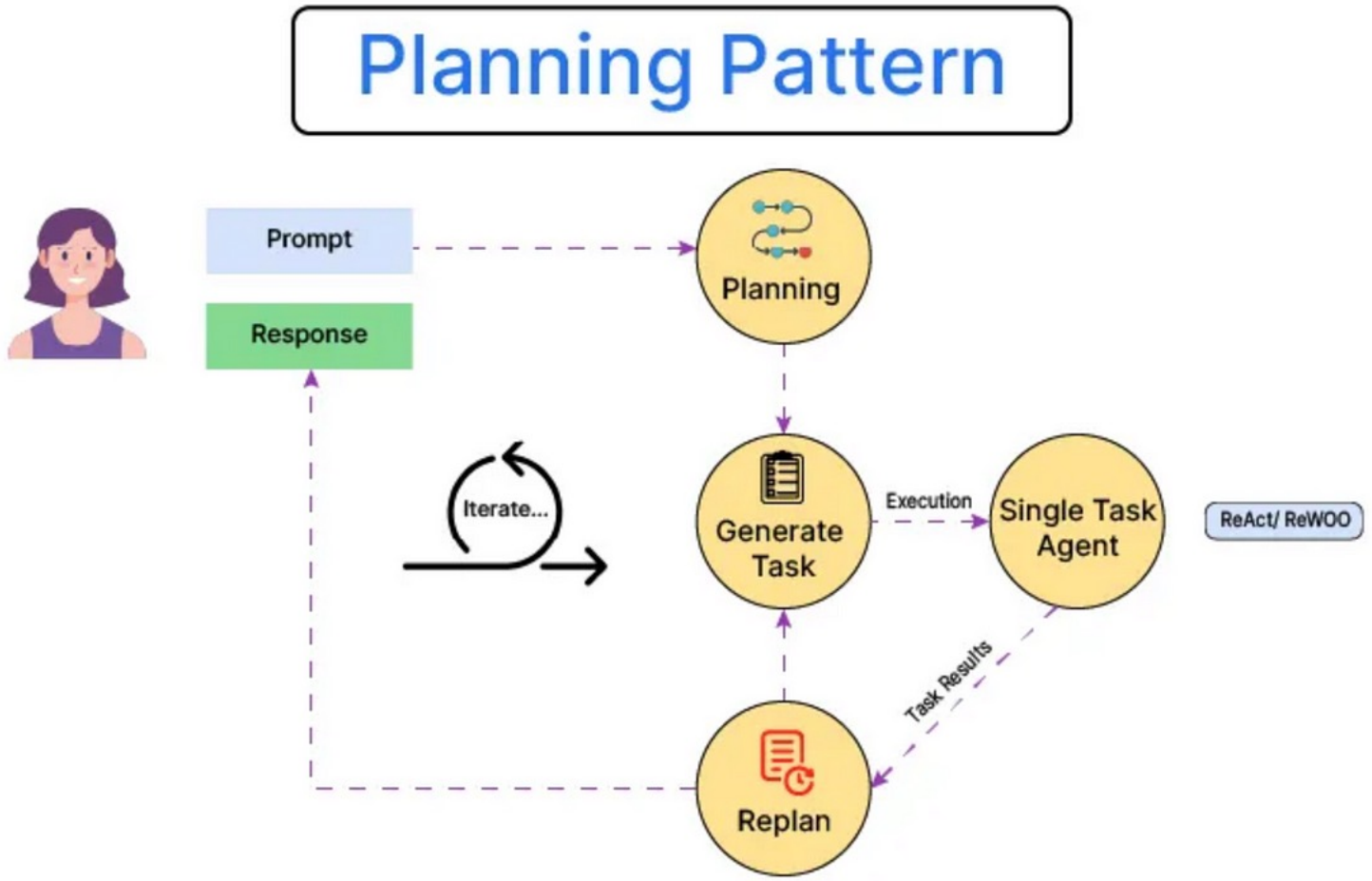
AI Agentic Patterns



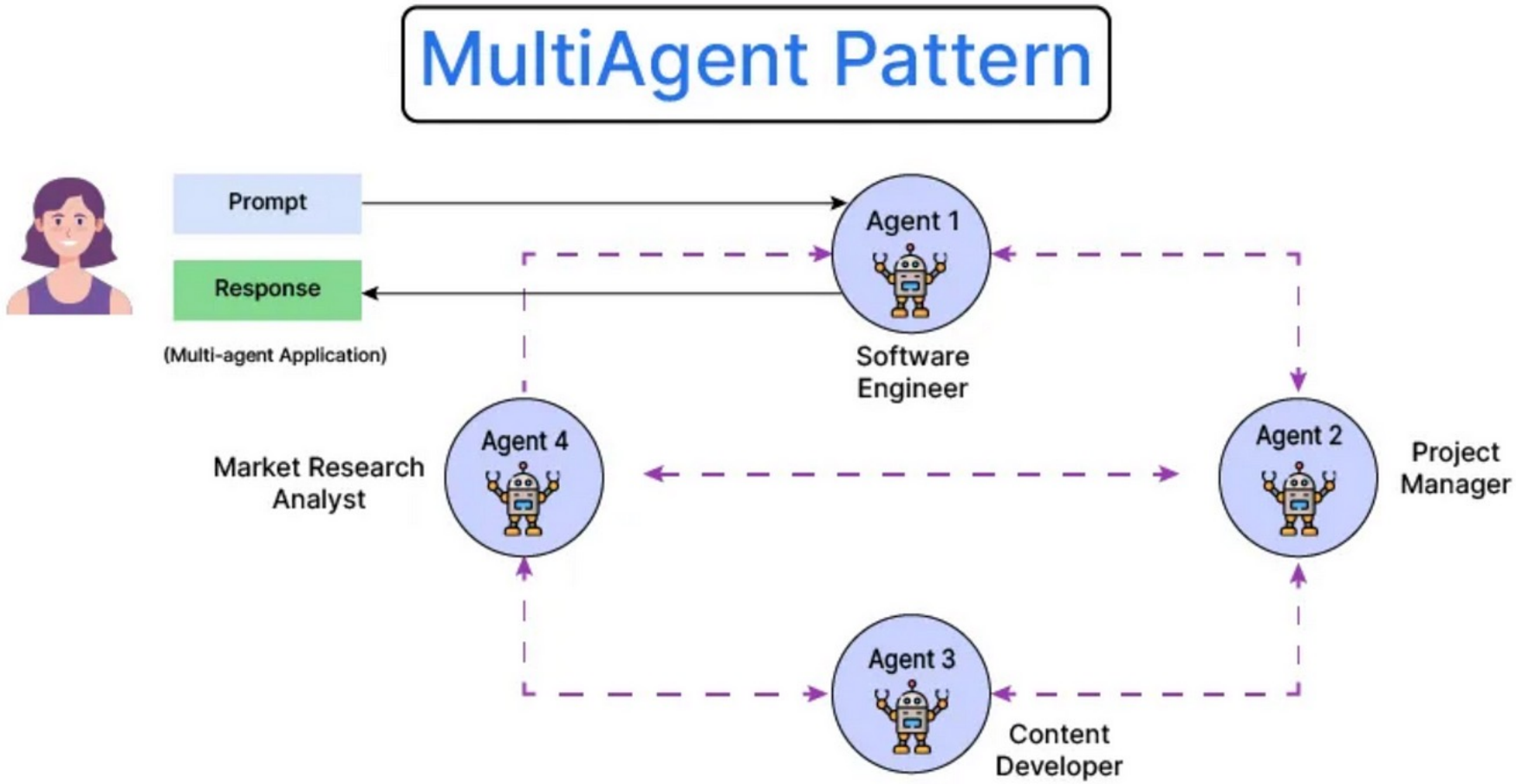
AI Agentic Patterns



AI Agentic Patterns



AI Agentic Patterns



Looking Forward

The Summer Window

The reality: The economy is challenging. Technical skills make you employable and adaptable.

When you learn software inside a studio project, the design becomes the constraint. When you learn it on its own, you build foundation skills that transfer anywhere.

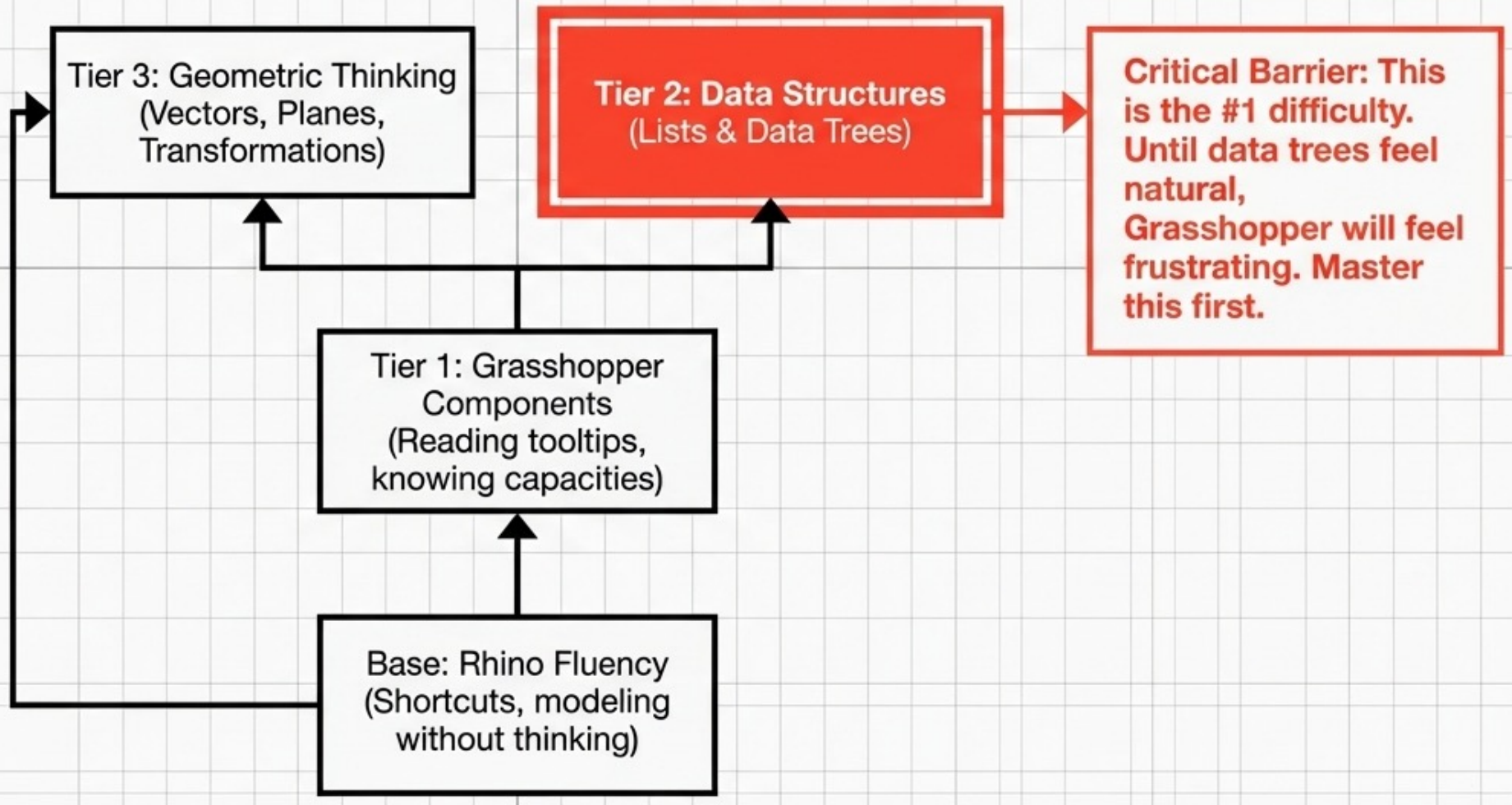


The strategy: Set aside two months for grade-free, focused technical learning.

NotebookLM

The Foundation Roadmap

It is like learning to type—slow at first, then faster than handwriting."



NotebookLM

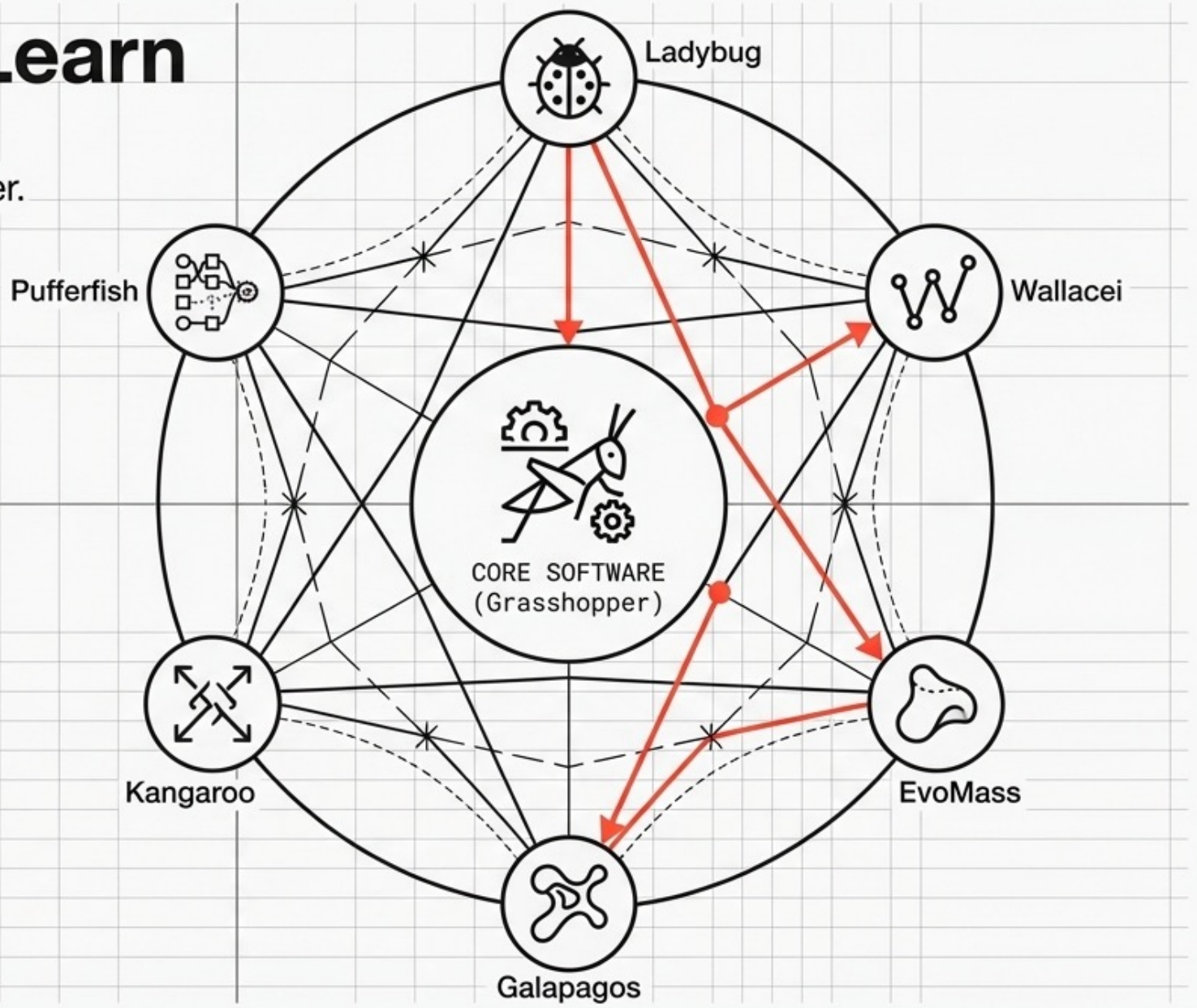
Learning How to Learn

Once you have practiced with a few, picking up new ones becomes much faster.

- **THE GOAL:**
  Do not try to memorize each plugin.

- **THE POWER:**
  The Food4Rhino ecosystem.

- **THE METHOD:**
  Understand the logic, read the documentation, test individual components.



NotebookLM

Your Co-Pilots for the Summer

Claude: The most capable assistant for reasoning and coding. Draft Python/ C# components or debug logic.

Claude

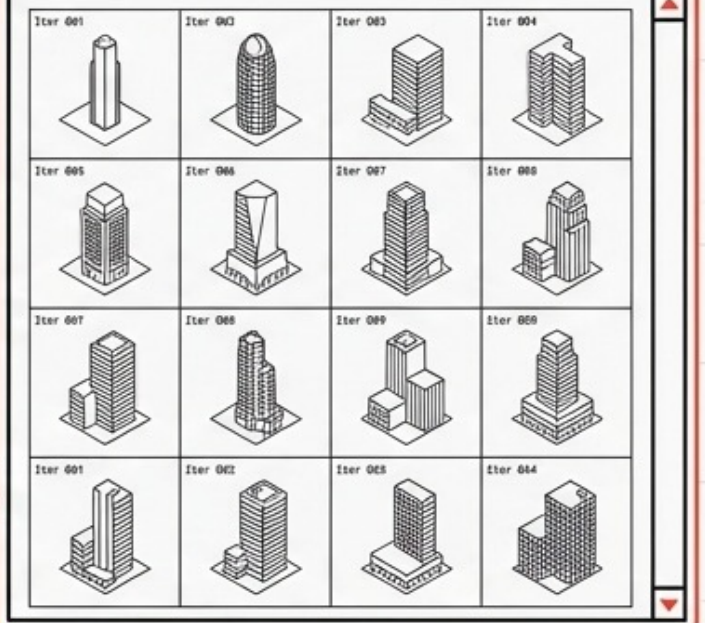
```
import rhinoscriptsyntax as rs

# Define base point
point = rs.GetPoint('Select center point')

# Create tower form
if point:
    for i in range(1, 21):
        height = i * 4
        rotation = i * 10
        circle = rs.AddCircle(point, 5)
        rs.MoveObject(circle, [0, 0, height])
        rs.RotateObject(circle, point, rotation
        # Extrude section

# Add refinement logic here
```

Nano Banana



Nano Banana: Utilize Google AI Studio credits for advanced, iterative image generation.

The Horizon (AI Agents): AI is shifting from answering questions to autonomous execution—writing code, running it, and checking results within Rhino. Stay curious. Watch the demos.

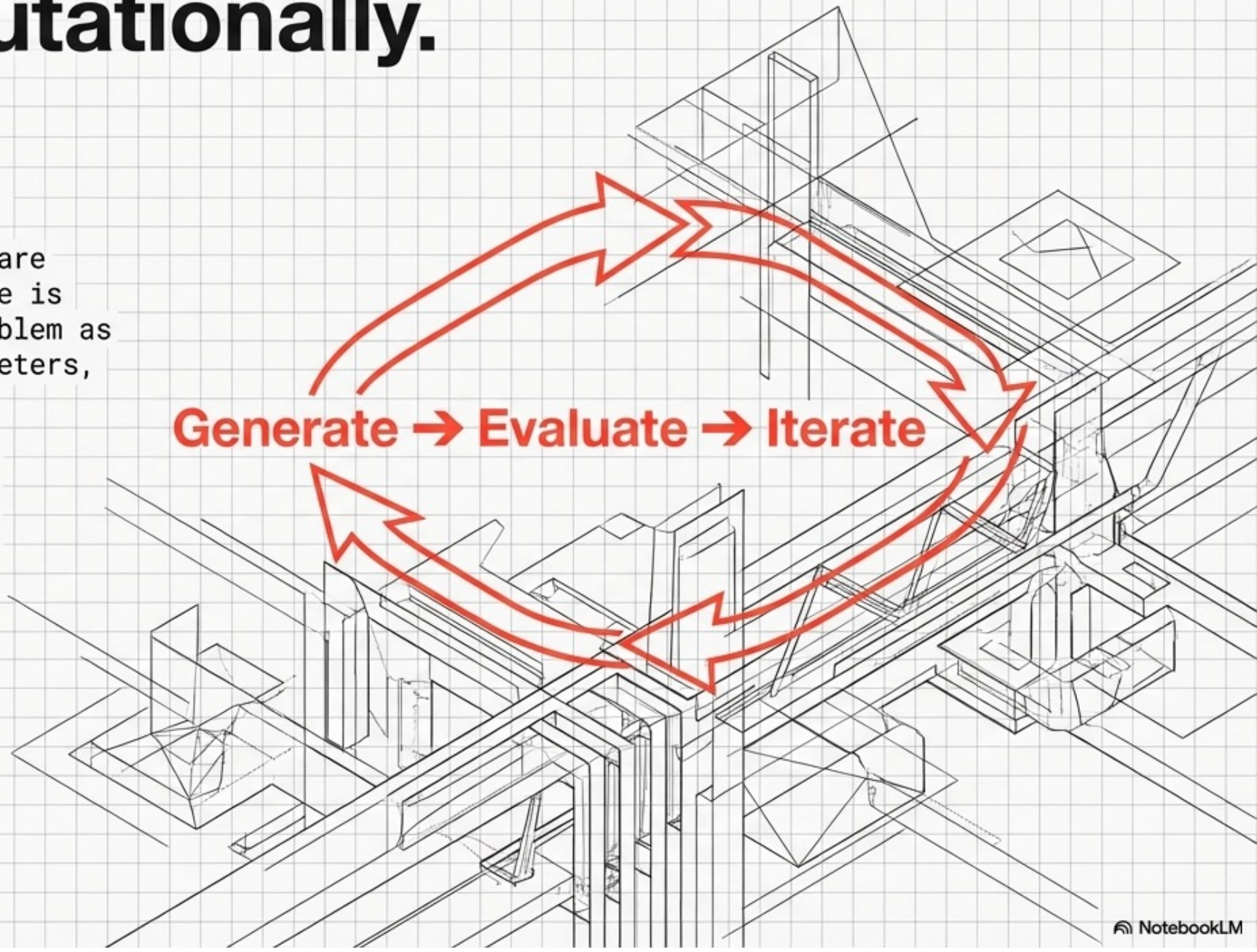
NotebookLM

Think Computationally.

Do not just learn software.
Learn the way to learn software.

The tools will change. The software will update. What will not change is your ability to see a design problem as a system of relationships, parameters, and feedback loops.

Do not let the tools you already know limit your design. Let your intent lead, and search for the right tool.



NotebookLM

The software will update.
The plugins will change.
The syntax will evolve.

What remains is your ability to think computationally—to view an architectural problem as a system of relationships, parameters, and feedback loops.

`Do not just learn software. Learn the architecture of the system.`

NotebookLM