

P O R T F O L I O

YUNHAO ZHONG | MARCH | GSAPP COLUMBIA | 2023-2026

Architecture as Systemic Intelligence: Between Ecology, Computation, and Governance

As contemporary architects, we stand at the threshold of a global transformation. Cities are no longer static entities but evolving systems shaped by climate urgency, energy transition, technological acceleration, and demographic shifts.

Architecture today must move beyond aesthetics to engage with the structural redefinition of human settlement. We are called to envision the next generation of urban systems—ones that integrate intelligent technologies, renewable infrastructures, ecological repair, and social resilience into a coherent spatial logic.

To do so, architects must position themselves at the intersection of urban strategy, technological governance, and systems design. We must adopt a planetary perspective, where buildings operate as infrastructural nodes embedded within data networks, energy flows, and economic circuits—responsive, adaptive, and anticipatory.

The future of architecture lies in the capacity to synthesize intelligence, scalability, and environmental agency. Our task is not merely to design forms, but to construct the spatial protocols of a new urban intelligence—dynamic, collective, and deeply attuned to the challenges of the 21st century.

May you sense this ambition and systemic clarity in the work that follows.

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- 07 **RE-THINKING MICRO LIVING**
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High Pass
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High Pass

THE FOREST ABOVE

REORGANIZING INFRASTRUCTURE, ECOLOGY, AND URBAN FLOWS INTO AN ELEVATED PUBLIC GROUND

Project Design
Advanced Studio VI
Critic: Galia Solomonoff
Spring 2026, GSAPP
Team: Yunhao Zhong, Yuanfeng Luo

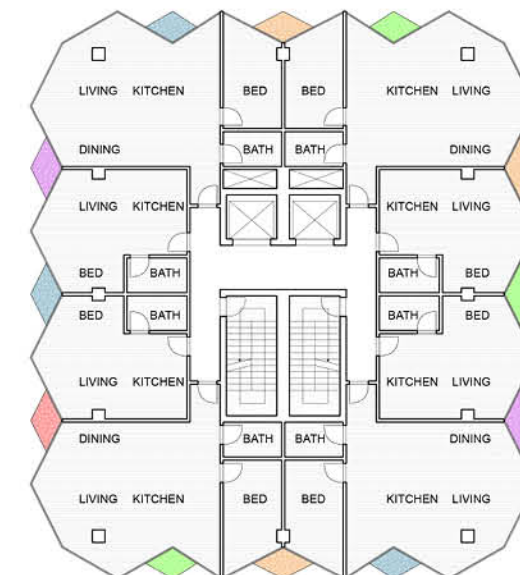
Carbon Caculation Portion of This Project
Footprint: Carbon and Design
Building Science & Technology Elective
Critic David Benjamin
Spring 2026, GSAPP

The Forest Above transforms the George Washington Bridge Bus Station and its surrounding infrastructure from an urban barrier into an elevated, layered vertical park. It explores multi-layer urbanism by reorganizing pedestrian movement, vehicle traffic, energy flow, logistics, landscape, and housing into connected but distinct layers. Instead of treating infrastructure as a boundary, the project turns it into a new public ground above traffic.

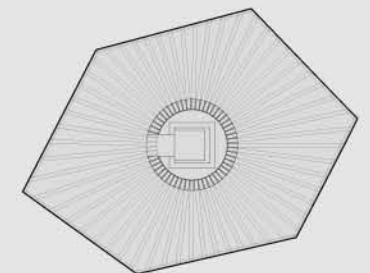
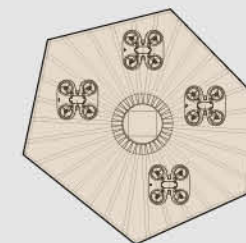
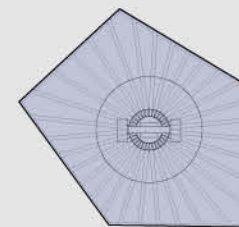
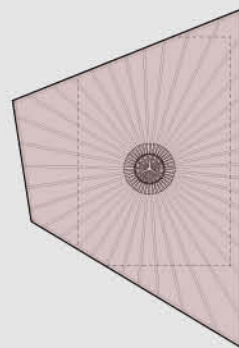
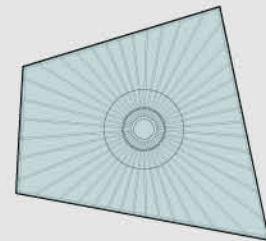
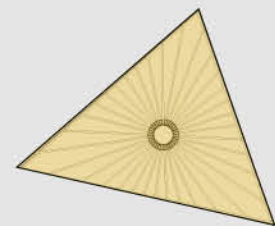
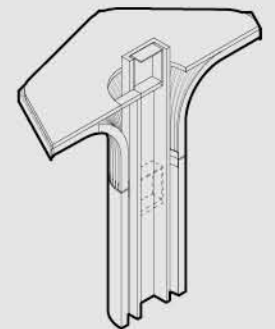
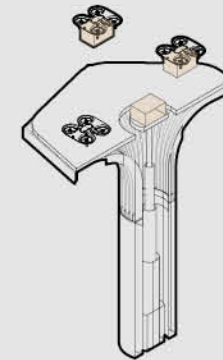
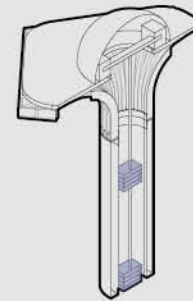
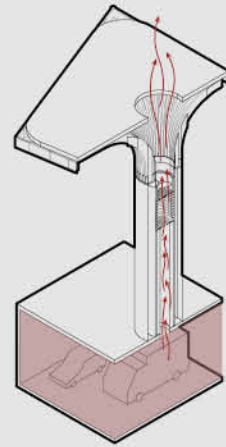
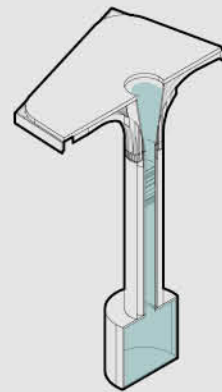
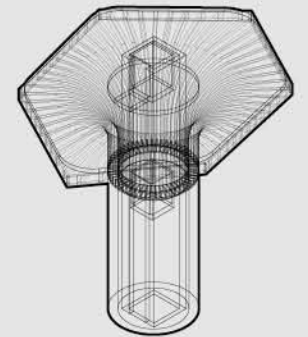
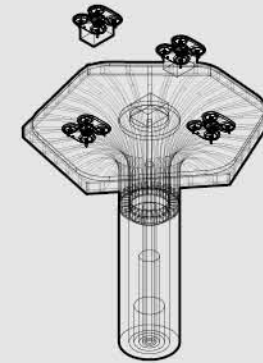
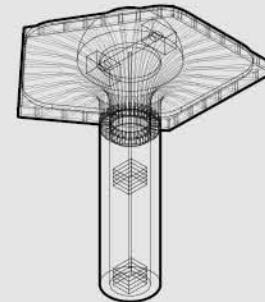
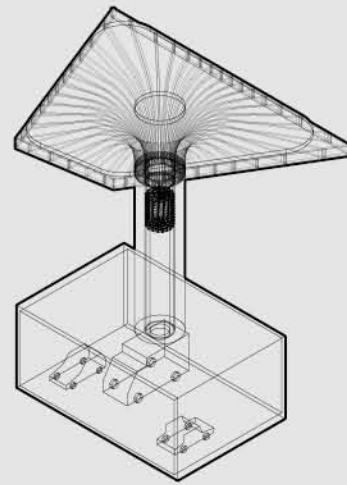
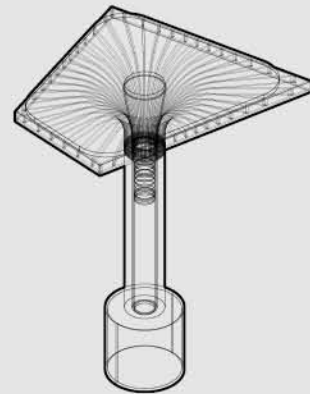
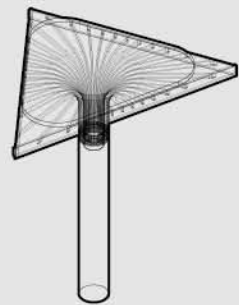
Inspired by biomimicry and Roberto Burle Marx's idea of landscape as painting, the project combines structural logic with spatial and ecological experience. Branching columns work like a forest, supporting platforms, guiding circulation, collecting rainwater, generating electricity from tunnel waste heat, storing energy, and enabling delivery systems. These columns also create tree-like, mushroom-like, and cave-like spaces, forming shaded, immersive public environments across hardscape and softscape.

Computation is used to control complex relationships between geometry, structure, landscape, and infrastructure. Through a modular Voronoi system, parametric modeling, scripting, and data management, the project coordinates an urban park, new housing, existing tower residences, delivery hubs, energy systems, and public circulation within one expandable framework. Together, it proposes a scalable urban forest where mobility, ecology, energy, logistics, and community life are integrated above existing infrastructure.





The project redefines housing entrances by lifting pedestrian access from congested street level to an elevated public ground. This separates pedestrians from vehicle traffic, creating safer connections between existing towers, new housing, landscape, and shared programs. The entrance becomes a future urban interface, integrating circulation, delivery, energy, and community life into everyday residential experience.



STRUCTURE

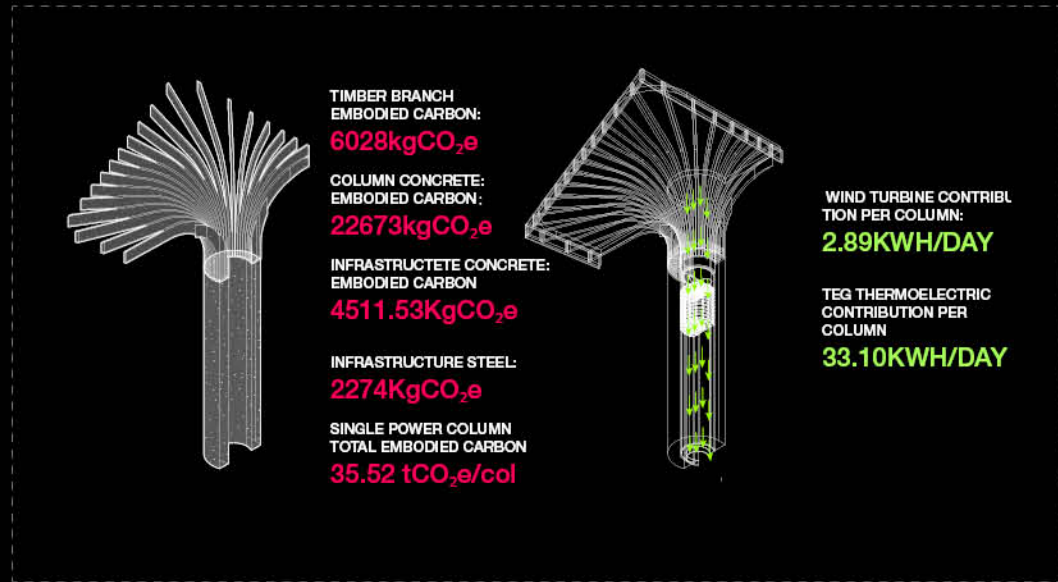
RAINWATER COLLECTION

THERMO-VENT POWER COLUMN

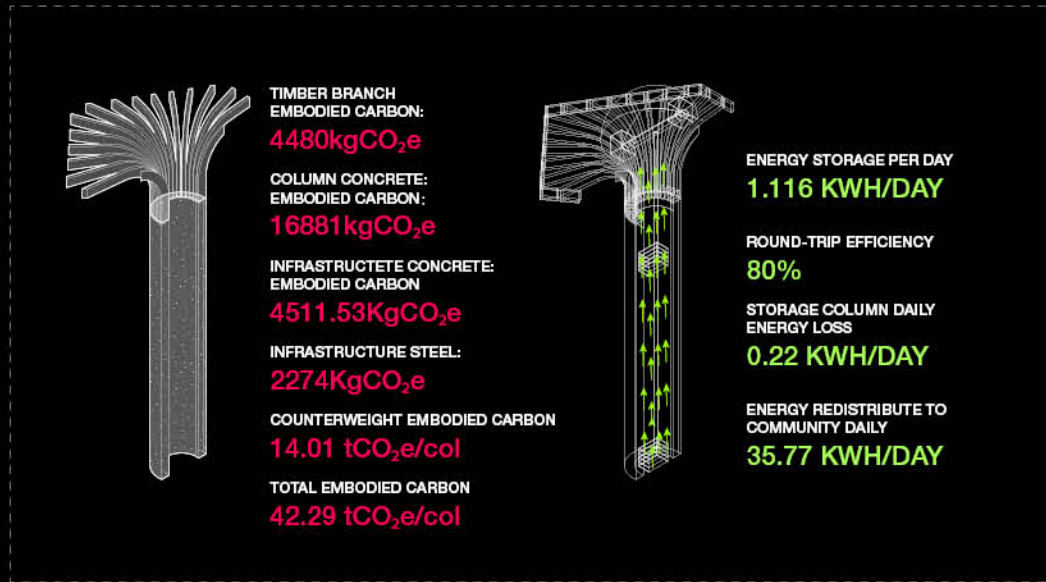
GAIVITY BATTERY

DRONE LOGISTICS COLUMN

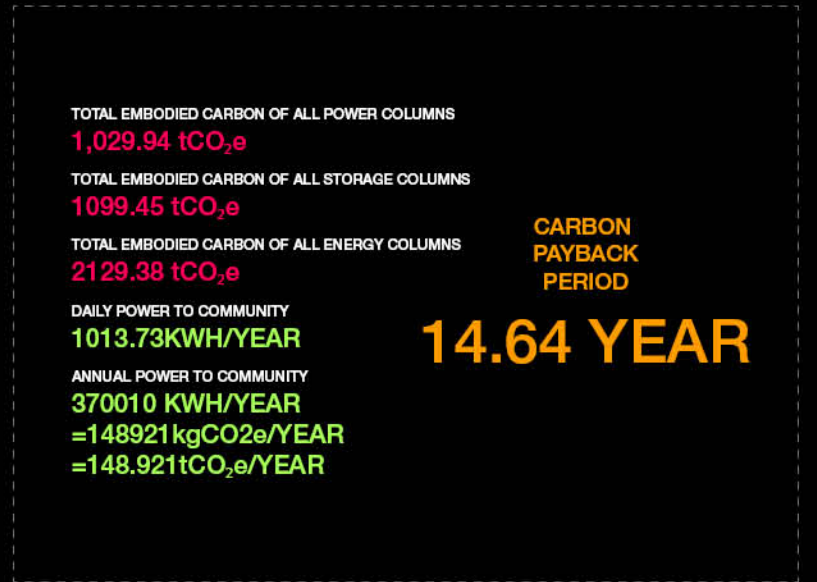
CIRCULATION CORE



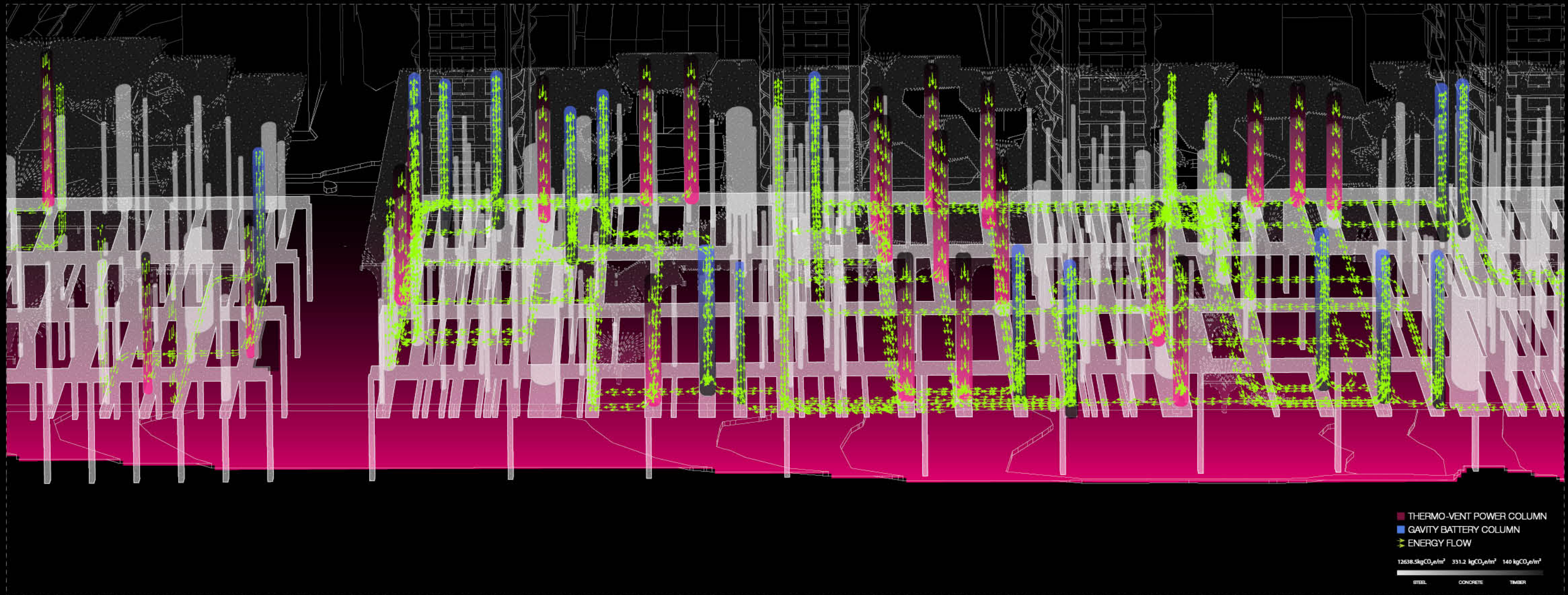
Heat Drive Power Column Carbon And Energy Calculation



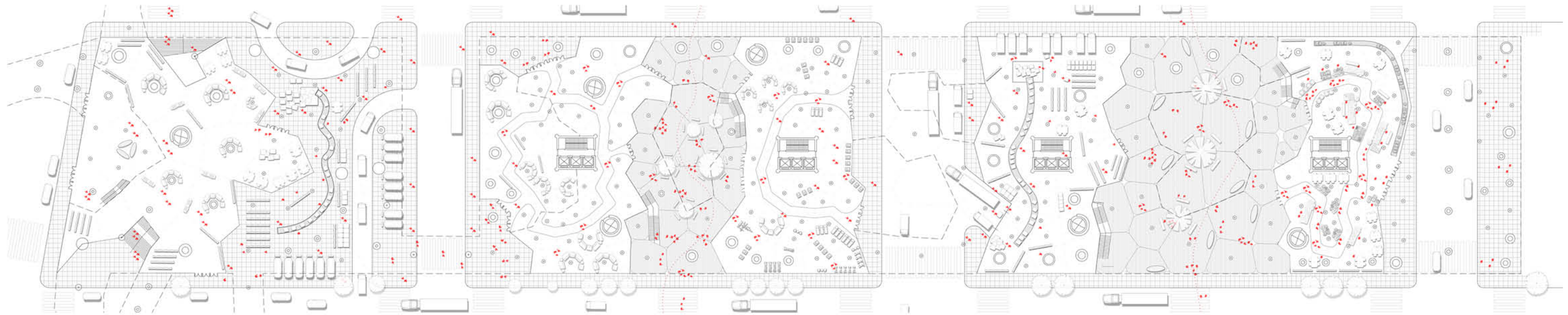
Gravity Battery Column Carbon And Energy Calculation



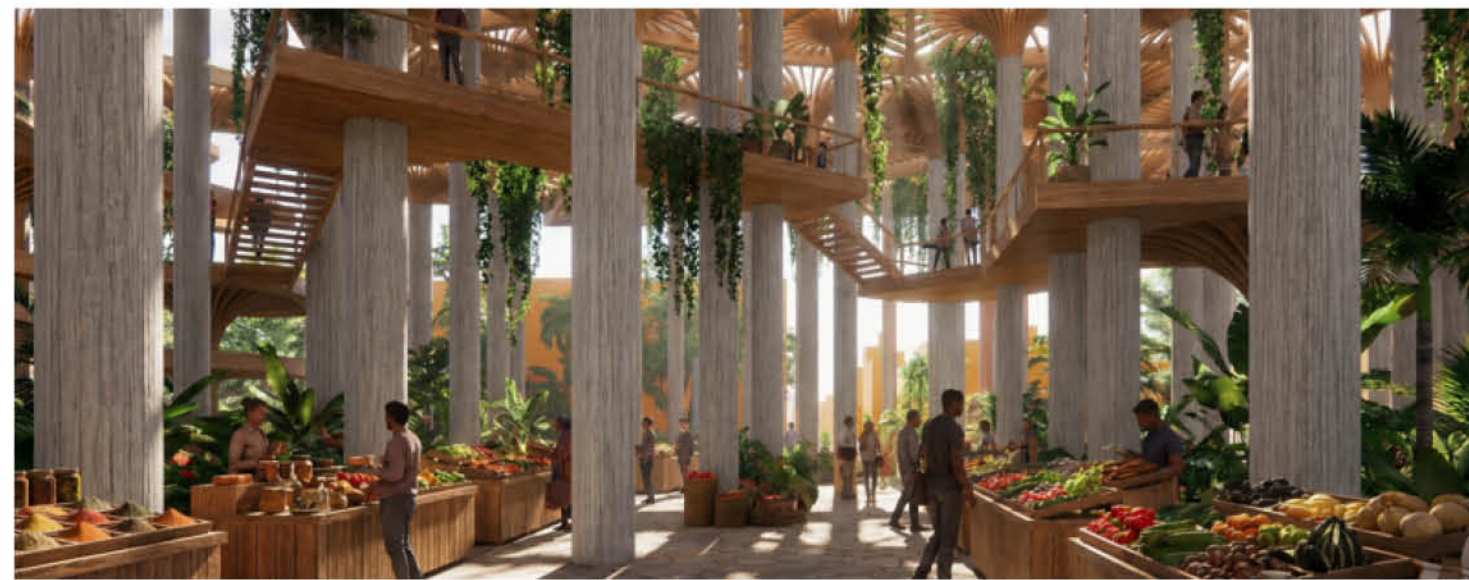
All Columns Carbon And Energy Calculation



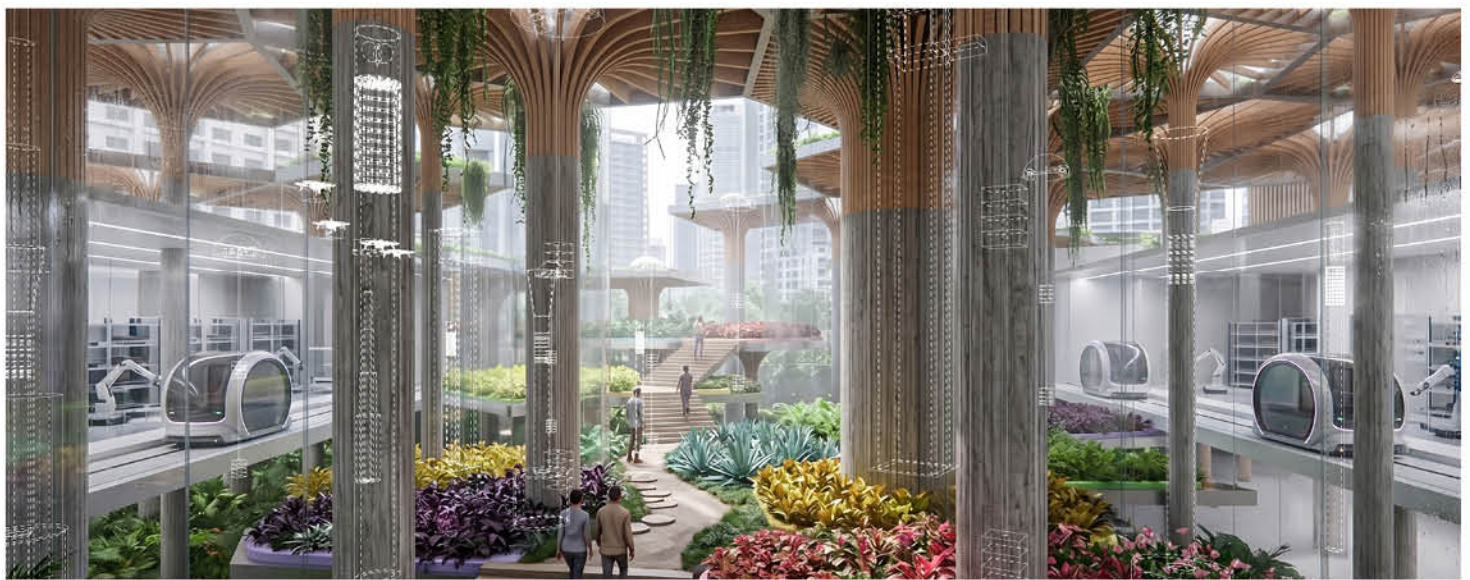
Simulation Of Energy Flow / Section Perspective Of Energy Infrastructure



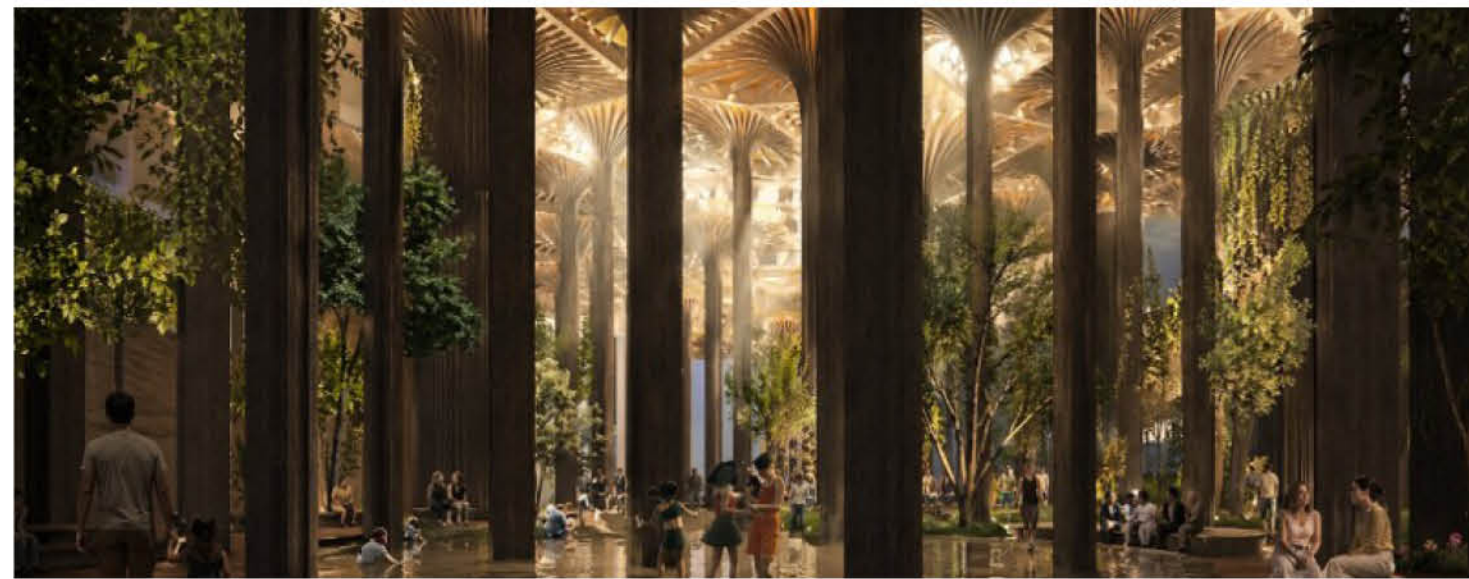
Ground Floor Plan



Interior Perspective of the Market Hall



Interior Perspective of the Cave-Like / Tree-Like Garden Space



Interior Perspective of the Community Center



Exterior Aerial Perspective of the Delivery Hub Rooftop Park



Drone In-orbit view

PK-3744
Transit
In Transit
Delivery Confirmed
PK-7744
PK-2222
PK-9972

PK-5738
PK-7744
Delivery Confirmed

PK-1223

PK-7718

PK-7724

PK-7718

PK-7718

PK-7718

70

TECHNOCRATIC EMPIRE

AMPLIFICATION AND CRITIQUE OF THE SOCIAL DAMAGE CAUSED BY TECHNOLOGICAL MONOPOLIES

Core Studio II
Critic: Abraham Murrell
Spring 2024, GSAPP
Personal Project

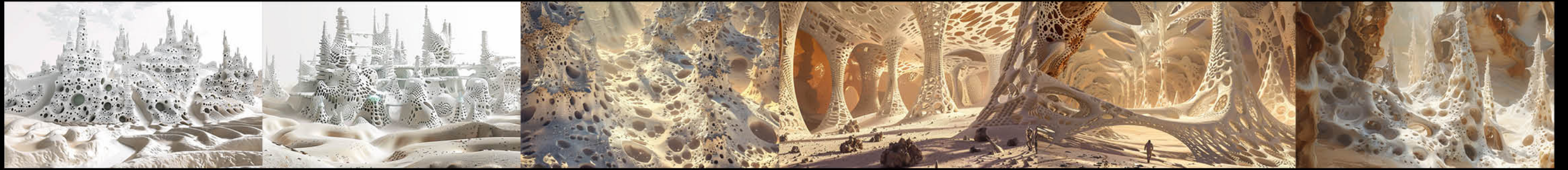
HIGH PASS

This project critiques Amazon's monopolistic control over advanced building technologies, exposing its harmful impact on labor rights and human dignity. Set two centuries in the future, it envisions a dystopian world where humans survive only inside colossal, organic mega-structures developed by a fictional Amazon. These buildings, constructed through robotic labor and human exploitation, serve only elite interests.

The project portrays a society ruled by techno-elites and corporate oligarchs, where gig workers and the digital underclass are marginalized under constant surveillance. Architecture becomes a tool of control, reinforcing social hierarchy and exclusion.

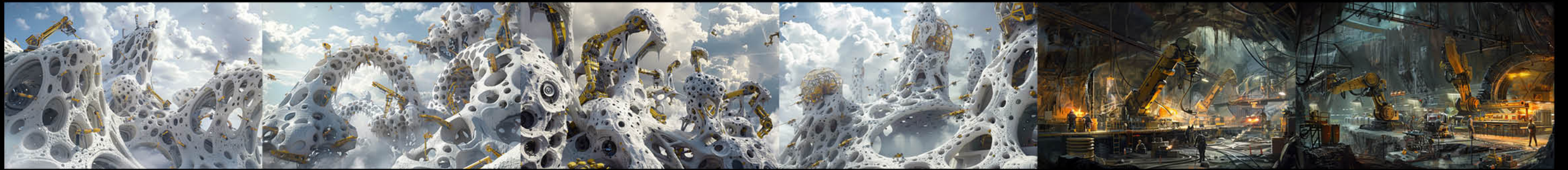
Through this speculative scenario, the project raises urgent questions about the consequences of technological monopolies. It critiques architecture's role in supporting power structures and advocates for a justice-oriented, human-centered design approach, one that resists domination, promotes equity, and reimagines space as a means of collective empowerment.





Future Climate Change

As climate collapse makes Earth unlivable, a fictional Amazon builds colossal organic mega-structures to shelter what remains of humanity.



Robotic Construction

These mega-structures rise through relentless, robotic labor, silently and efficiently fusing ecological form with totalizing architectural control.



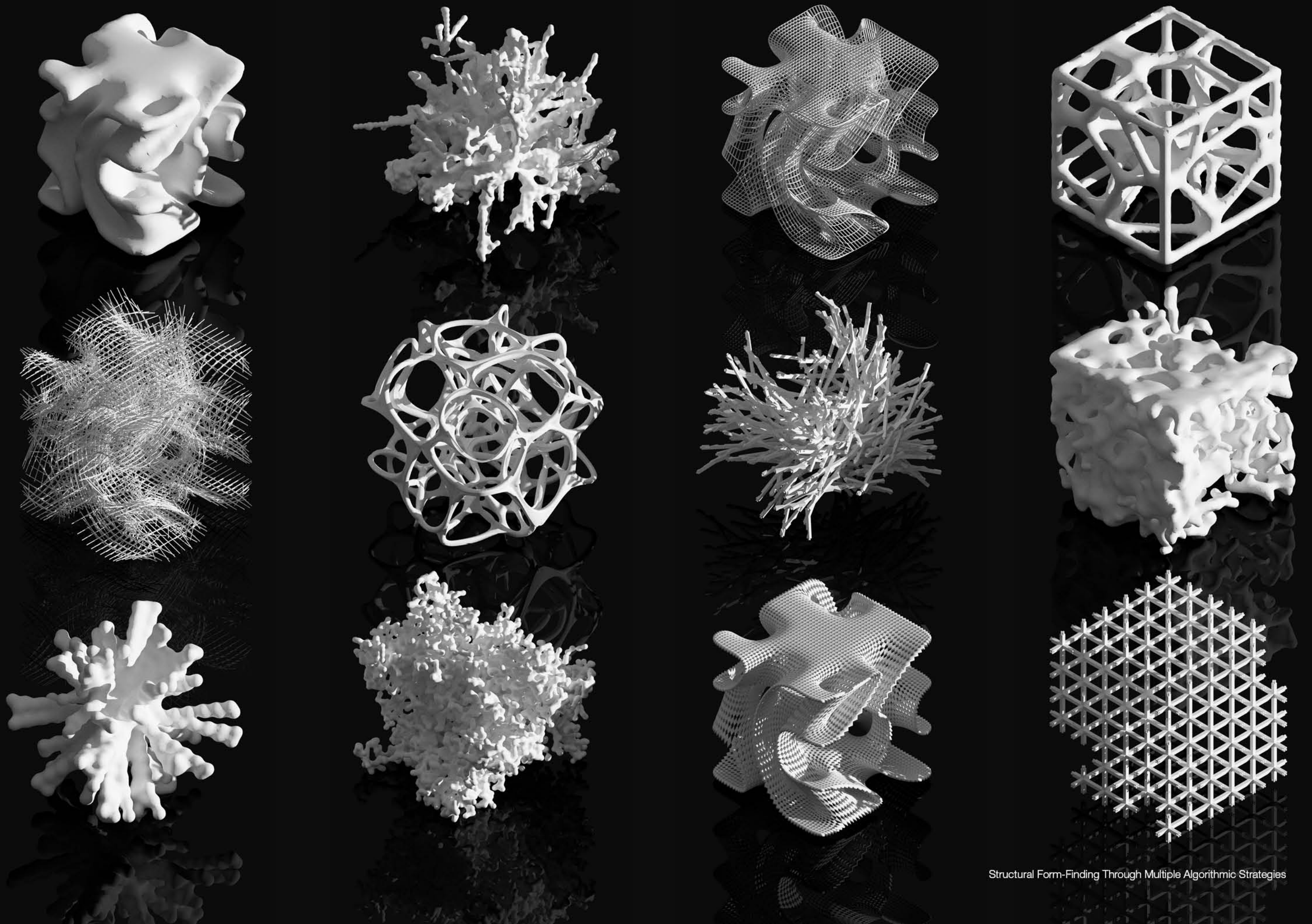
Labor Exploitation

Beneath the automation lies brutal human exploitation, as gig workers and the digital underclass sustain the empire under constant surveillance.

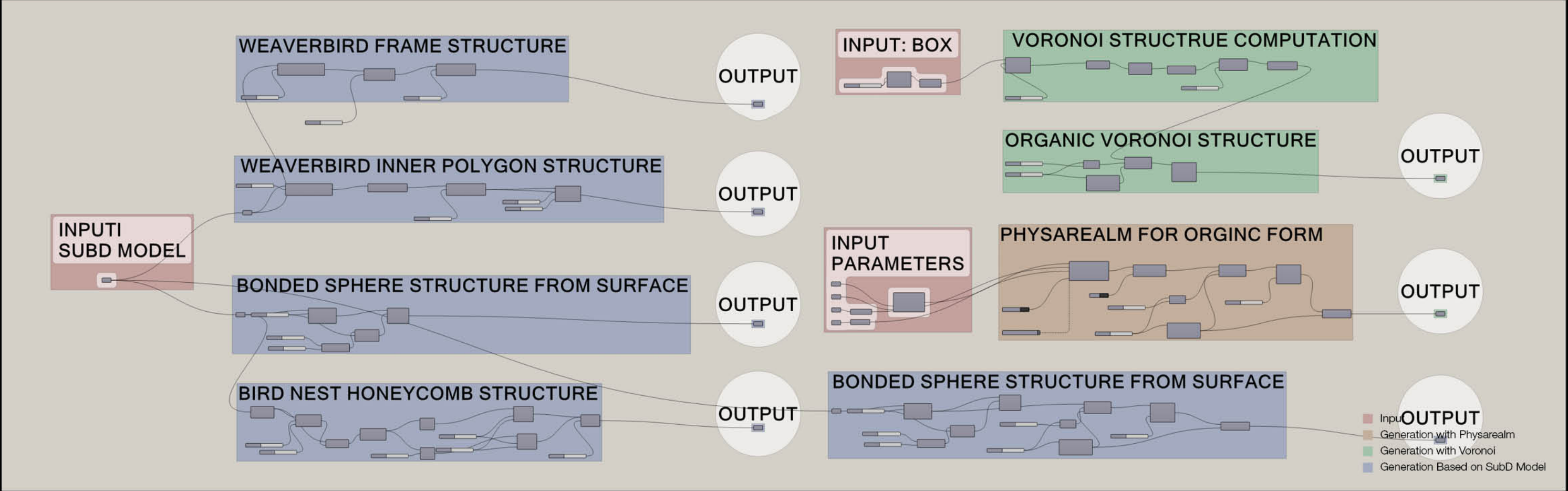


Interior Empire

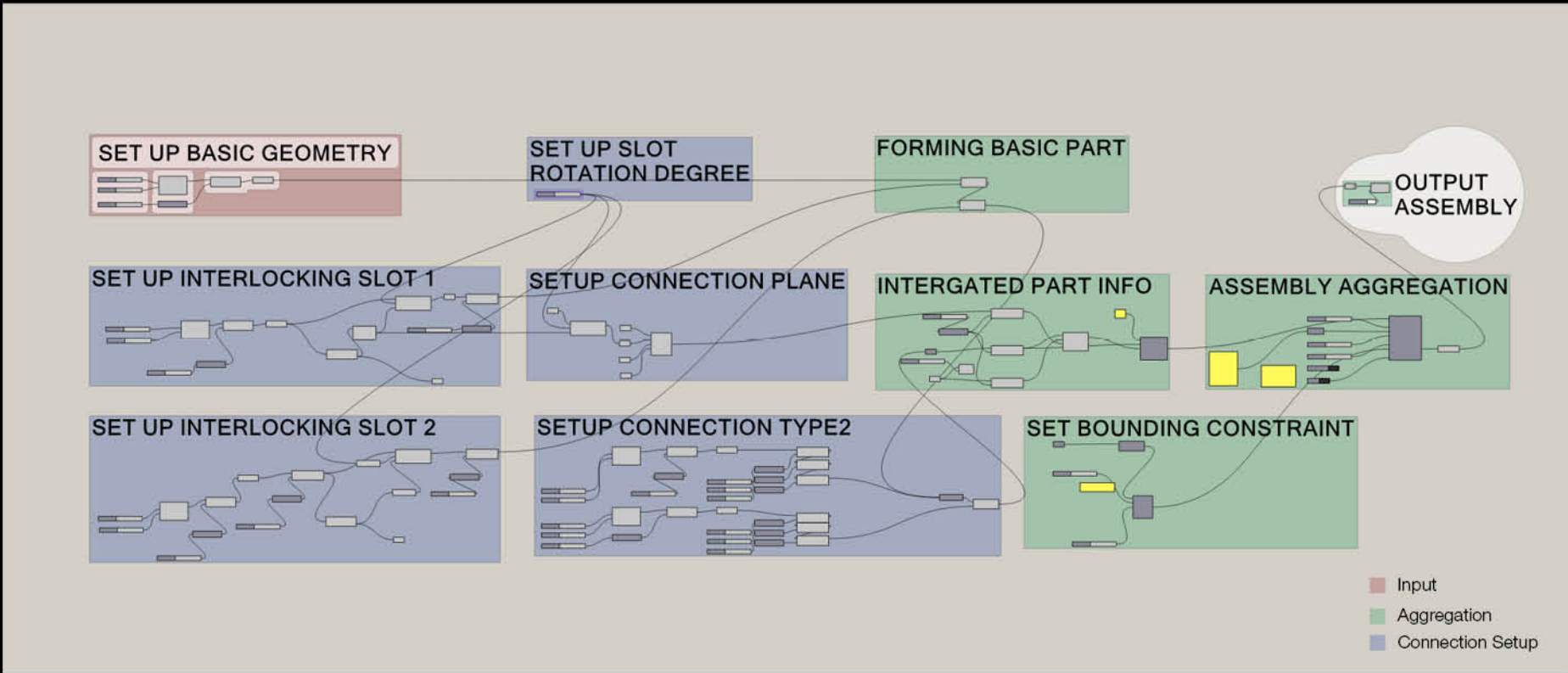
Inside these sealed environments, techno-elites inhabit lush, tightly hyper-controlled interiors—luxury born from labor, isolation, and exclusion.



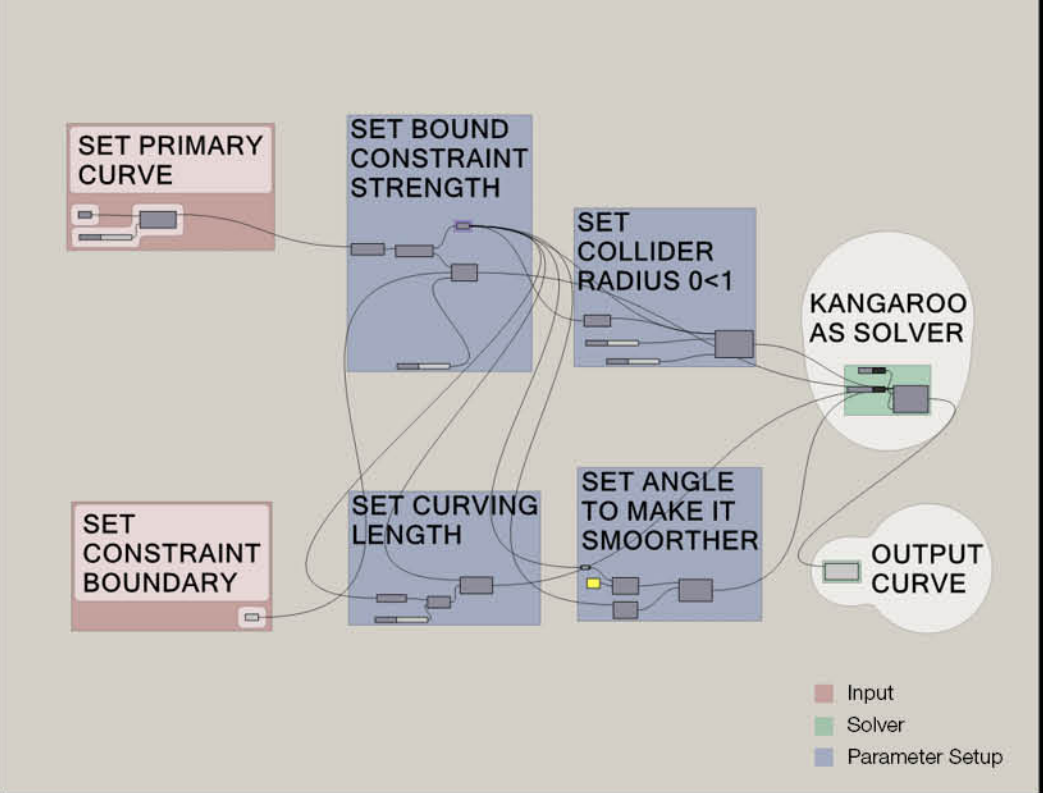
APPLIED PER-FAÇADE PANELS, REORDERED POINTS, ADDED 5TH ADAPTIVE CONTROL, EXPORTED TO REVIT.



WASP TO BUILD INTERLOCKING AGGREGATES WITH DESIGNED JOINTS.

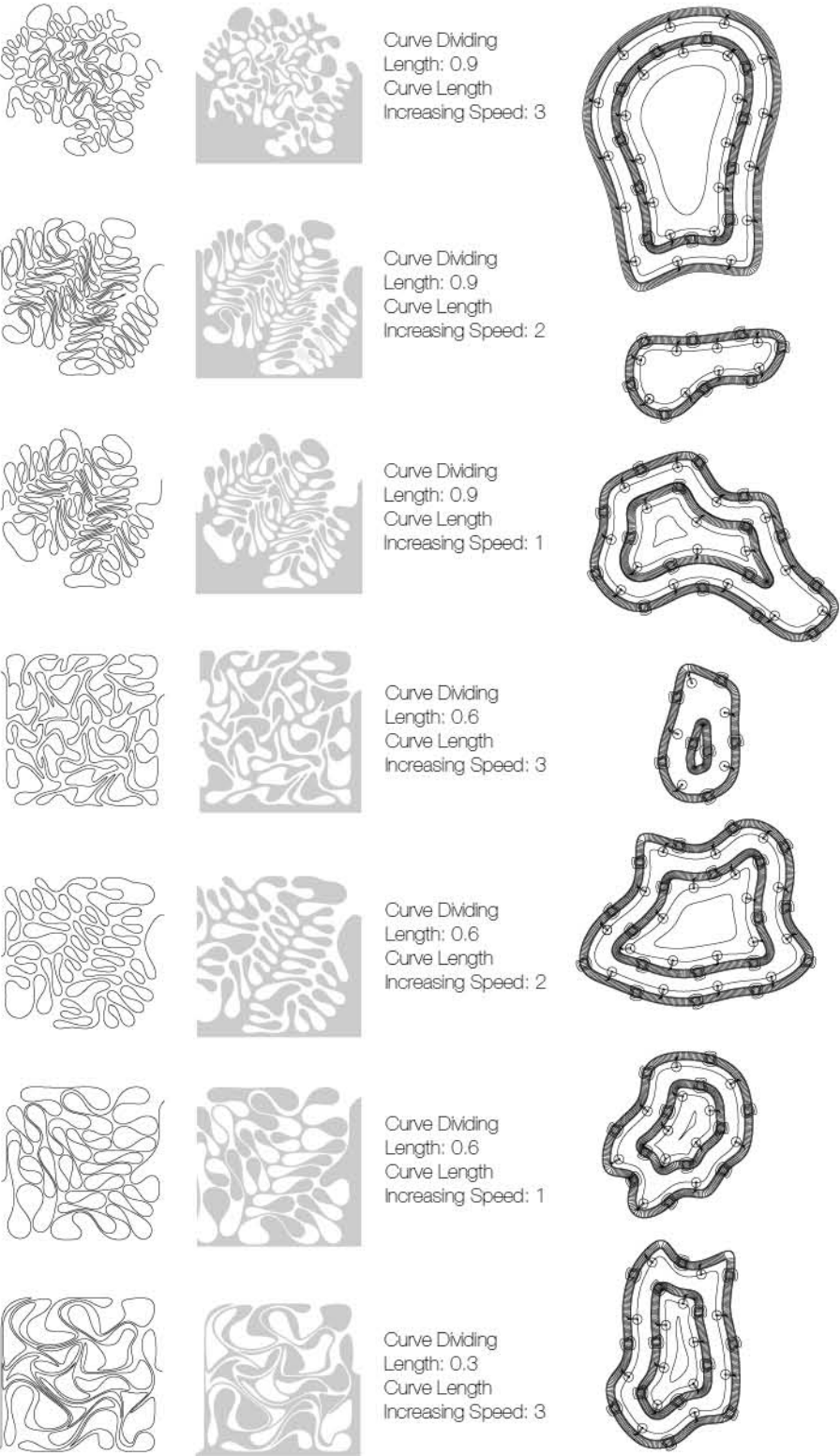


KANGAROO TO SOLVE & GENERATE CURVED PLANAR LAYOUT



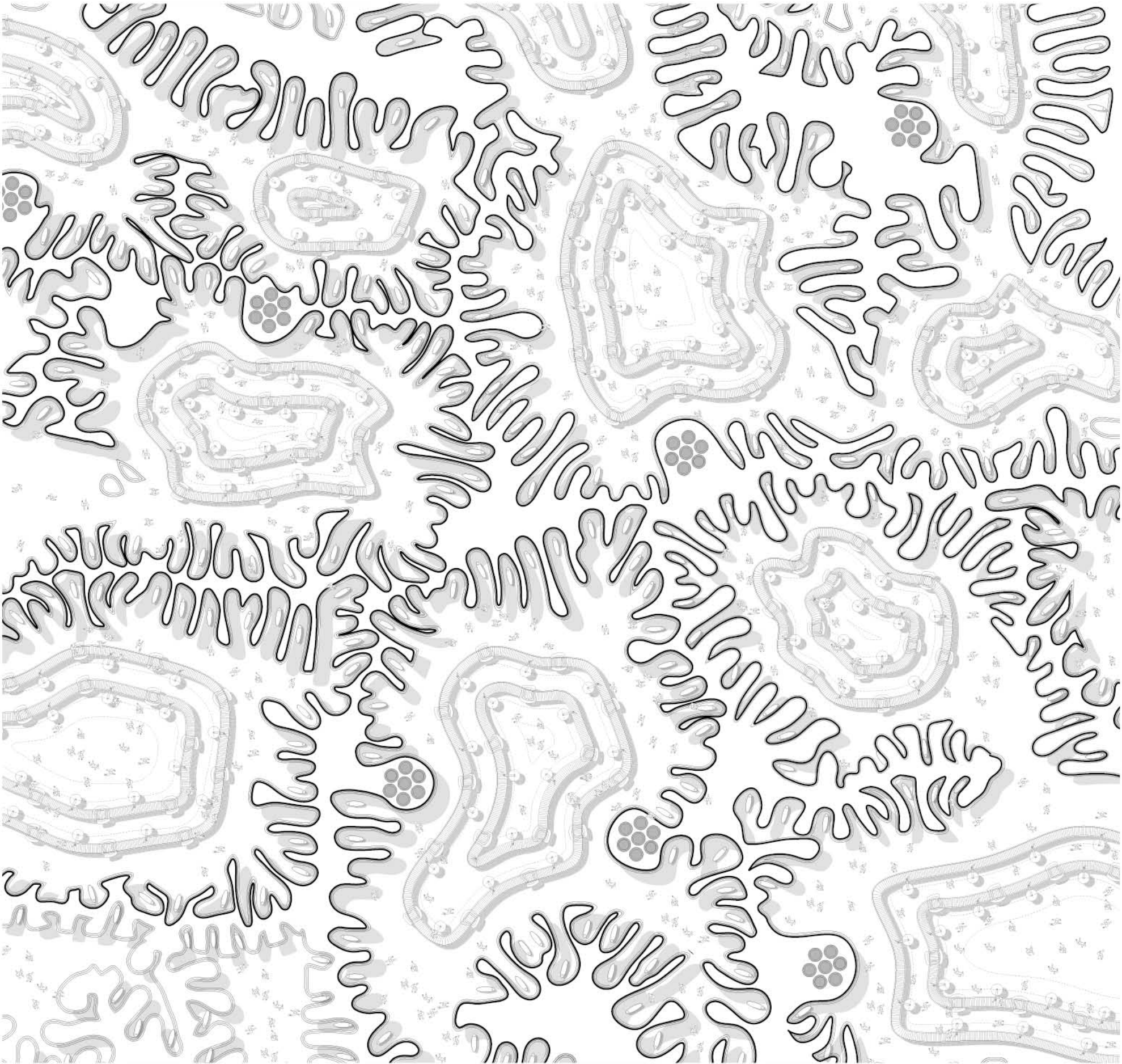
HUMAN-AI COLLABORATIVE WORKFLOW

The project explores human-AI collaborative drawing where hand-drawn sections are iteratively processed through AI generation. My workflow reflects the integration of manual input and algorithmic transformation. This raises a key question: how can we balance creative agency with computational power?

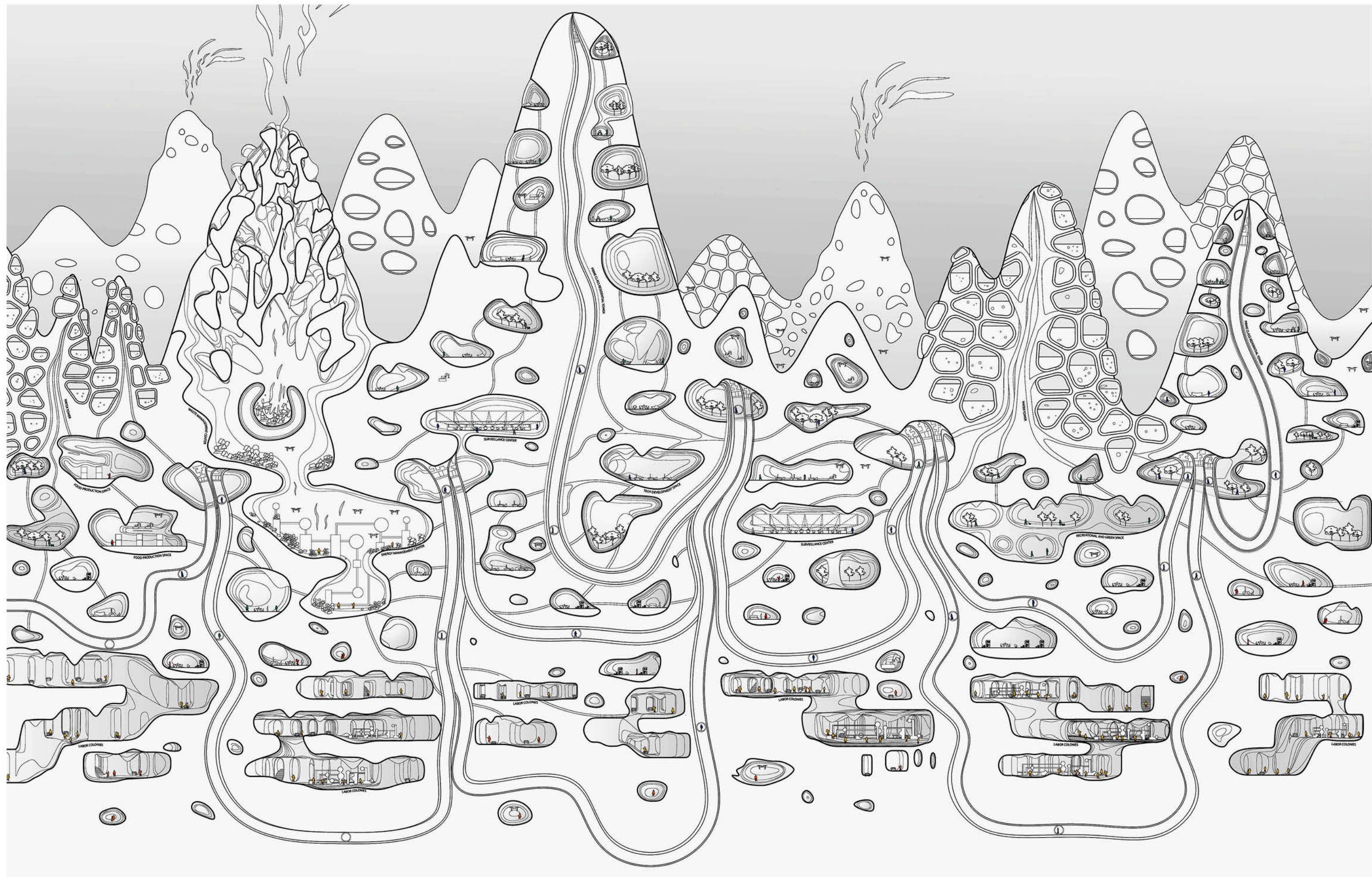


Algorithmic Pattern Generation

Automated Layout



Lower Level Plan - Digital Underclass - Labor Colonies

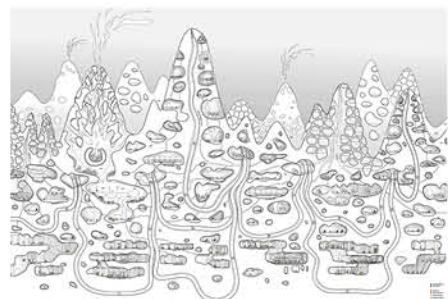


■ Precariat & Proletariat ■ Digital Underclass ■ Knowledge Workers ■ Gig Workers ■ Techno - Elite ■ Corporate Oligarchs

Hand Drawn Section - Technocratic Empire



Human-AI Collaborative Drawing



Manual Input



AI Iteration x10



AI Iteration x15



AI Iteration x30

Final Prompts: organic architecture section, architectural outaway, ant farm, detail furniture, people, urbanism, commercial empire, lots of furniture, luxury furniture, people life ,architectural section perspective, architectural section drawings, ultra-detailed organic architecture section, intricate architectural outaway with layered spaces, ant farm-style section with visible structural systems, photorealistic furniture arrangements, animated people interacting, dense urban fabric, commercial megastructure empire, packed with diverse high-end furniture, luxury textures (leather, marble, brushed metal), daily life scenes, immersive architectural section perspective, complex section drawings with exploded axonometric elements, high-tech components, futuristic AI systems, embedded robotics, parametric geometry, glass and concrete material palette, glowing ambient lighting, reflections, soft shadows, advanced fabrication detailing, cybernetic infrastructure, indoor vegetation and vertical farming, smart home interfaces, mechanical arms, drones, suspended platforms, automated systems in motion, hyper-realistic rendering, cinematic mood, depth of field, cut-through core with elevators, escalators, mechanical shafts, underground layers, cross-programmed commercial-residential spaces --ar 16:9 --v 6.1

THE VAULT OF TRUST

ARCHITECTURE AS A CIVIC LEDGER FOR
CARBON, VALUE, AND GOVERNANCE

(A CIVIC-INSTITUTIONAL SYSTEM
FOR CARBON VERIFICATION,
STORAGE, DAO GOVERNANCE,
CHARCOIN ISSUANCE, AND
BIOCHAR-BASED HOUSING.)

Advanced Studio V
Critic: David Benjamin
Autumn 2025, GSAPP
Personal Project

The Vault of Trust recasts architecture as a civic ledger, making carbon, value, and governance auditable, binding proof to policy. In 2030, Ludhiana District, Punjab, India, rice-straw smog and climate shocks undermine banks, data credibility, and carbon accounting. Villages convert rice straw into biochar through low-oxygen pyrolysis and test each batch for stability. A Decentralized Autonomous Organization (DAO) defines MRV (measurement, reporting, and verification), issues blockchain-anchored material passports, and mints CharCoin, one coin per verified kilogram, backed 1:1 by sequestered carbon.

The building stages the system in public, synchronizing loading, testing, registration, storage, and deliberation with an on-chain digital twin. Thick black biochar walls hold thirty percent as a visible reserve; seventy percent becomes biochar-composite housing, translating carbon evidence into housing and savings.

A computational model links rice-straw and biochar yields, Vault capacity, and seasonal carbon flows, positioning the Vault as replicable infrastructure for autonomy and climate-era public trust.

By turning verification into a civic ritual, the Vault converts an invisible planetary debt into a shared local asset. It links atmosphere, agriculture, and settlement in one accountable loop, where material reserves ground monetary claims. As this typology multiplies, it outlines a postbanking commons for climate governance across regions and generations.



HYBRID DRAWINGS
Orchestrating a Multi-Layered Civic System
Biochar as Currency, Architecture as a Ledger for Carbon, Value, and Governance



1.SYSTEMIC CRISIS OF TRUST
Rice-straw smoke, failed programs and volatile markets leave villages outside money and carbon.



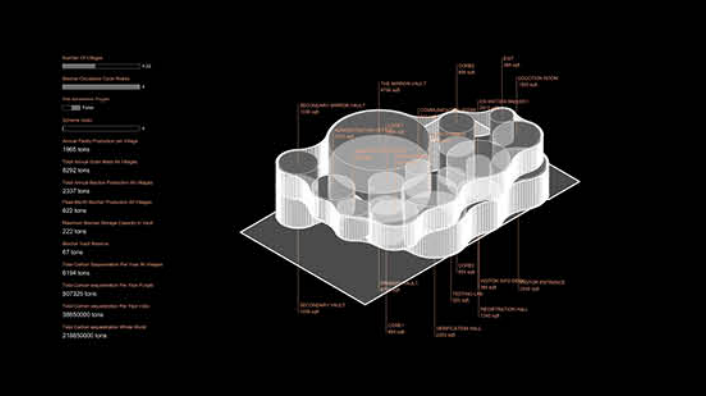
2.BIOCHAR RECOGNISED AS SURVIVAL VALUE
Biochar from low-oxygen kilns locks carbon, revives soil and becomes our last survival rope.



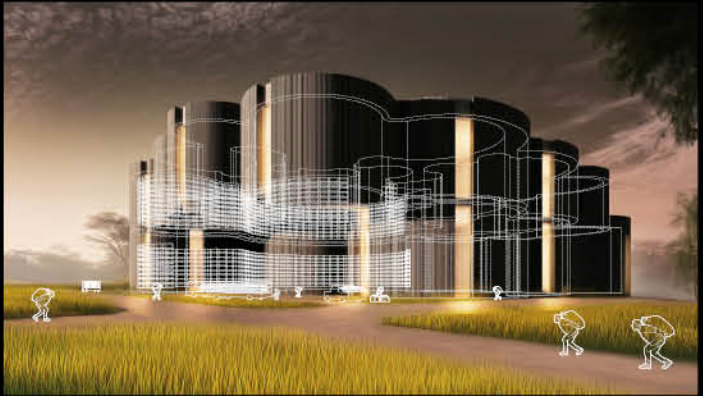
3.COLLECTIVE ACTION, NEED FOR PROOF
Five families buy mobile kilns, exposing the need for shared measurement and proof.



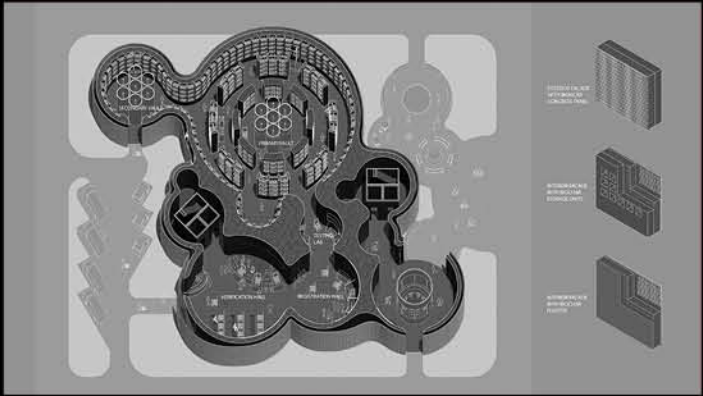
4.VILLAGE DAO AND PROPOSAL OF THE VAULT
Five villages form a DAO with an architect and propose the Vault of Trust.



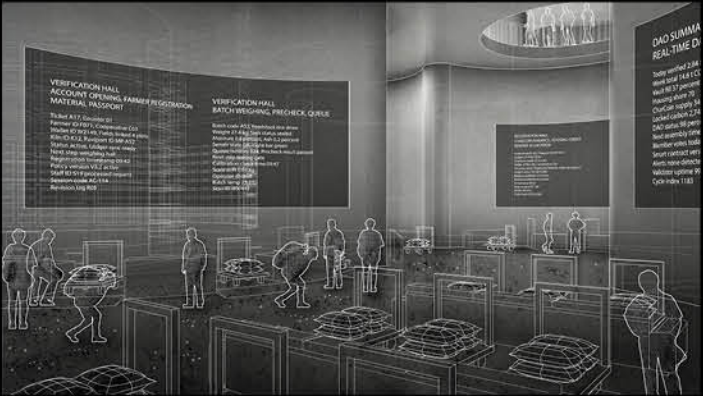
5.MODELLING FLOWS, REPLICABLE PROTOTYPE
The architect models village data and biochar yields into a replicable Vault for carbon removal.



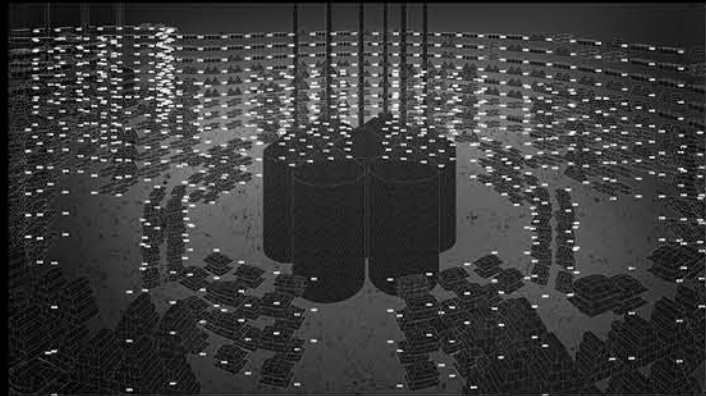
6.BUILDING THE FIRST VAULT AND CHARCOIN RULES
The first Vault mints CharCoin, holding visible reserves while routing carbon into housing.



7.GROUND FLOOR AS CARBON LEDGER
Loading, weighing, registration and storage turn the ground floor into a transparent carbon ledger.



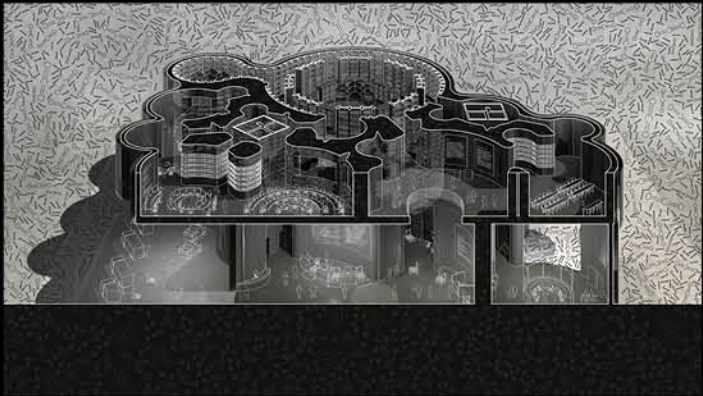
8.MRV FRAMEWORK ISSUING CHARCOIN
A DAO-governed MRV framework turns verified carbon into CharCoin as a transparent value system.



9.STORED CARBON AS PHYSICAL LEDGER
Stored biochar anchors the currency as a traceable physical ledger paired with its digital twin.



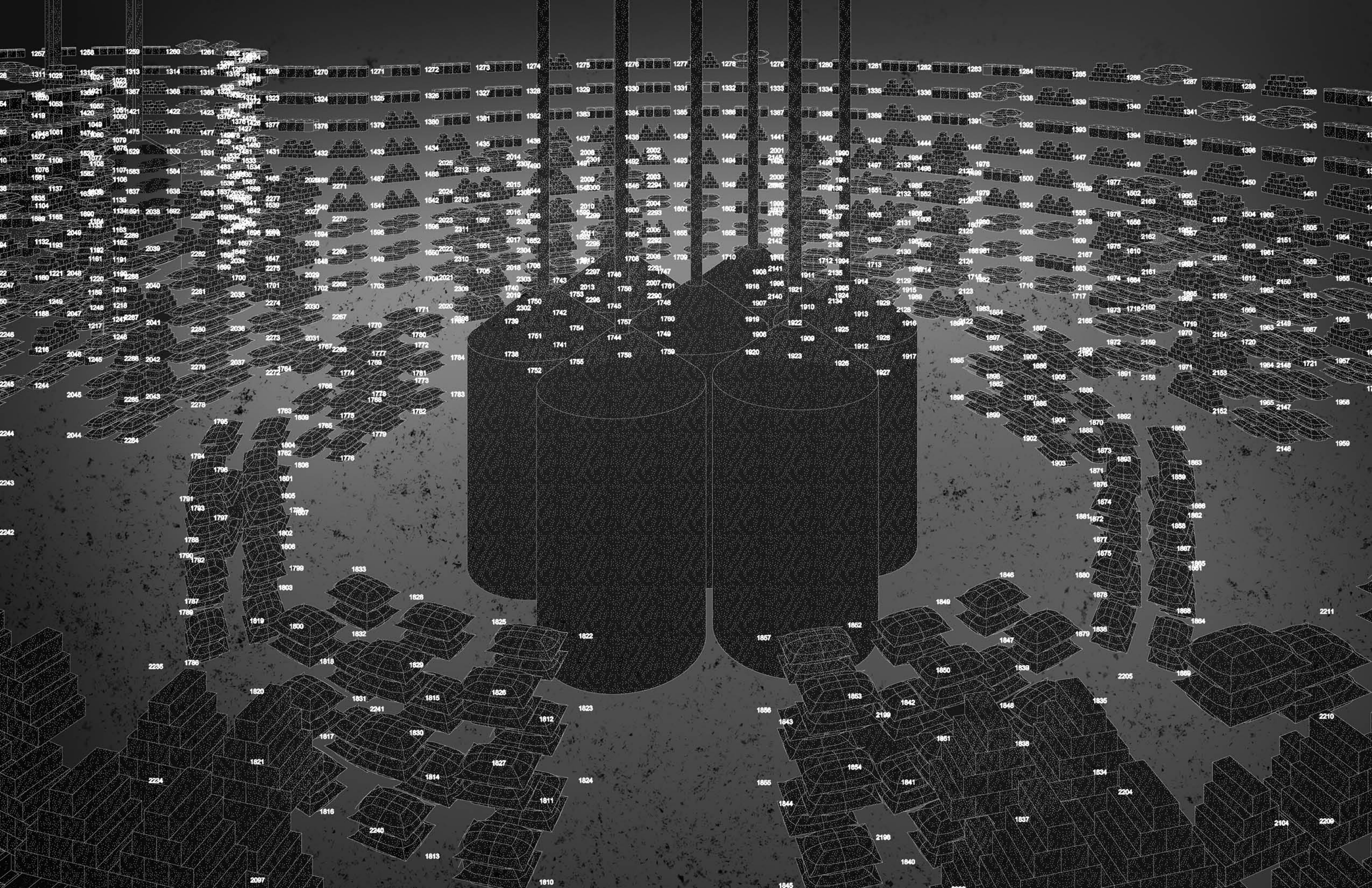
10.CHARCOIN IN DAILY LIFE
Farmers pay wages, trade in markets and run local shops using CharCoin in digital wallets.

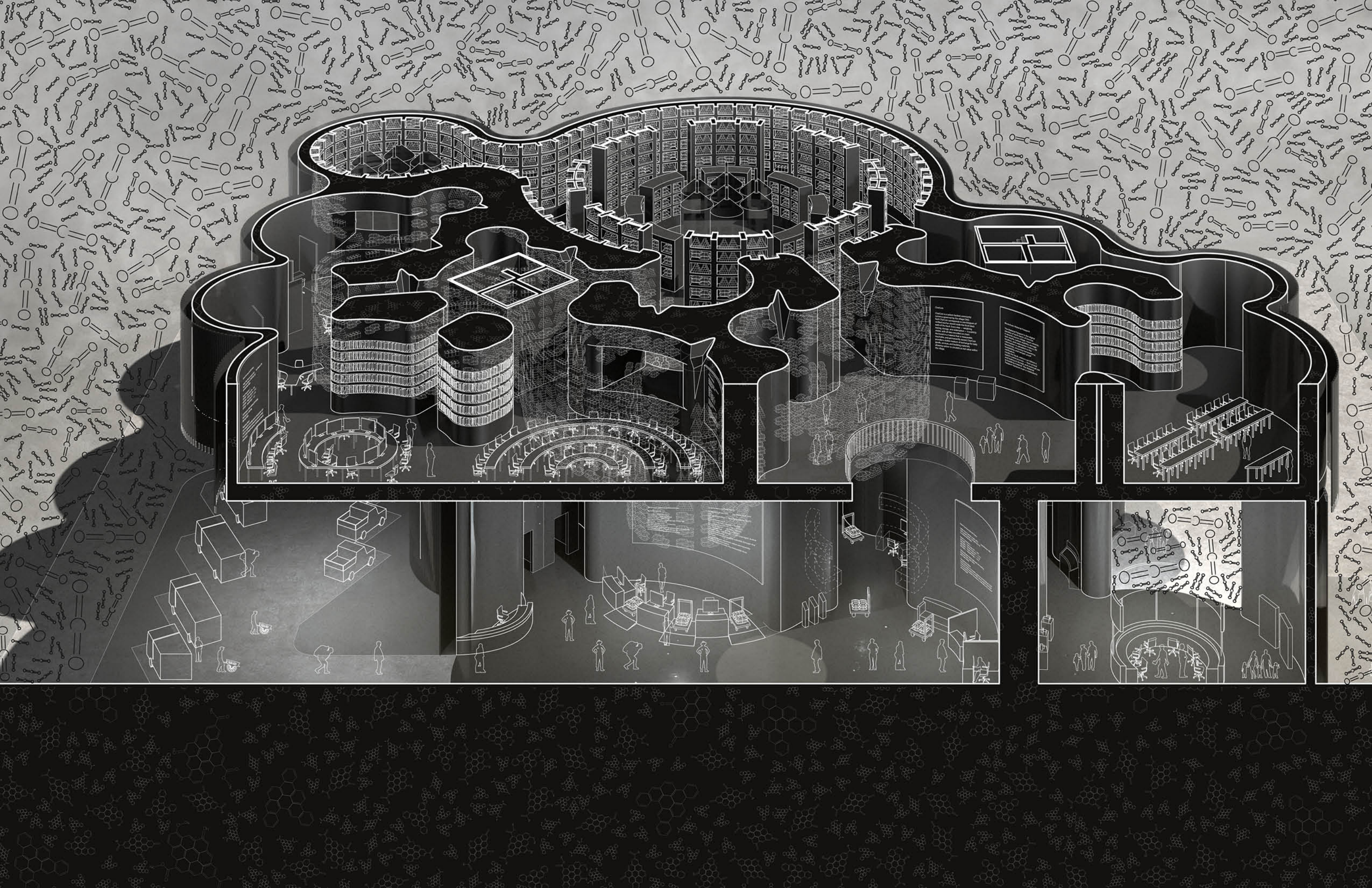


11.PUBLIC GOVERNANCE AND OUTSIDE TRUST
Public halls and sightlines reveal testing, storage and voting as a visible carbon governance system.



12.EVERYDAY LIFE AS CARBON SINK
Biochar homes turn daily life into a visible carbon sink, their black walls signaling shared trust.





ADAPTIVE INTELLIGENCE

Revolutionizing Waterfront Dynamics for Urban Resilience

Core Studio I
Critic: Lindy Roy
Autumn 2023, GSAPP
Personal Work

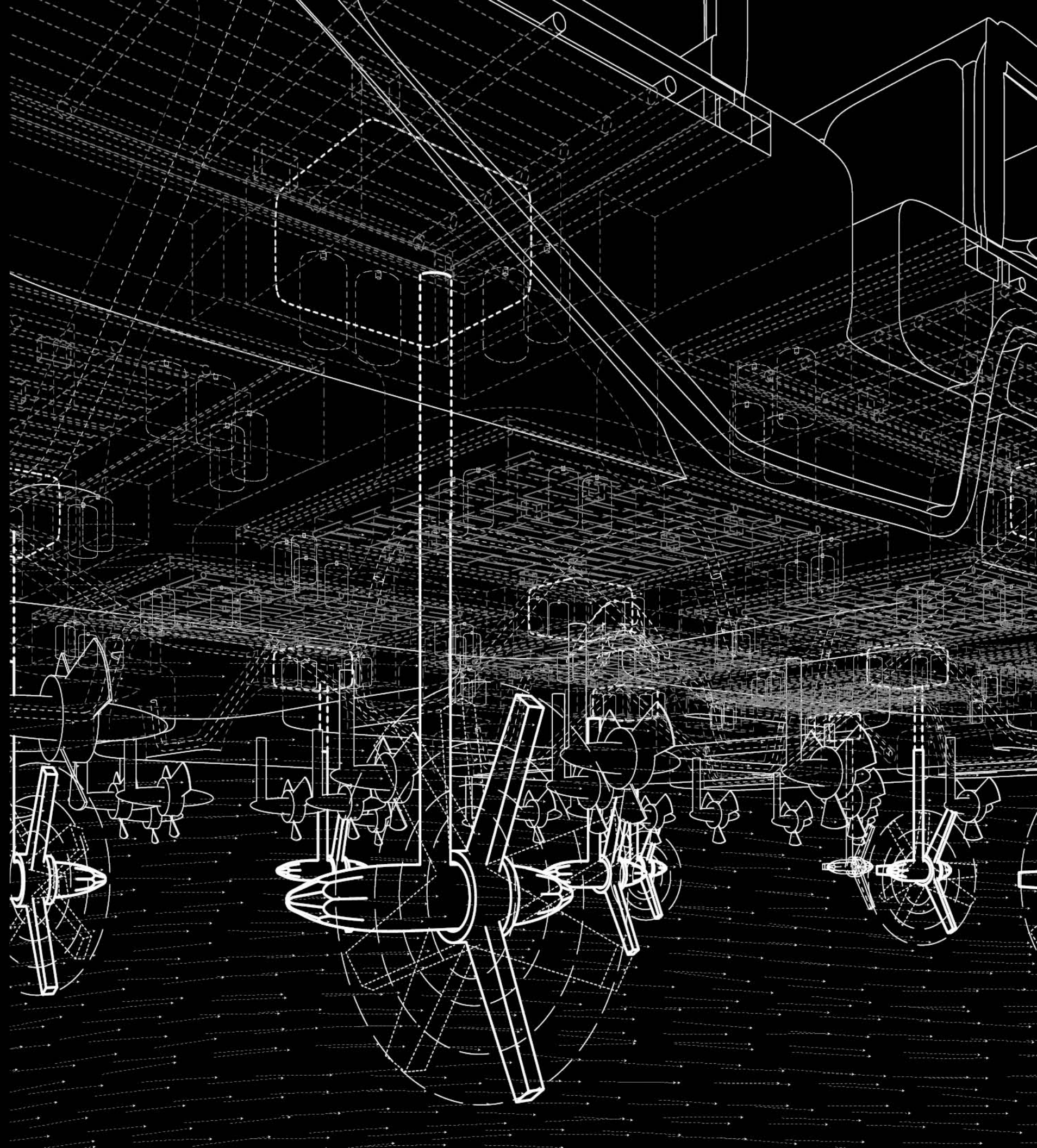
HIGH PASS

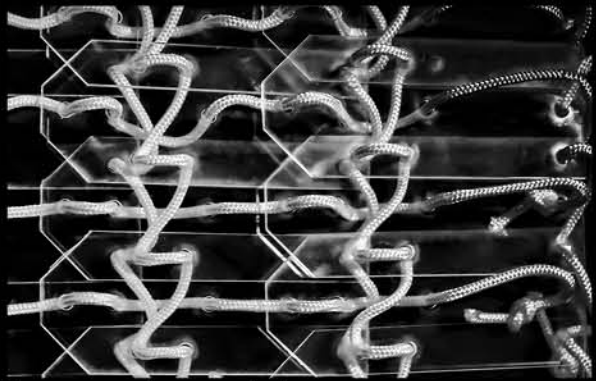
The design addresses the dynamic water environment in Manhattan, New York, responding to the daily rise and fall of the sea and ecological richness due to its estuarine location. Challenges include tidal and eco system and the flooding threat.

Inspired by ancient armor, the design aims to create a scalable resilient building system that respond to the rise and fall of the water and floods.

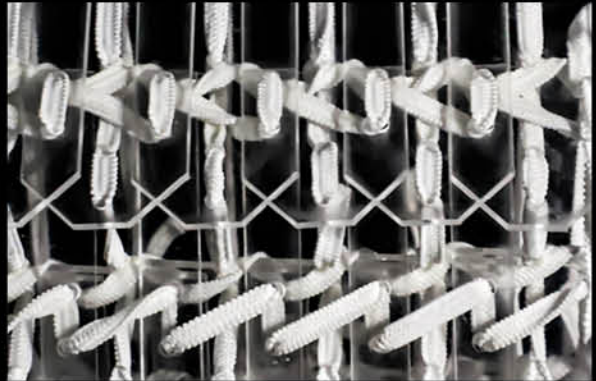
The incorporation of smart technologies, including generative design, as well as artificial intelligence and robotic construction, allows the system to be realized at sea and adapt to the changing ocean currents. The system also integrates dynamic elements, such as flexible nodes and movement building elements, creating a responsive system to changes in the water condition.

The system is capable of being placed in diverse situations. For example, it can be used as a place for recreation and activities, such as a landscaped park. The suspended modules capture tidal energy and generate electricity through turbine generators. In case of emergency, it can also provide inflatable shelters. This demonstrates the design's potential for a wide range of applications in complex dynamic environments.

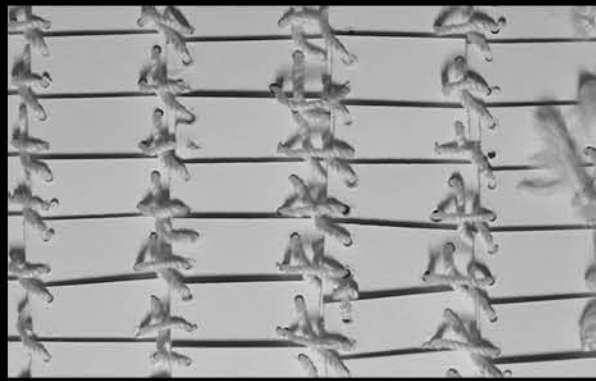




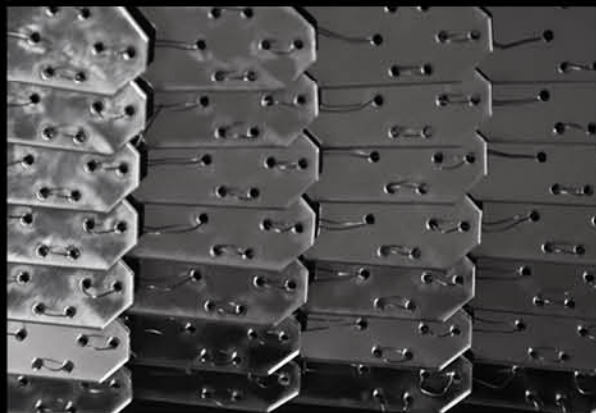
Transparent scales + non-elastic rope



Transparent scales + elastic rope

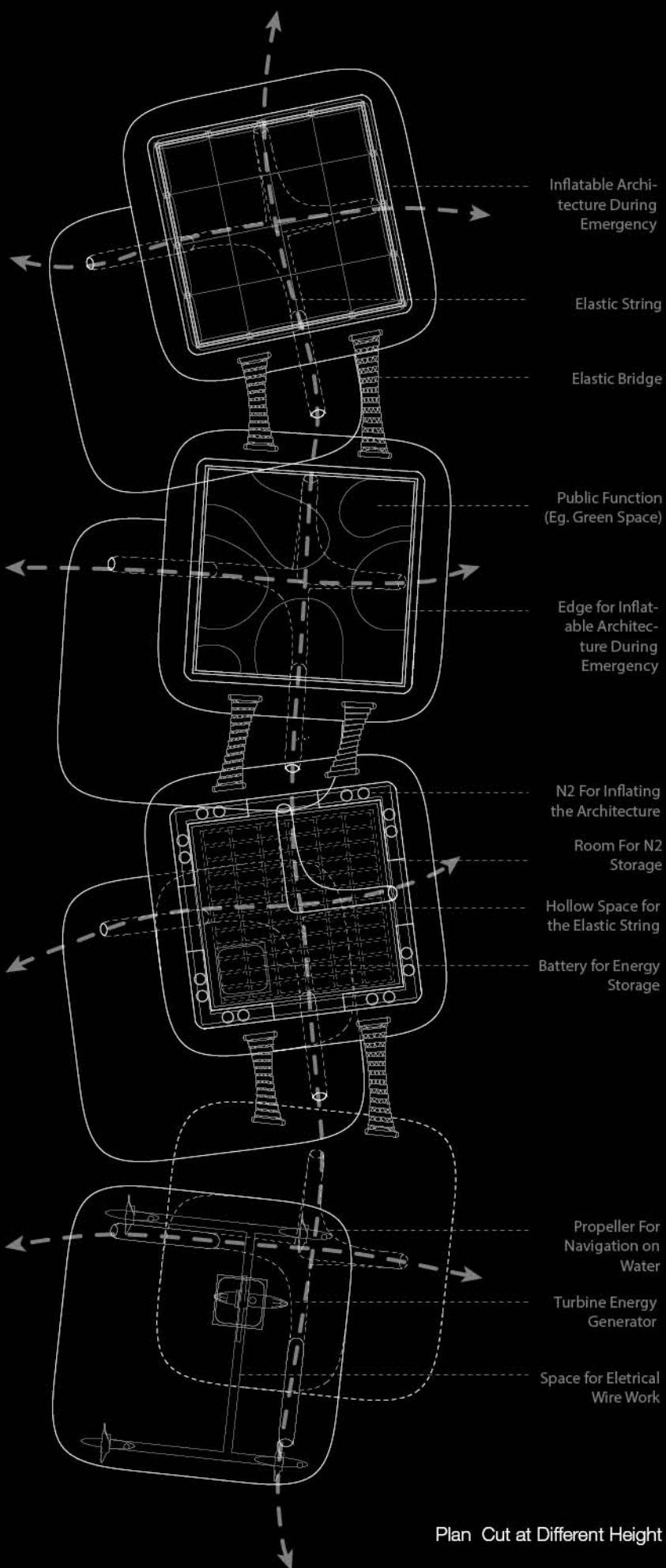


Opaque, non-reflective scales + non-elastic rope

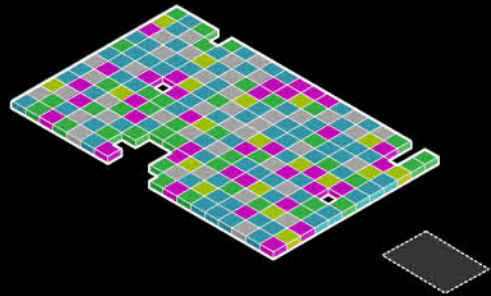


Reflective scales + steel cable

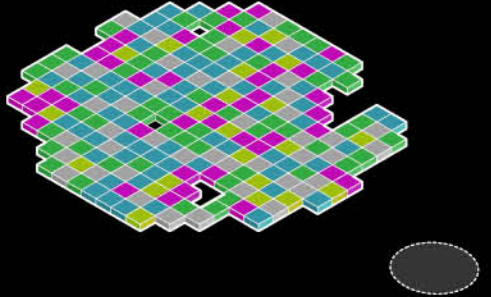
Model - Armor - Material Register System



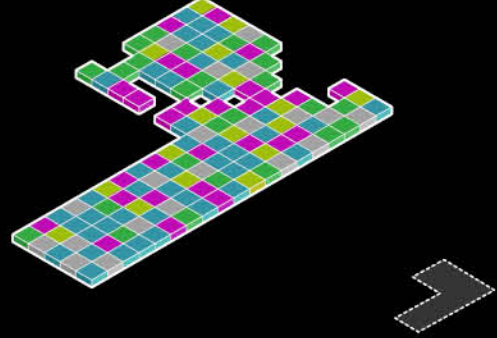
Plan Cut at Different Height



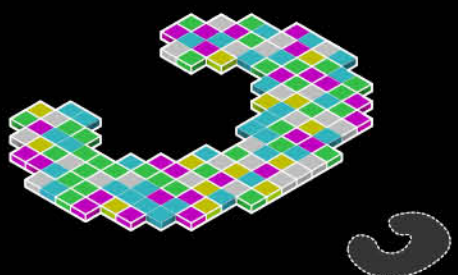
Seed 77 Qty 240



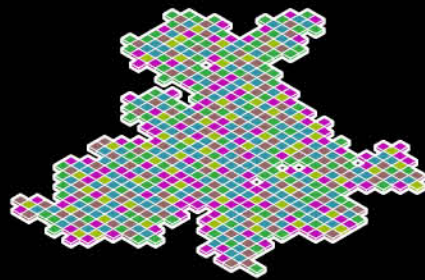
Seed 68 Qty 235



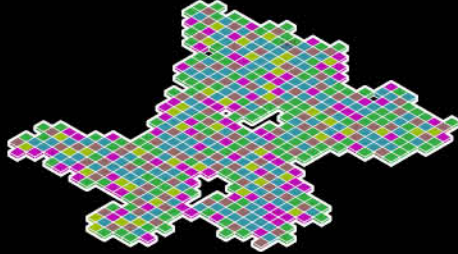
Seed 87 Qty 137



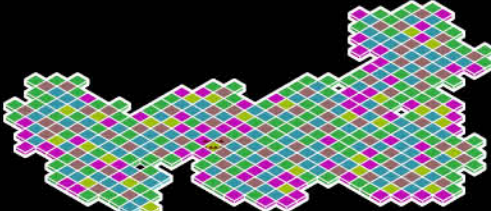
Seed 90 Qty 168



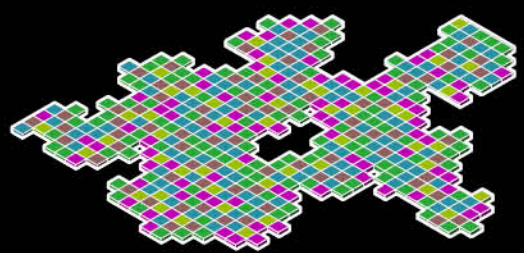
Seed 104 Qty 765



Seed 98 Qty 623

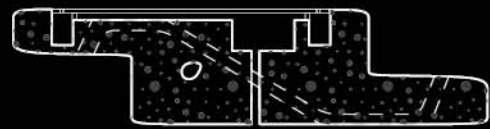


Seed 73 Qty 525



Seed 63 Qty 458

Layout Generation



100' Module



15' Module



Elastic Ropes



AI Unit



Distributed Robots



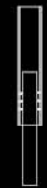
Cloud Communicator



GPS



Sensor



Sliding Rail System



Ball Joint Connection



Spring System



Propeller



Hydraulic System



Turbine Energy Generator



Inflatable Architecture



1st Round Inflating Package



2nd Round Inflating Package



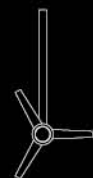
Energy Battery



Elastic Inflatable pack



Sliding Rail



Turbine Energy Generator

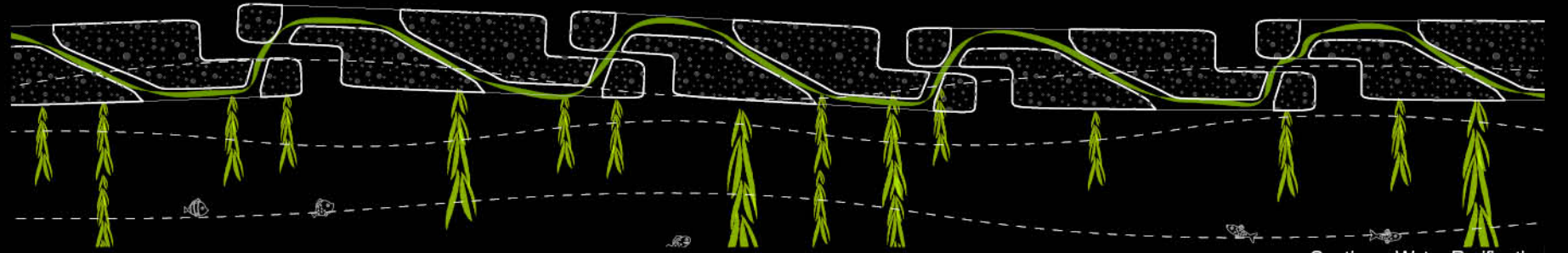


Nitrogen Liquid

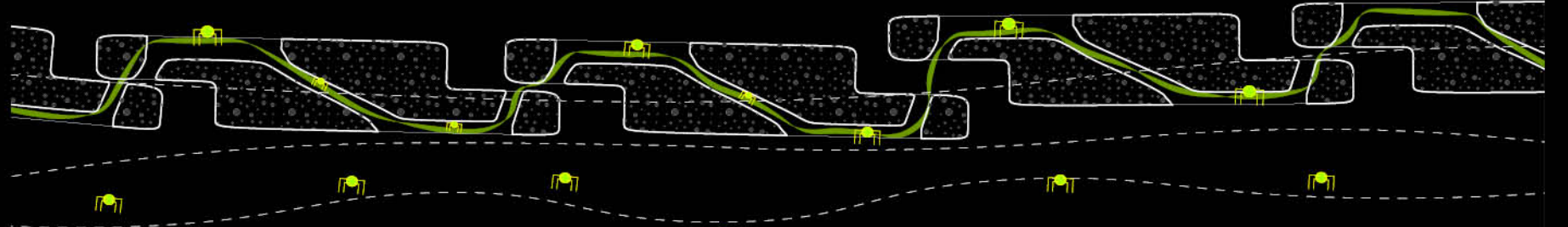


Elastic Bridge

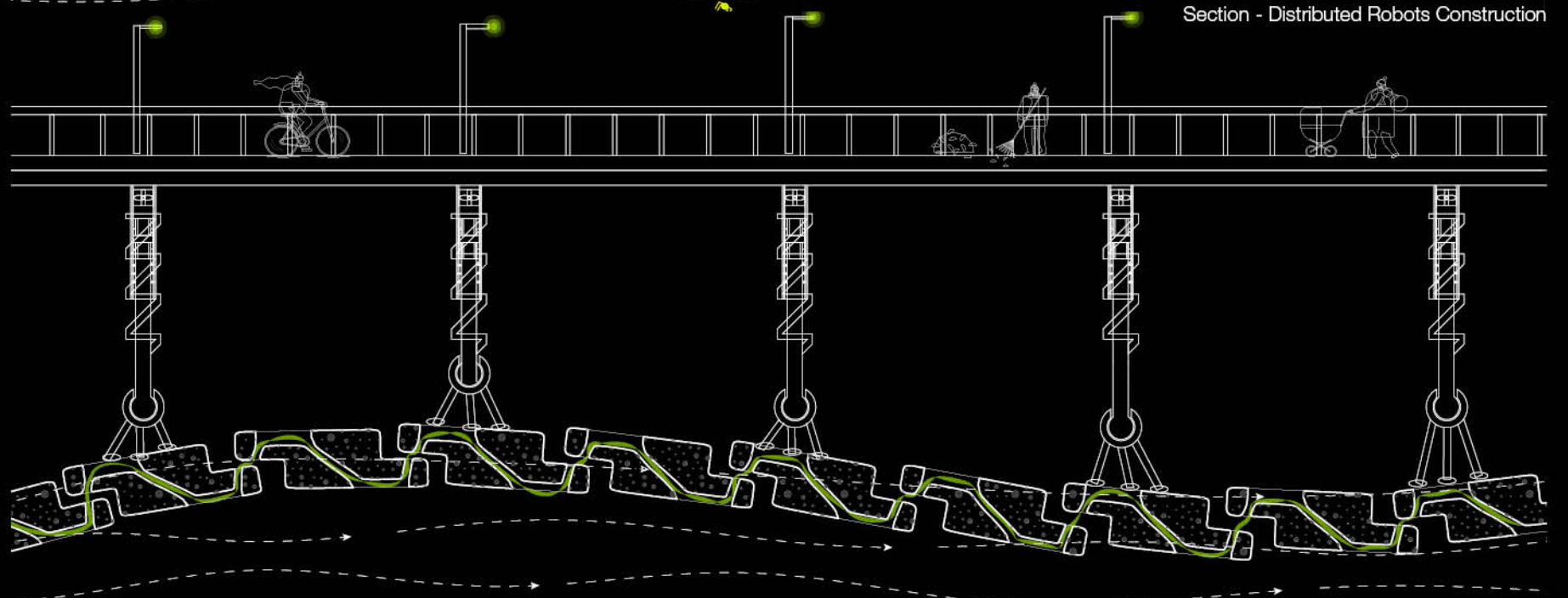
Design Part for Intelligent and Resilient System



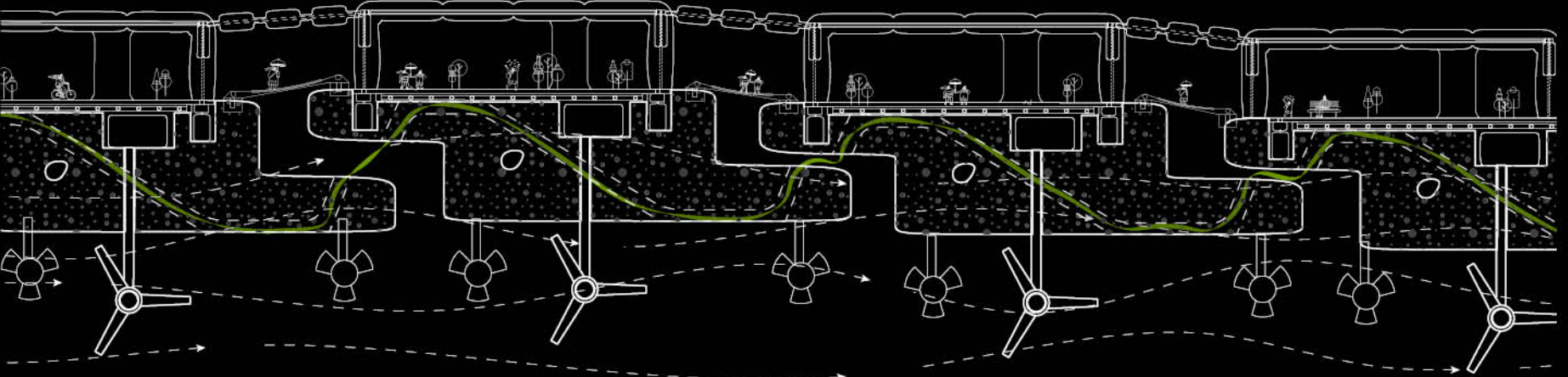
Section - Water Purification



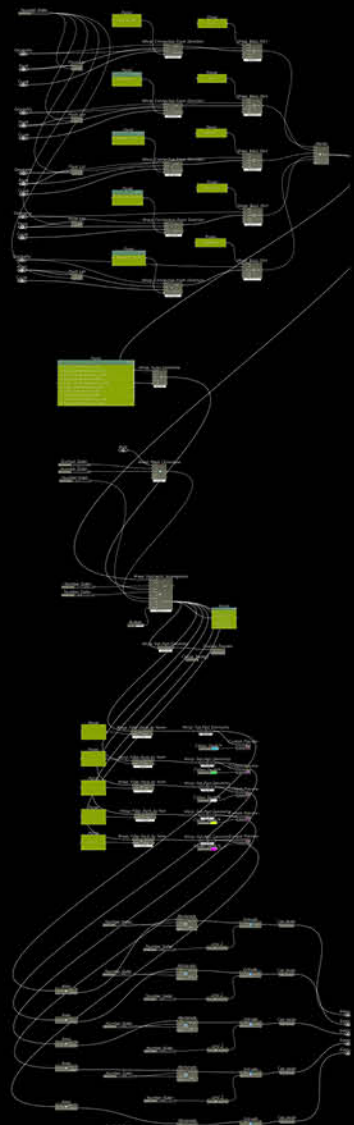
Section - Distributed Robots Construction



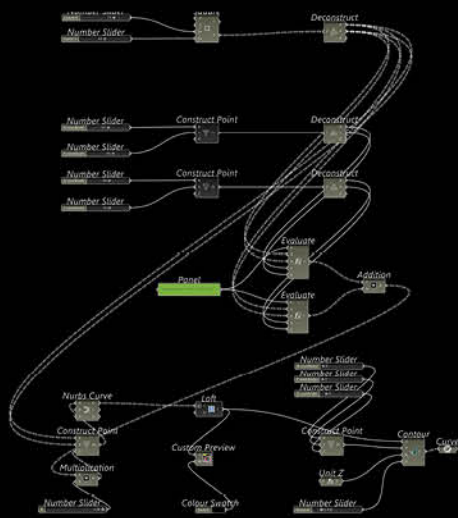
Section - Self - Stable Platform and Dynamic Water Adaptation



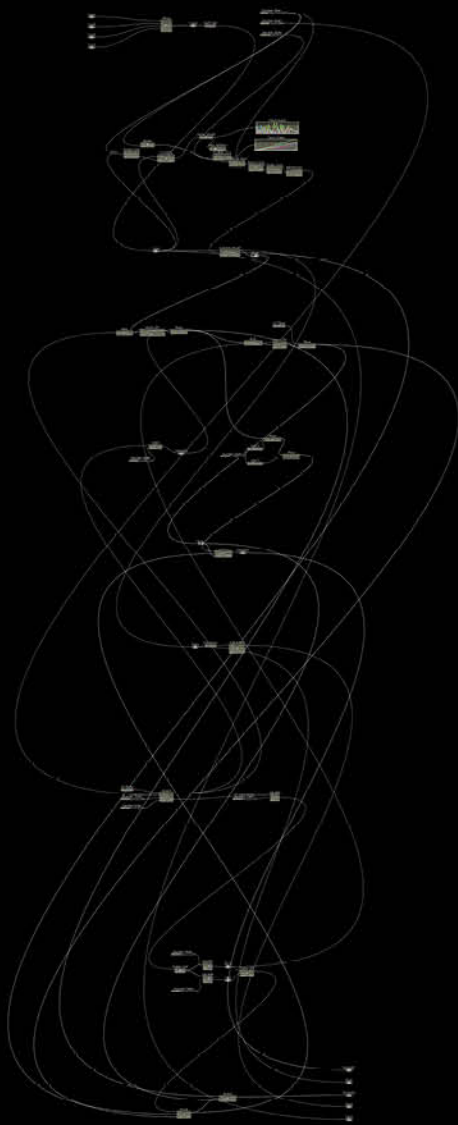
Section - Emergency Scenario - Inflatable Architecture & Energy Generation



Automated Layout System



Water Intervention Simulation System



River Current Flow Simulation



Automated Drawing System

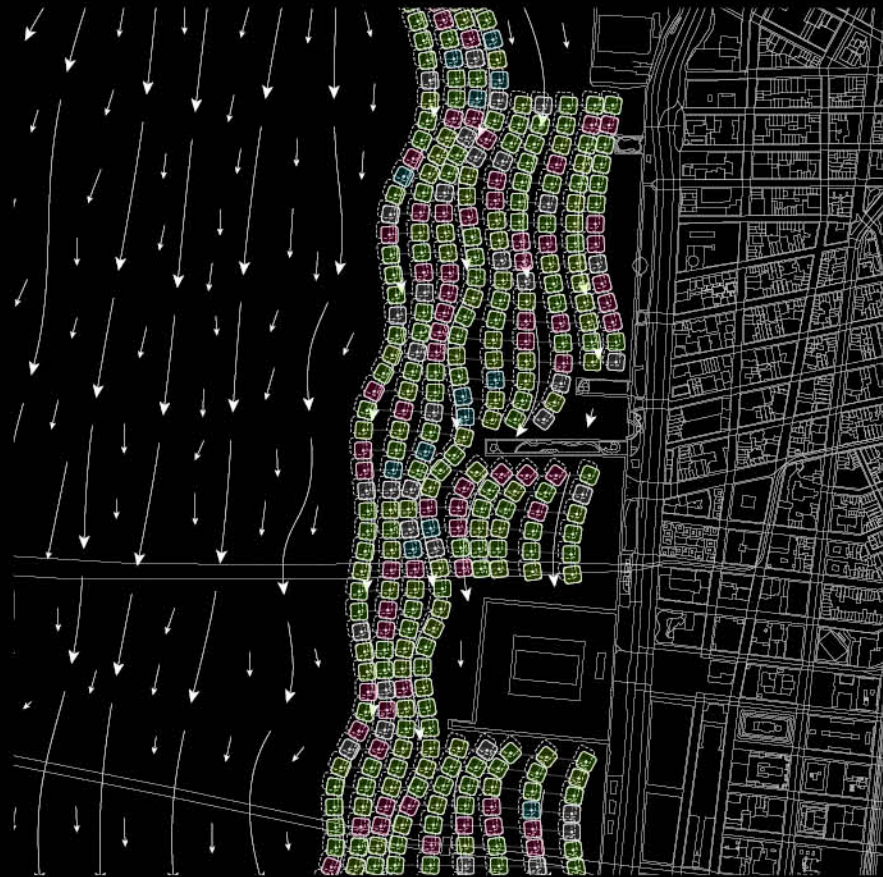
Adaptive System Development in Grasshopper



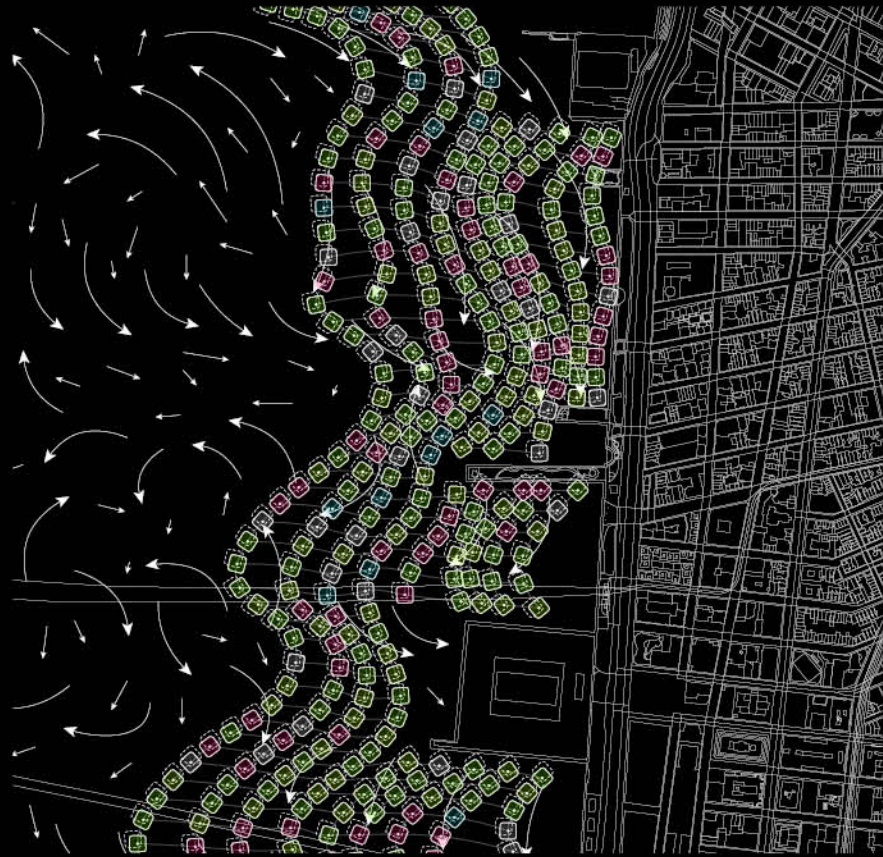
Nov 23, 2023 11:00-12:00



Nov 19, 2023 15:00-16:00



Nov 23, 2023 1:00-2:00



Nov 23, 2023 16:00-17:00

Plan - Adaptive System to Water Flow

SYMVEIL

HOUSING AS A THEATER TO CATALYZE LIFE (HOUSING PROTOTYPE)

Core Studio III

Critic: Eric Bunge

Autumn 2024, GSAPP

Team: Yunhao Zhong and Tsz Tung Kwong

Role: Conceptual, formal, programmatic, light, modeling,
drawing development

HIGH PASS

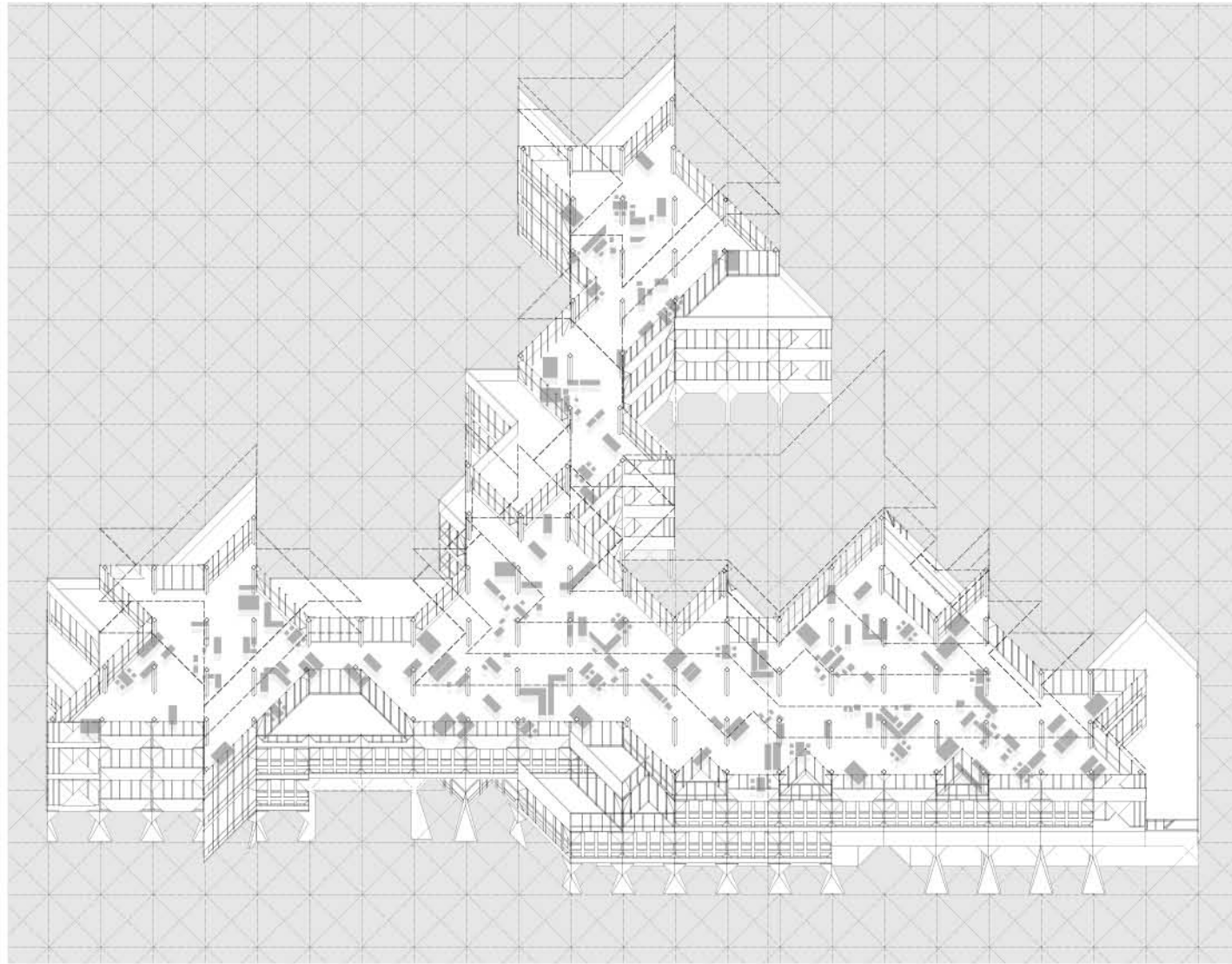
This project reimagines housing as a living ecosystem that nurtures collective life. Inspired by the Wood Wide Web, it centers on a vertical core as the trunk, with branching connectors replacing traditional corridors. These connectors are more than circulation—they become spaces for gardening, play, performance, and gathering. Movement becomes interaction, and architecture becomes stage.

Located in Harlem, the design draws from the area's rich artistic legacy. Three large public portals cut through the building, inviting the city inward and connecting to an interior civic spine—a continuous street linking ground-level programs like shops, studios, and planting zones with residential life above. This interface weaves together urban and domestic scales.

Housing units are arranged in slim sections to optimize light and airflow. Access occurs via open-air connectors on the third and sixth floors, eliminating enclosed corridors. These bridges vary in function—some become lounges, others gardens or theaters—encouraging interaction and healthy circulation.

As residents move through the building, they witness or participate in daily life unfolding across levels. These overlapping views create a “vertical theater” where community life is visible and shared. In this vision, housing becomes not just a place to live, but a spatial framework for belonging, resilience, and connection.

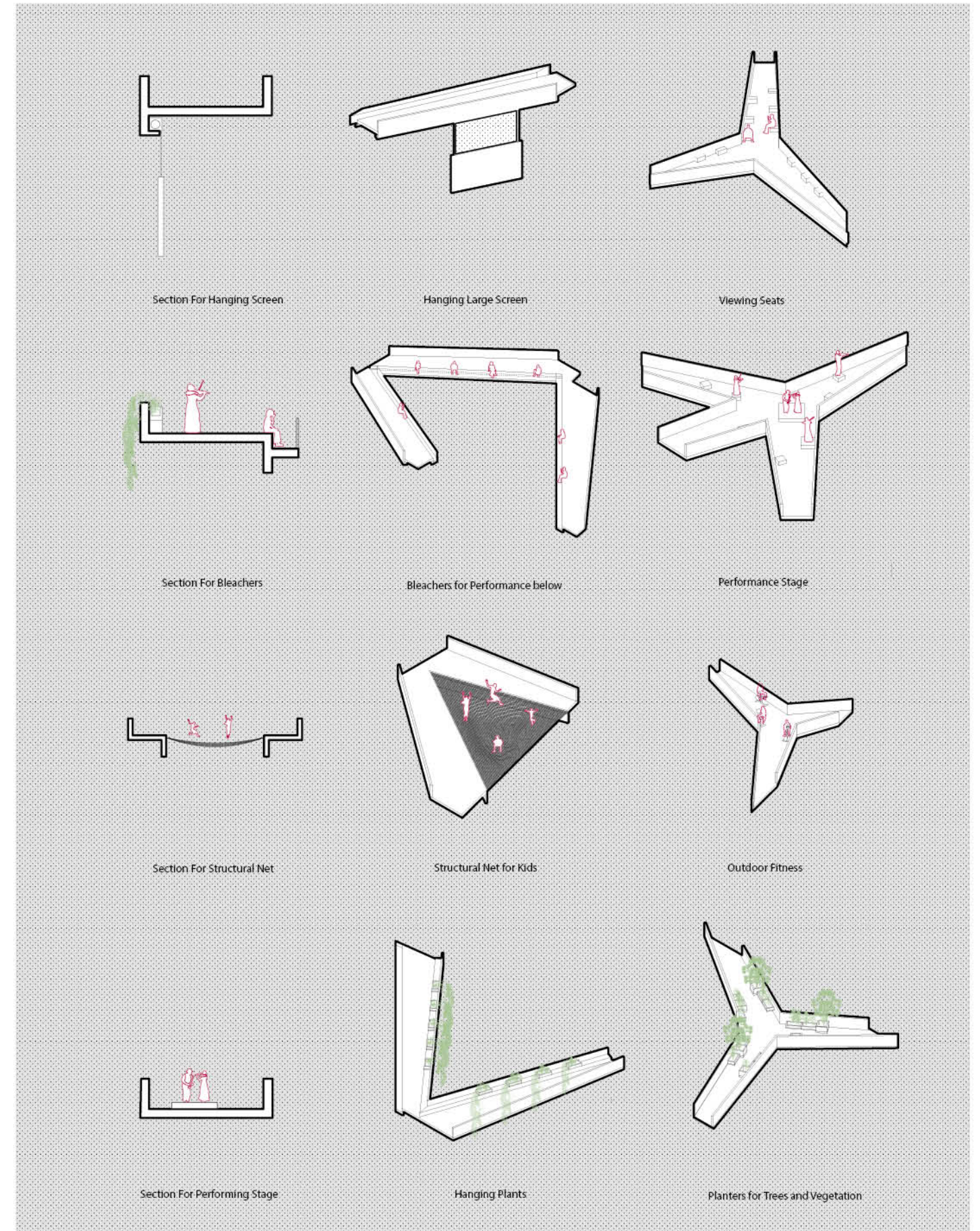




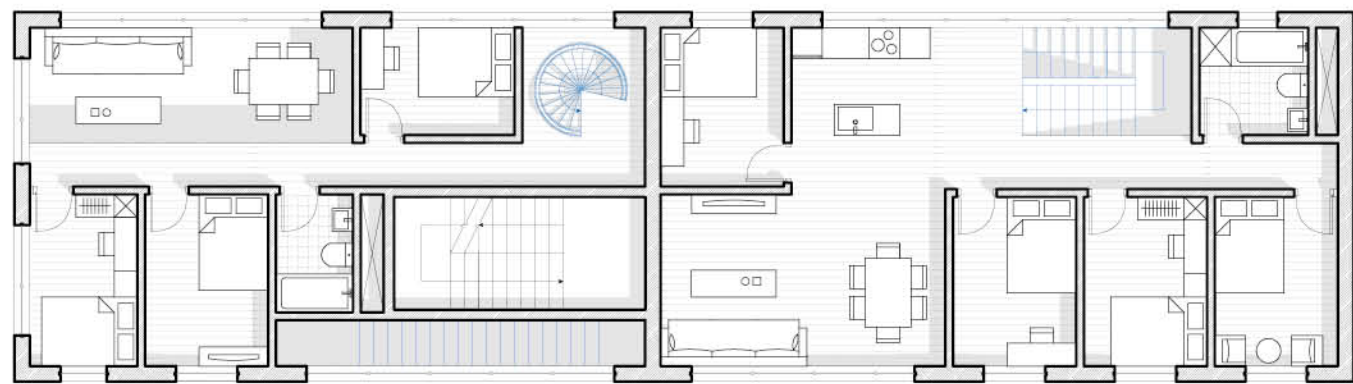
Reinterpretation of the Project Les Étoiles – Plan Oblique

Les Étoiles, Ivry-sur-Seine, by Jean Renaudie and Renée Gailhoustet, challenges the uniformity of public housing by blending individuality with community. My drawing shows how each apartment is formally distinct yet fits into a cohesive whole, where shared rules coexist with personal expression. This was part of my early research for the SymVeil project and was publicly presented by Eric Bunge (nARCHITECTS) in the Drawing Project lecture.

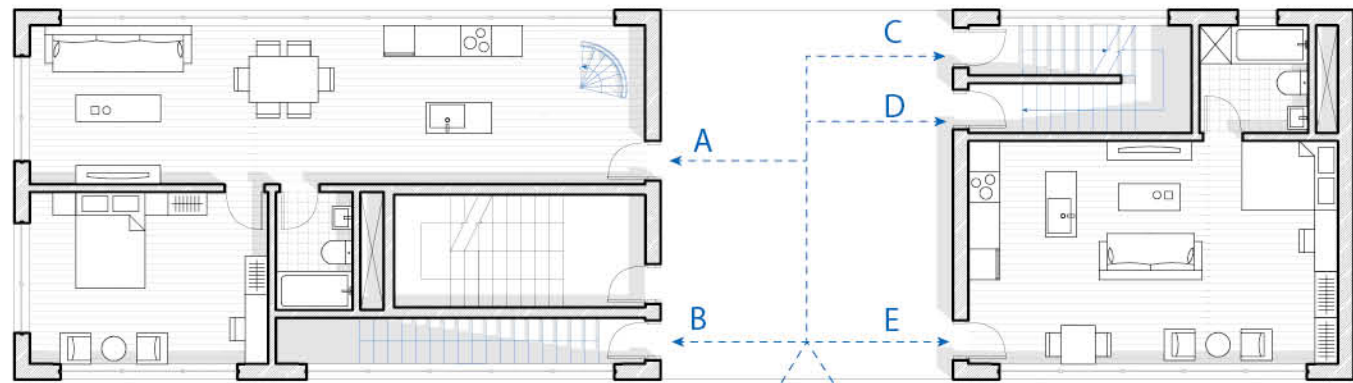
This evolved into a broader design inquiry on the relationship between housing and life. In our project, we envisioned housing as a stage—a space where everyday life is performed. At the scale of architectural elements, we introduced a series of connectors with distinct forms. These connectors became spatial instruments through which people could express and enact their own ways of living.



Different Connector Types: Housing as Theater at the Elemental Scale



Typical Plan on 4th and 7th Floors

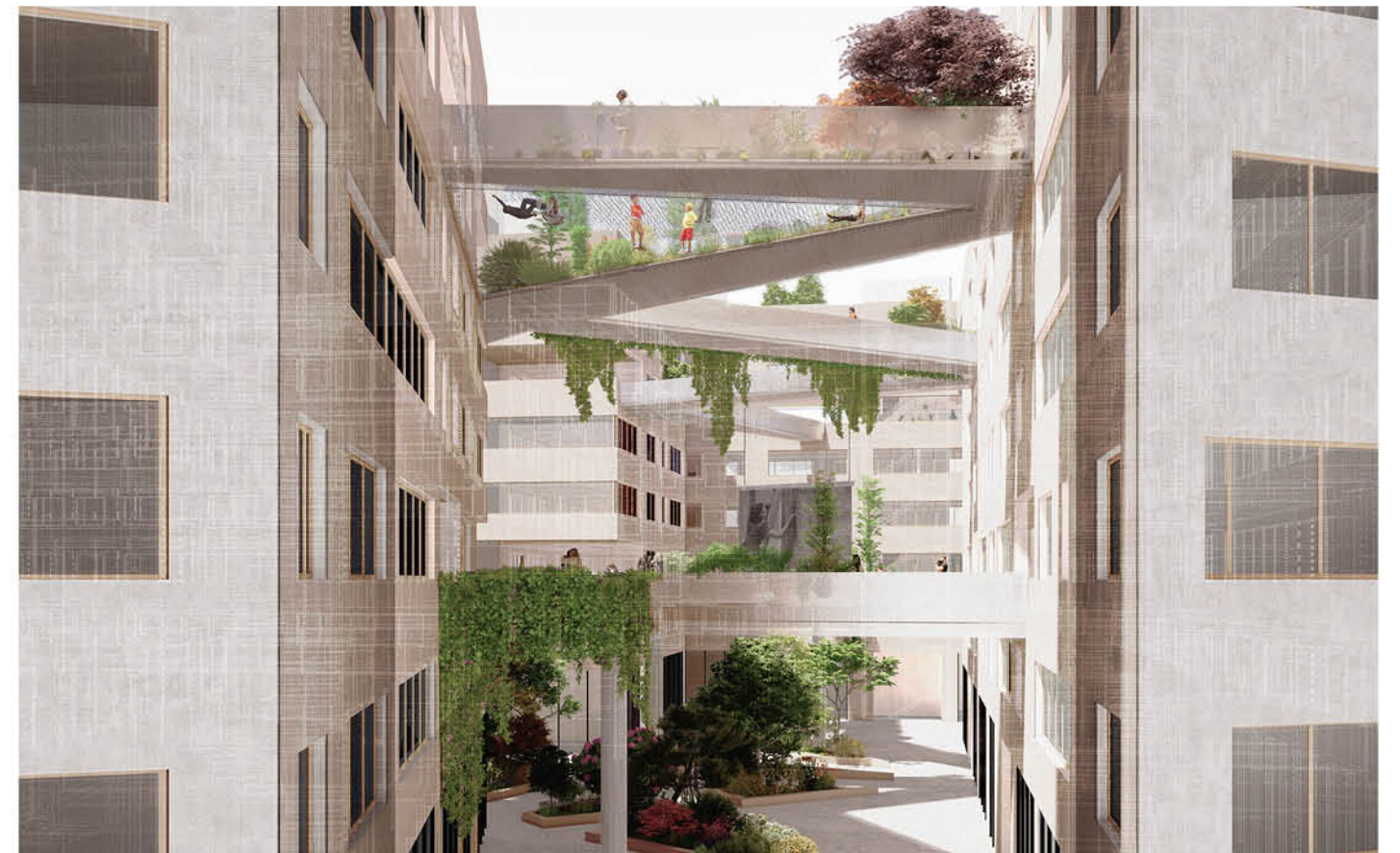


Typical Plan on 3rd and 6th Floors

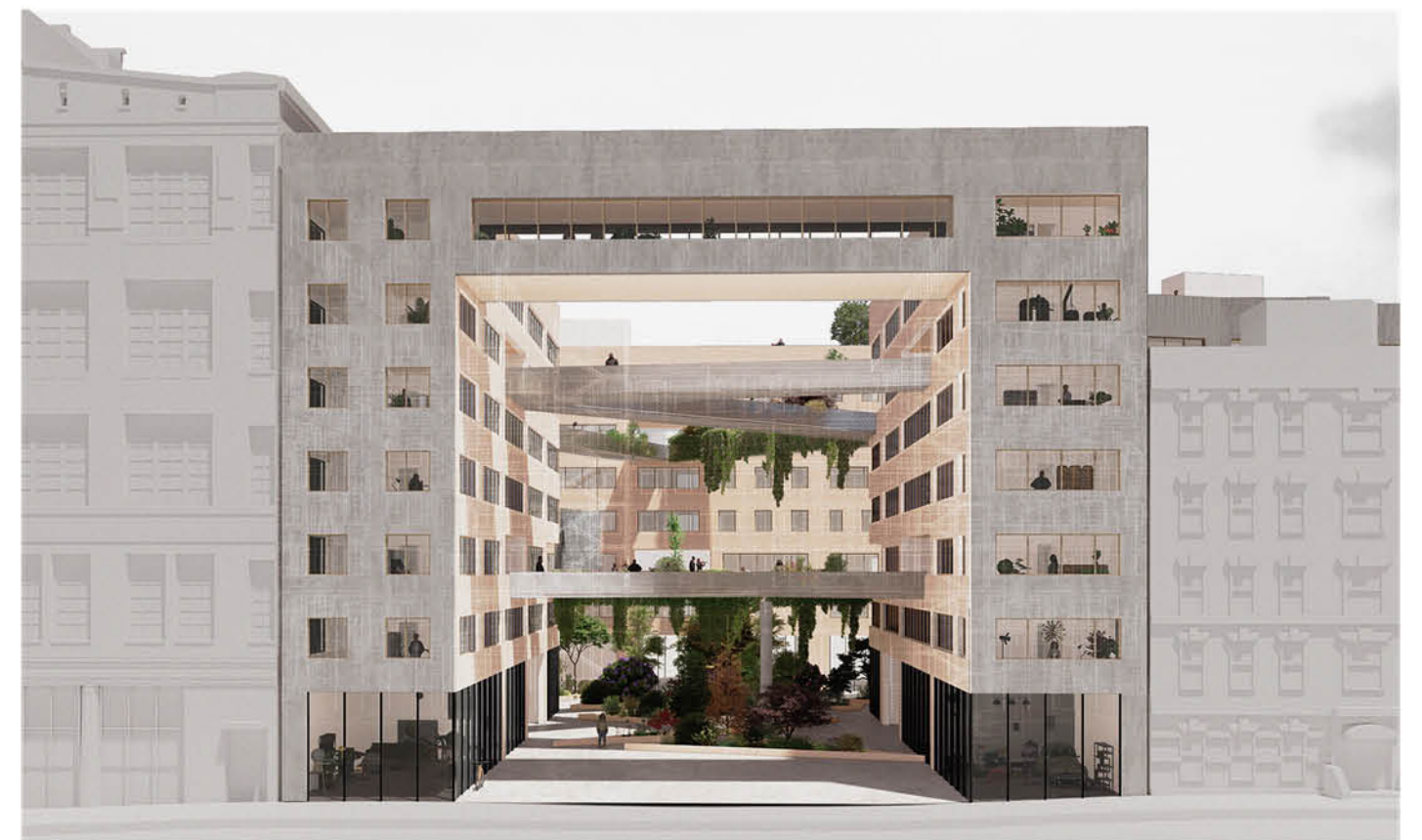


Typical Plan on 2nd and 5th Floors

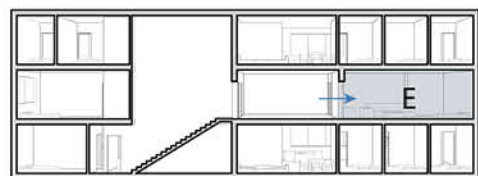
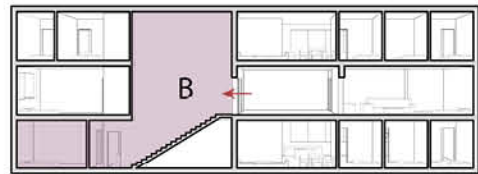
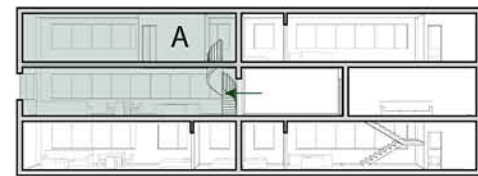
The connectors support communal activities like outdoor screenings, gardening, and play, turning circulation into shared, multifunctional spaces. Rather than mere passageways, they act as spatial anchors that foster interaction across levels. Each leads to a public node connected directly to various apartment types. Without traditional corridors, the housing mass becomes thinner and more porous, improving light, ventilation, and spatial flow.



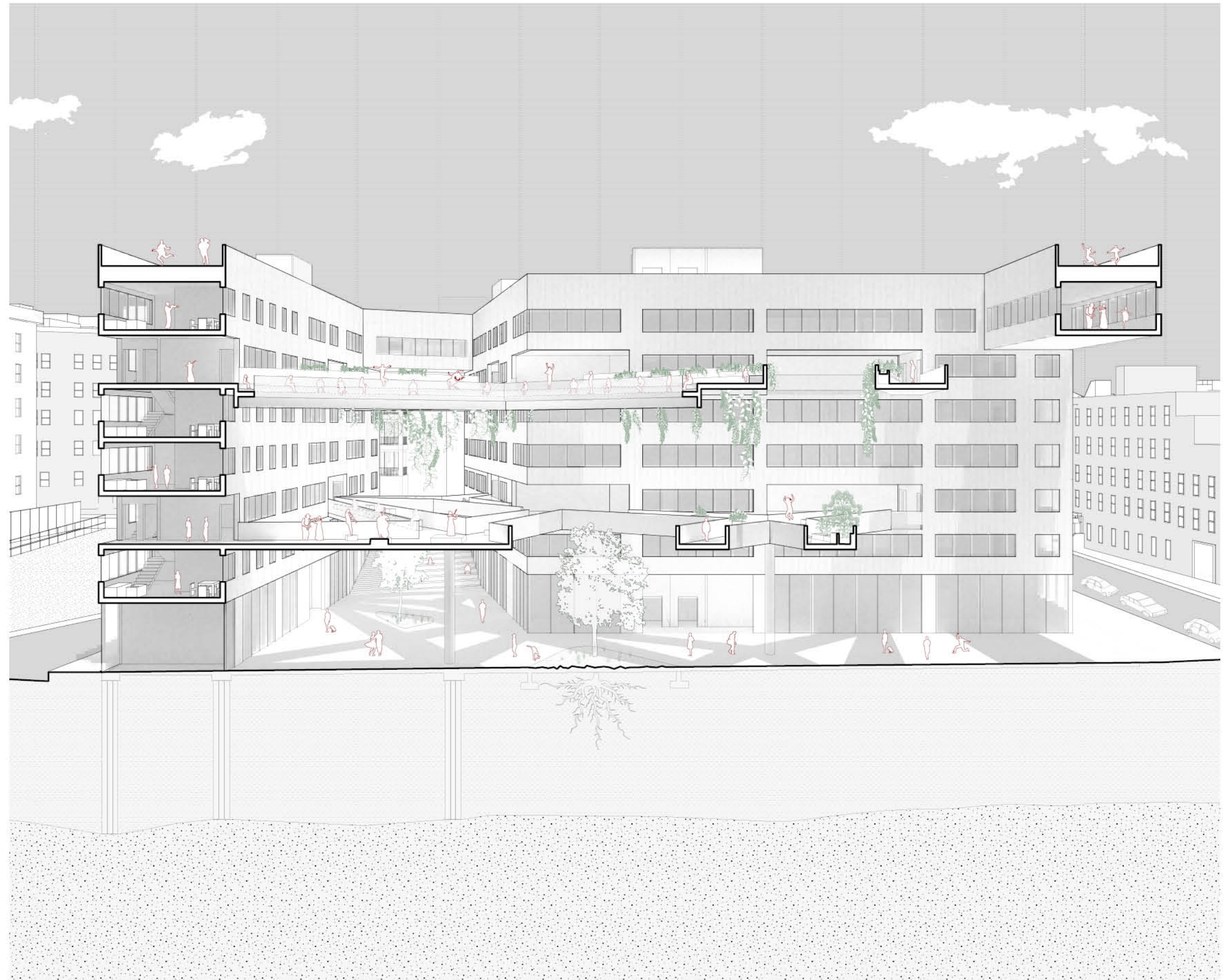
Exterior Perspective | Interior Street of Housing | Looking from East Entrance to West



Exterior Perspective | Interior Street of Housing | Looking from South Entrance to North

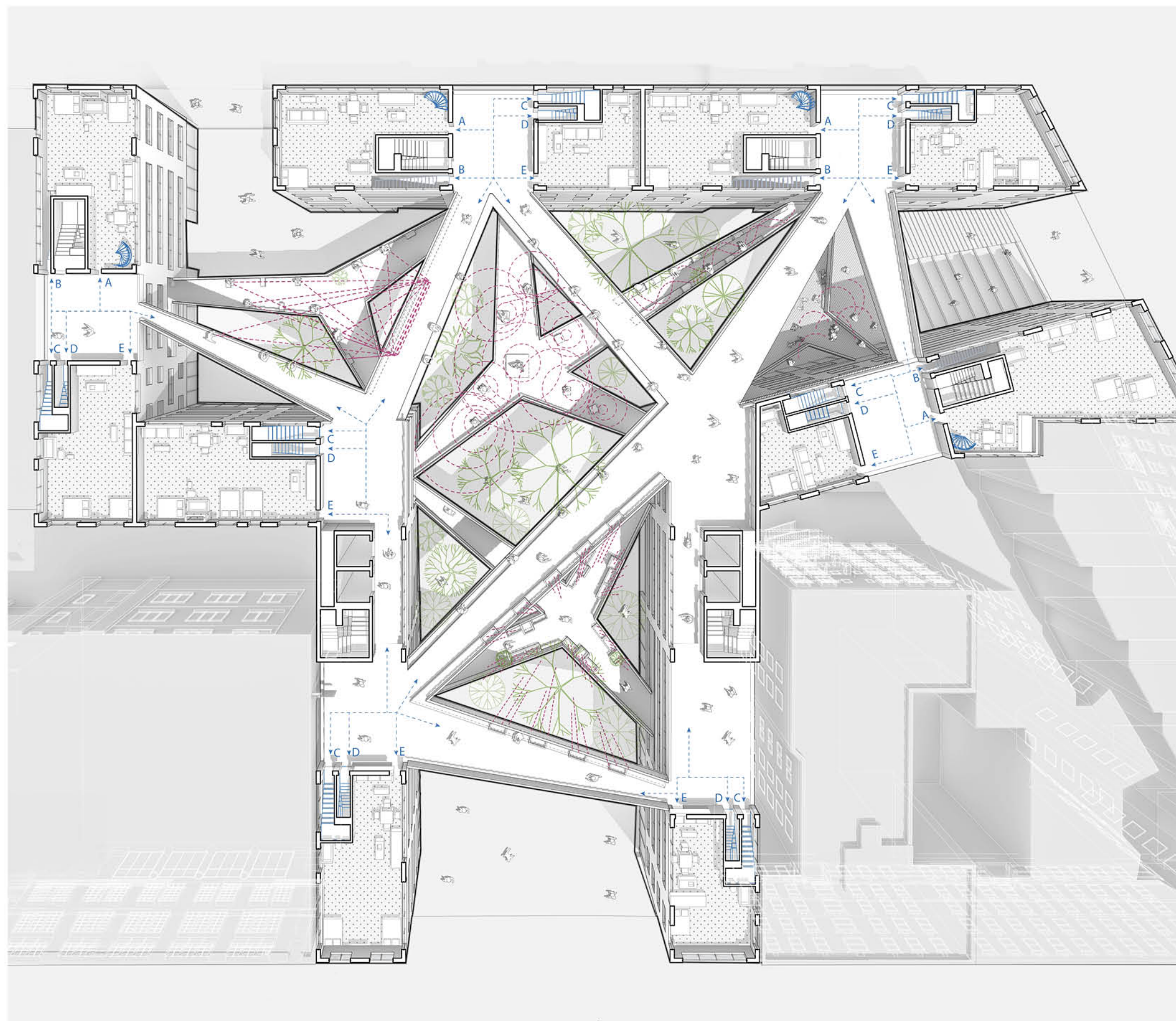


Residents access their homes through these nodes, entering single-floor units, duplexes, or triplexes without passing through enclosed hallways—making daily life more open, social, and performative.





In our vision, housing becomes a stage for daily life. Circulation becomes performance, and interaction forms a shared spatial story. Residents both observe and participate, blurring private routines with communal expression. Architecture, in this way, choreographs connection and turns everyday life into a living theater.



THRONE 30

COMPUTATIONAL BIM DELIVERY WORKFLOW

Re-thinking BIM

Computation

Critic: Joe Brennan

Autumn 2025, GSAPP

Team: Yunhao Zhong, Tommy Wang, Mia Miao, Judy Zhu.

Role: Led computation in of BIM4REAL Team.

Adapted and extended studio starter scripts for zoning, structure, and facade. Expanded the structural system beyond the base column-beam setup and upgraded the facade family to 5-point adaptive family. Authored original view + wind analysis scripts and diagrams. Post-review, reauthored all portfolio drawings and renderings and substantially rebuilt the Revit model (dual-core revision, reworked program and circulation).

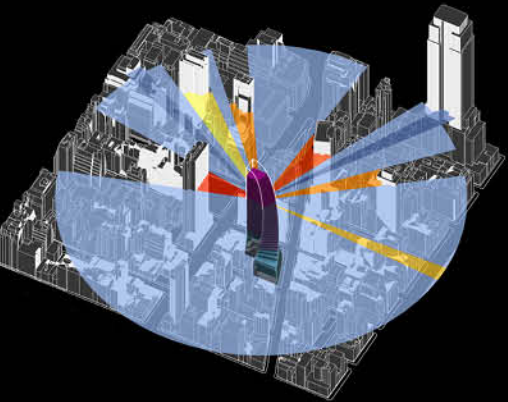
HIGH PASS

Throne 30 is a simulation-driven mixed-use tower for a NoMad neighborhood in transition, rising at 30th Street within parametrically verified zoning constraints of the M1-8A/R12 envelope. A three-story retail podium extends Broadway's public energy into the base, while eight floors of Class A office space form a high-end workplace calibrated for single-tenant use today and multi-tenant flexibility tomorrow, defined by controlled arrival, shared view lounges, and quiet focus edges. Above, thirty-four residential floors rise as a slender volume carefully tuned to sightlines, privacy, and comfort, positioning the tower as both an urban marker and a data-informed vertical environment

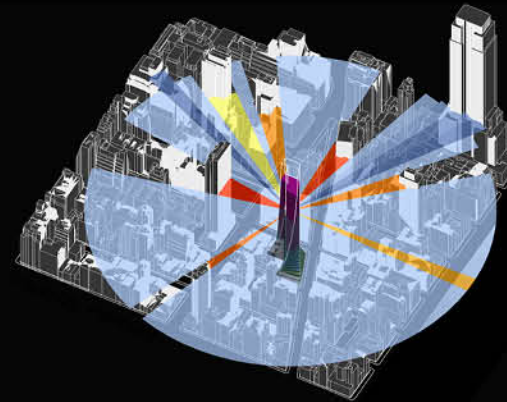
View and wind simulations are treated as primary generative drivers rather than post-rationalized checks. Iterative CFD analysis in OpenFOAM informed a rotated parallelogram massing that redirects view vectors away from western obstructions while minimizing wind exposure. A continuous north-facing curve becomes the project's defining gesture, generated through Grasshopper optimization to carve terraces oriented toward the Empire State Building. Zoning, structure, facade, and floor slabs are parametrically generated in Grasshopper and pushed to Revit, enabling rapid iteration without sacrificing rigor. A five-point adaptive facade family modulates transparency and solidity by program, opening the commercial base and tightening where privacy and acoustic control are critical. Throne 30 positions computation as a bridge between urban constraint, architectural expression, and BIM-ready delivery



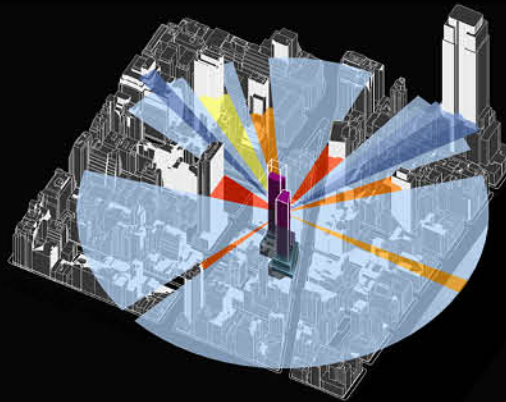
PANORAMIC VIEW ANALYSIS VIA GRASSHOPPER



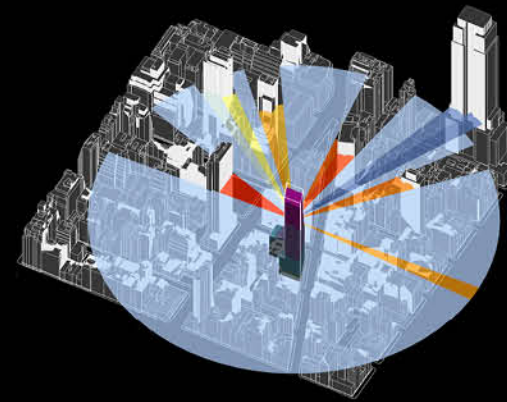
Option 01 | South-Facing Curved Massing



Option 02 | Spiral Tower Massing



Option 03 | Twin-Tower Massing

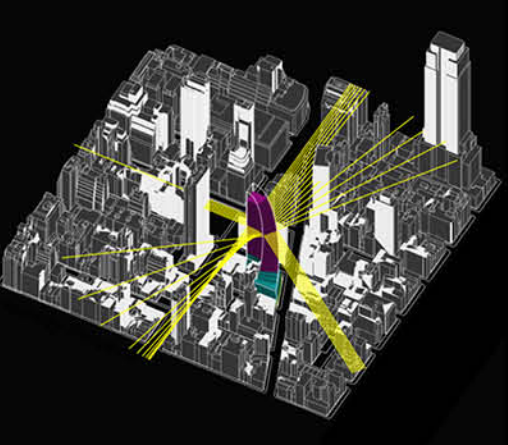


Option 04 | North-Facing Curved Massing

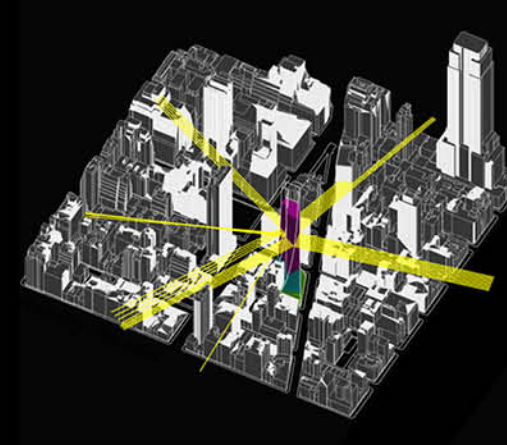
Reveals severe west-side residential obstruction to primary view corridors.



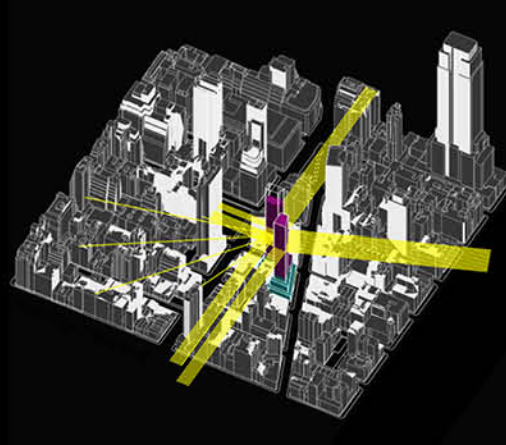
DIRECTED VIEW VECTOR ANALYSIS VIA GRASSHOPPER



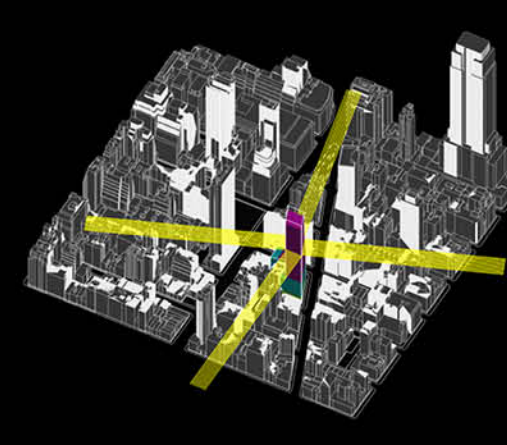
Option 01 | South-Facing Curved Massing



Option 02 | Spiral Tower Massing



Option 03 | Twin-Tower Massing

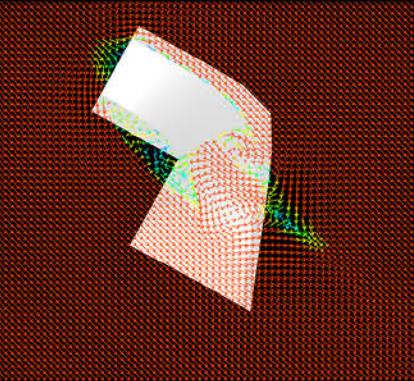


Option 04 | North-Facing Curved Massing

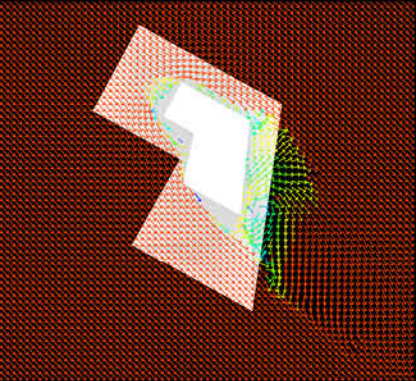
Façade orientation avoids direct visual exposure to opposing buildings.



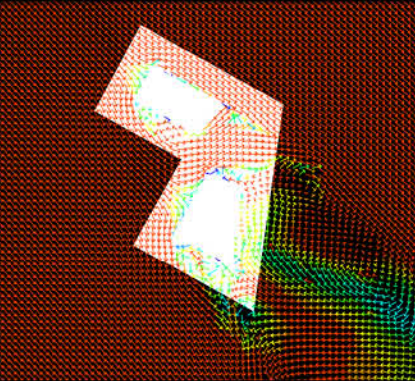
CFD WIND ANALYSIS - EDDY3D



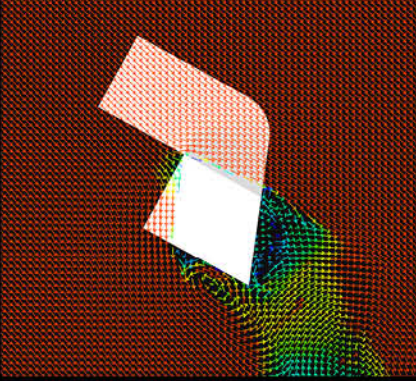
Option 01 | South-Facing Curved Massing



Option 02 | Spiral Tower Massing

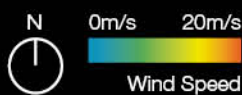


Option 03 | Twin-Tower Massing

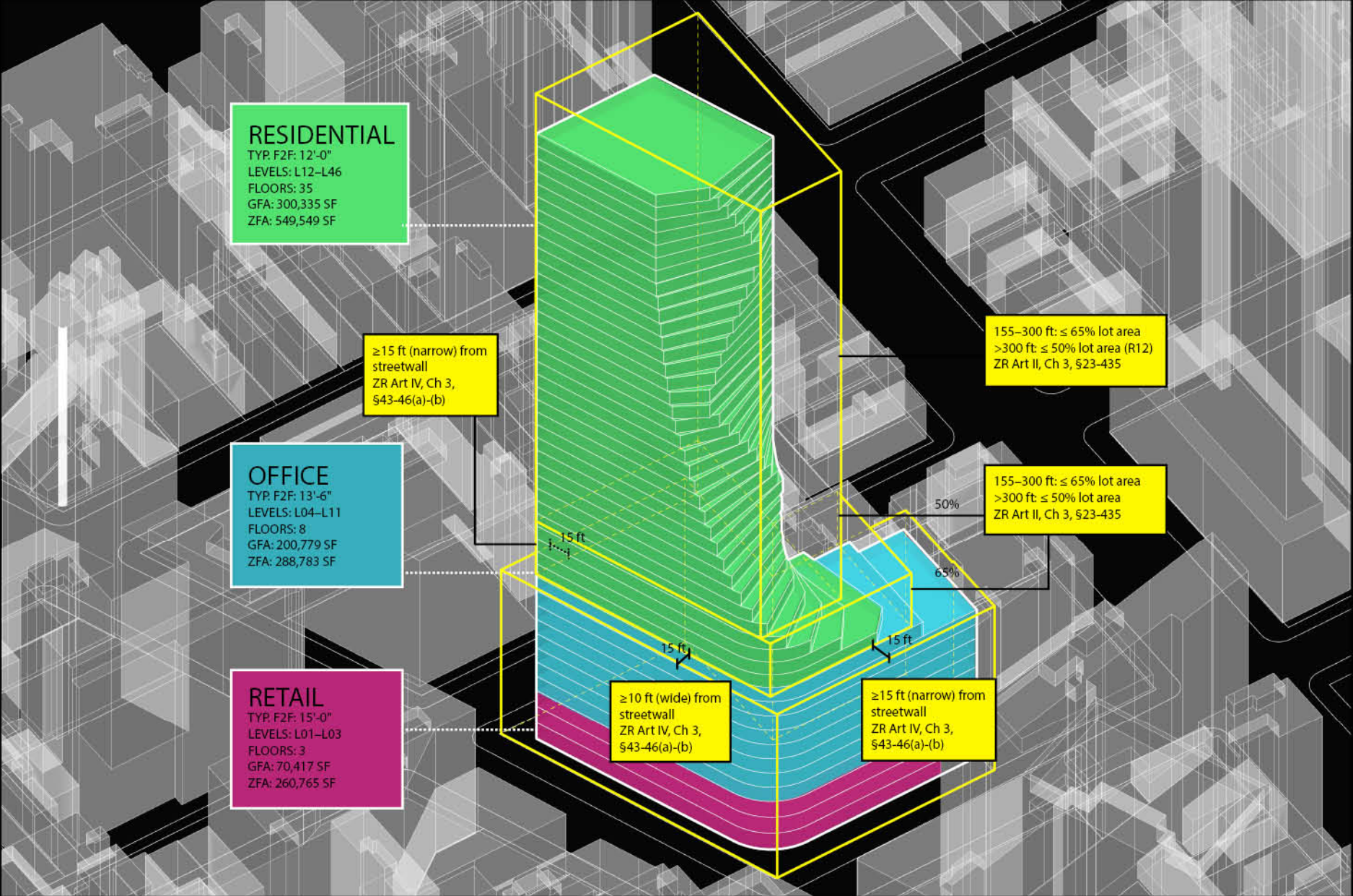


Option 04 | North-Facing Curved Massing

Parallelogram massing reduces wind resistance through streamlined geometry.

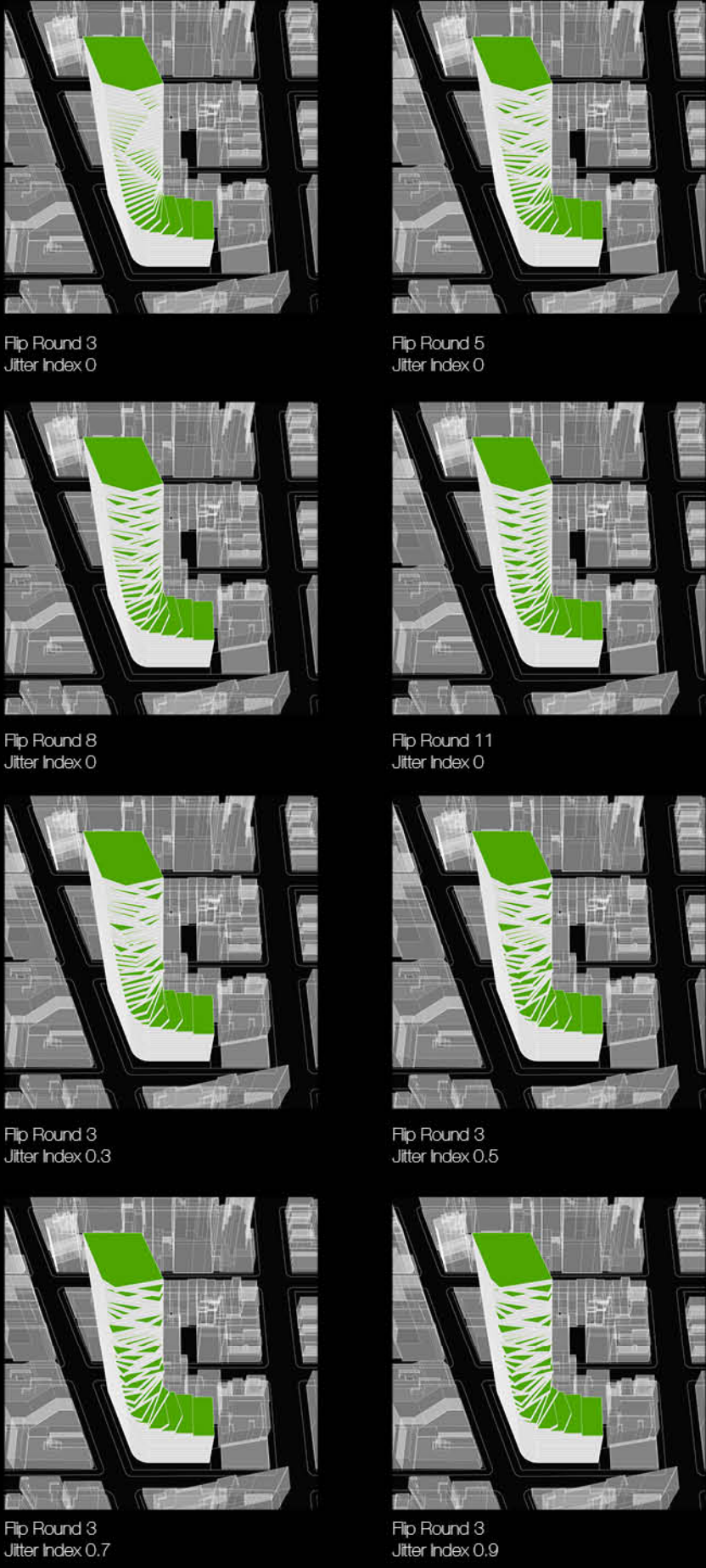


ZONING ANALYSIS

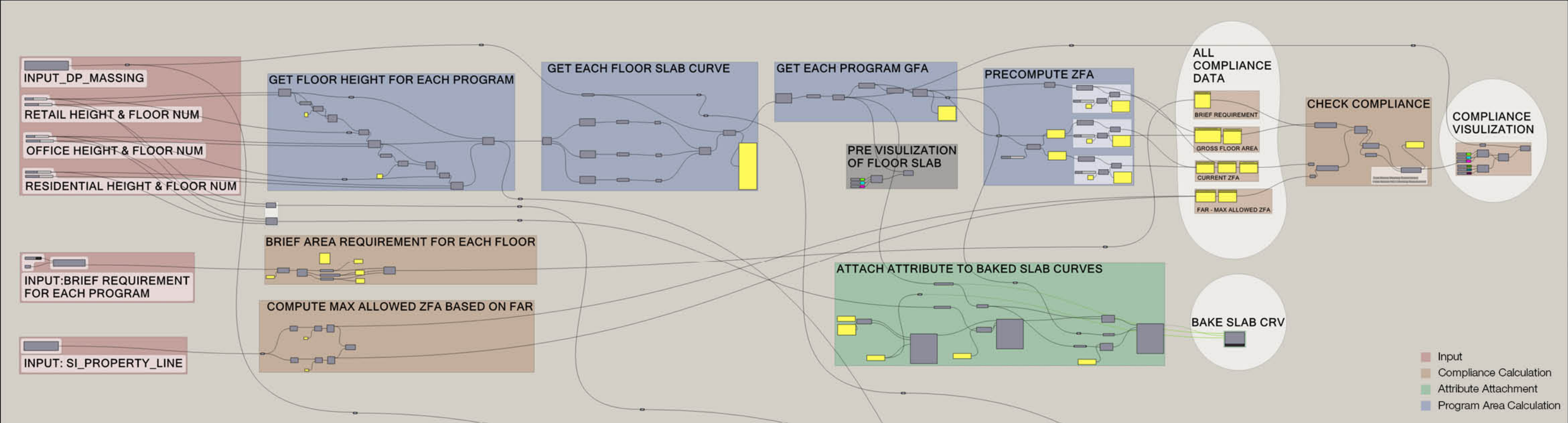


CHECK	ZONING REF	REQUIREMENT	PROPOSAL	STATUS	CHECK	ZONING REF	REQUIREMENT	PROPOSAL	STATUS
Program Targets	Brief (program)	Retail 60-90k; Office/Manuf 200-250k+; Res 200-250k+; Total 540k+	GFA: Retail 70,417; Office 200,779; Res 300,335; Total 571,531	PASS	Use stacking (res above non-res)	ZR Art XII, Ch 3, §123-31	Commercial/manuf only below lowest story with dwelling units	Retail L01-L03; Office L04-L11; Res L12-L46	PASS
FAR caps (by use)	ZR Article IV, Ch.3, §43-132 ZR Article II, Ch.3, §23-22 (R12) (M1-8A)	M1-8A max FAR 12.0 R12 res FAR 18.0 (qualifying affordable)	Comm ZFA 260,765 (8.52 FAR); Res ZFA 288,783 (9.43 FAR)	PASS	Base height + required setback above	ZR Art IV, Ch 3, §43-46(a)-(b)	M1-8A max base height 155 ft; above base height setback ≥10 ft (wide) / ≥15 ft (narrow) from streetwall	Within Coverage Envelop	PASS
Total ZFA cap (mixed use)	ZR Article XII, Ch.3, §123-623(a)(4)	Mixed-use total floor area ≤ allowed floor area largest type	Total ZFA 549,549. 18 FAR cap: Max = 550,962	PASS	Tower coverage	ZR Art II, Ch 3, §23-435 ZR Art IV, Ch 3, §43-46(c)	155-300 ft: ≤ 65% lot area >300 ft: ≤ 50% lot area (R12) Portion above 350 ft: max lot coverage 50% (M1-8A)	Within Coverage Envelop	PASS

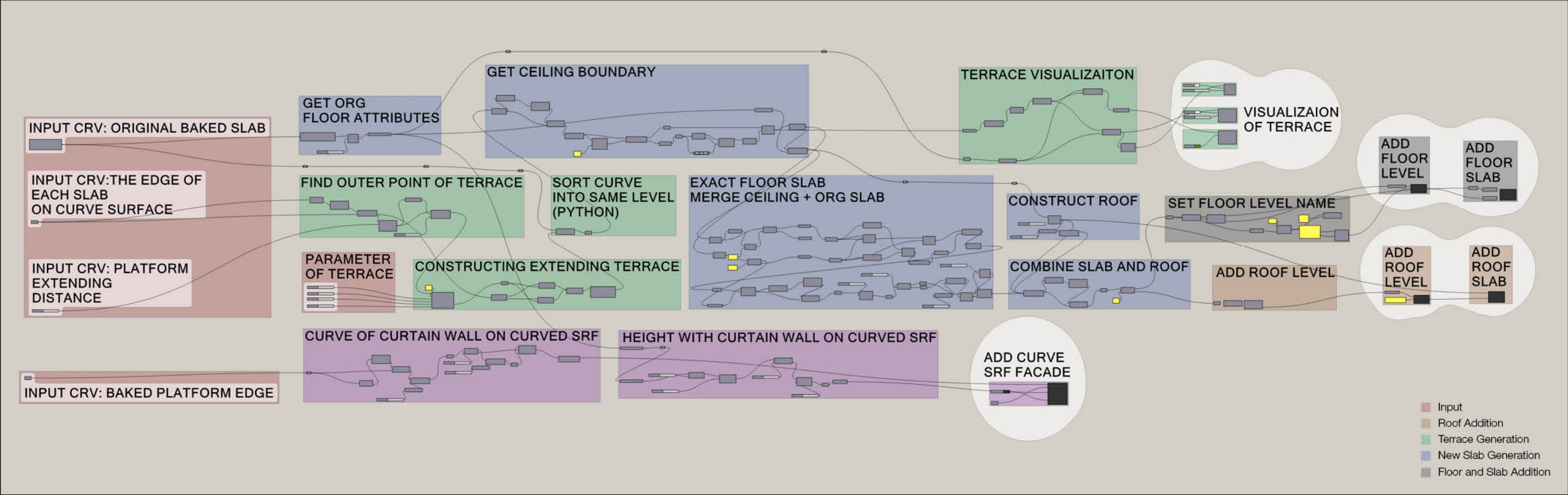
TERRACE GENERATIVE DESIGN



EXTRACTED MASSING AREAS, CALCULATED NET METRICS, VERIFIED COMPLIANCE.



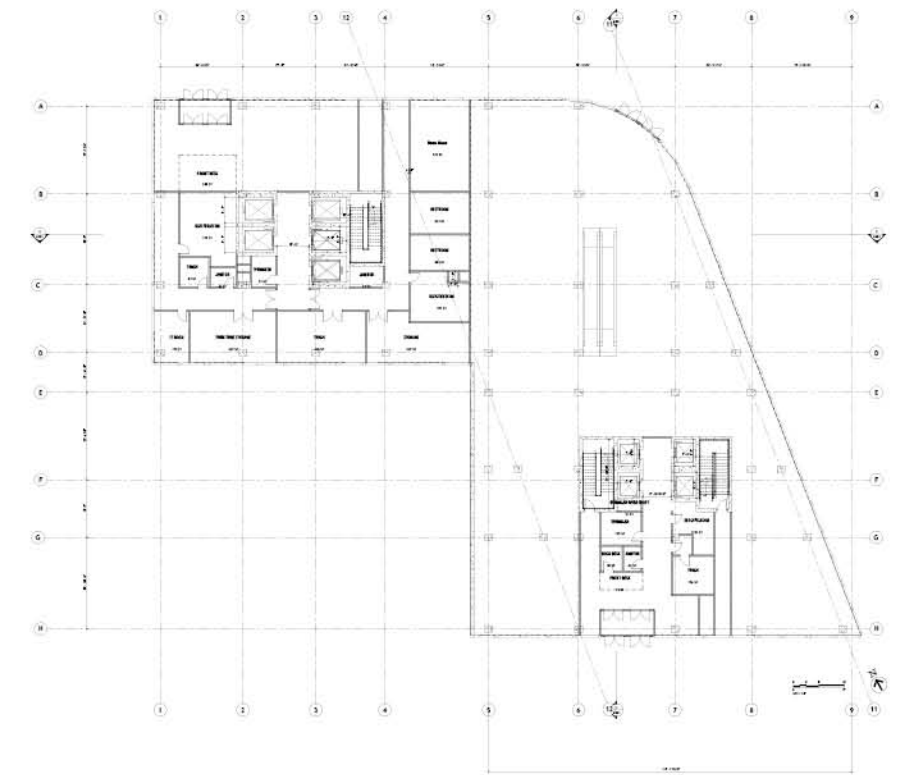
GENERATED PARAMETRIC TERRACES, REBUILT SLABS/Ceilings, EXPORTED DYNAMIC FACADE.



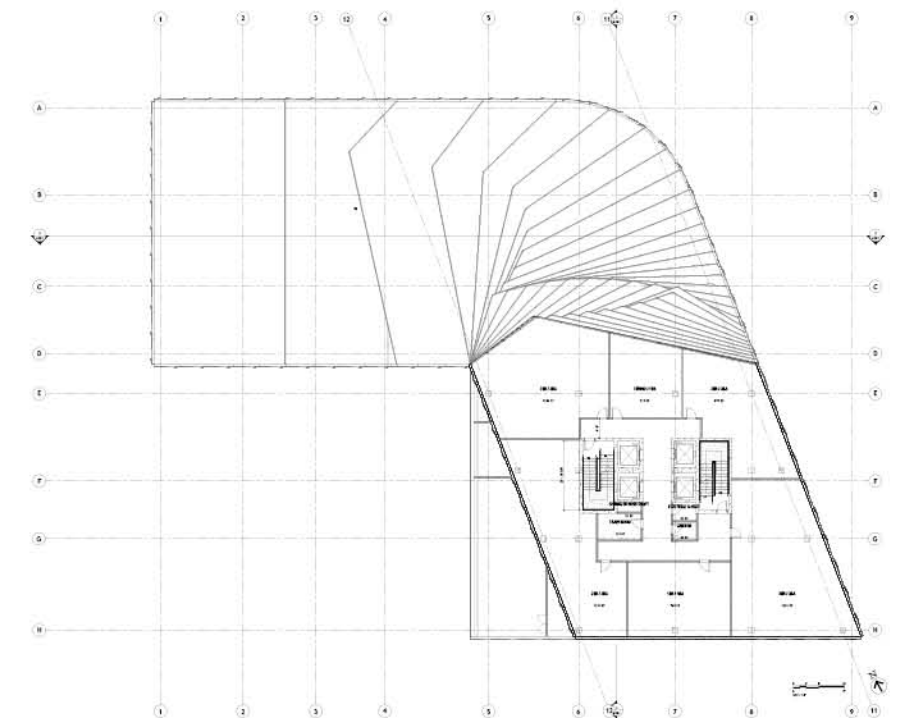


Office - Level_10 Plan

High-end Class A offices deliver a calm, daylight-rich workplace of open neighborhoods, quiet edges, and shared skyline lounges. Single-tenant now, multi-tenant ready later, with clean demising lines and calibrated services for leasing.

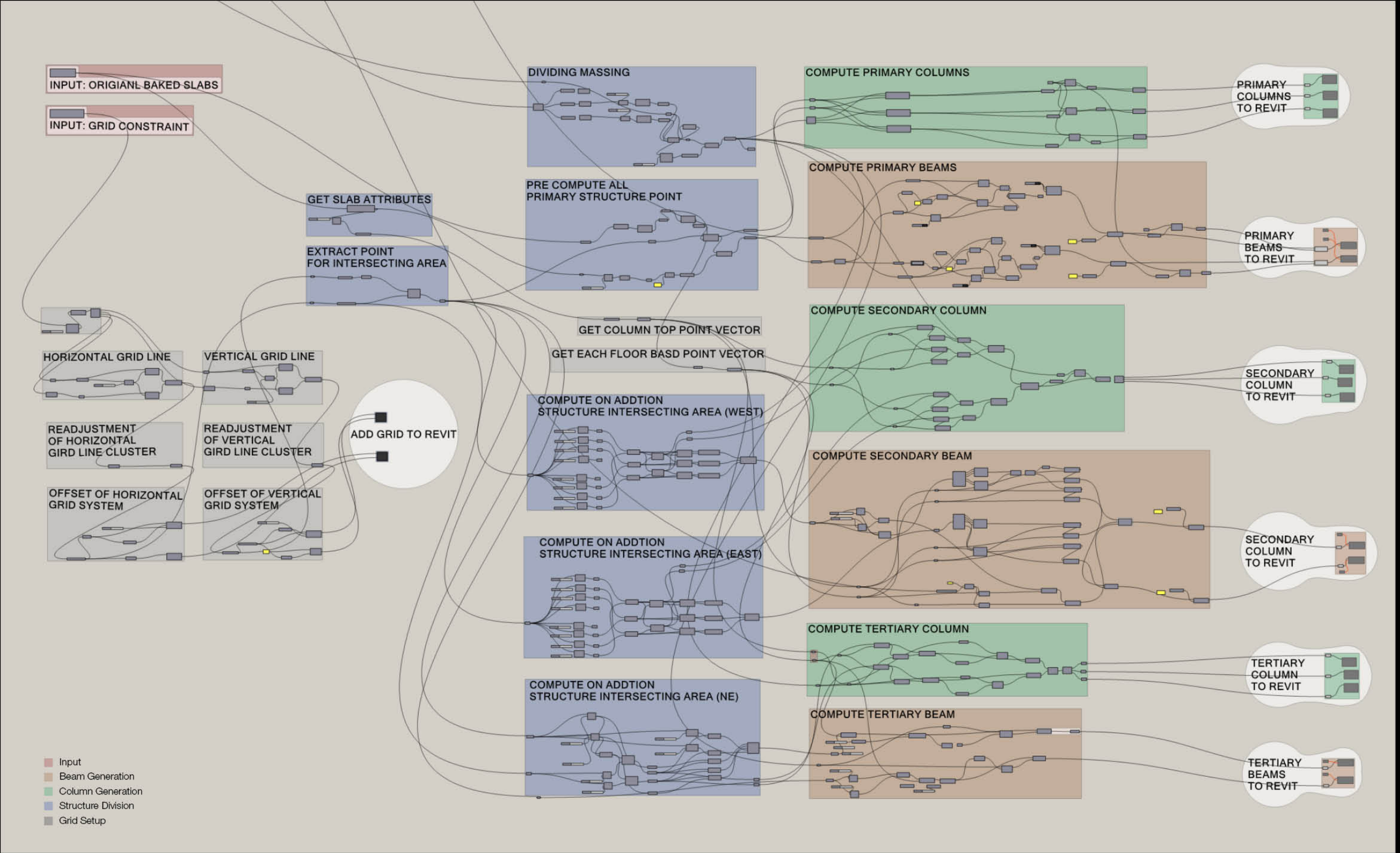


Ground - Level_01 Plan

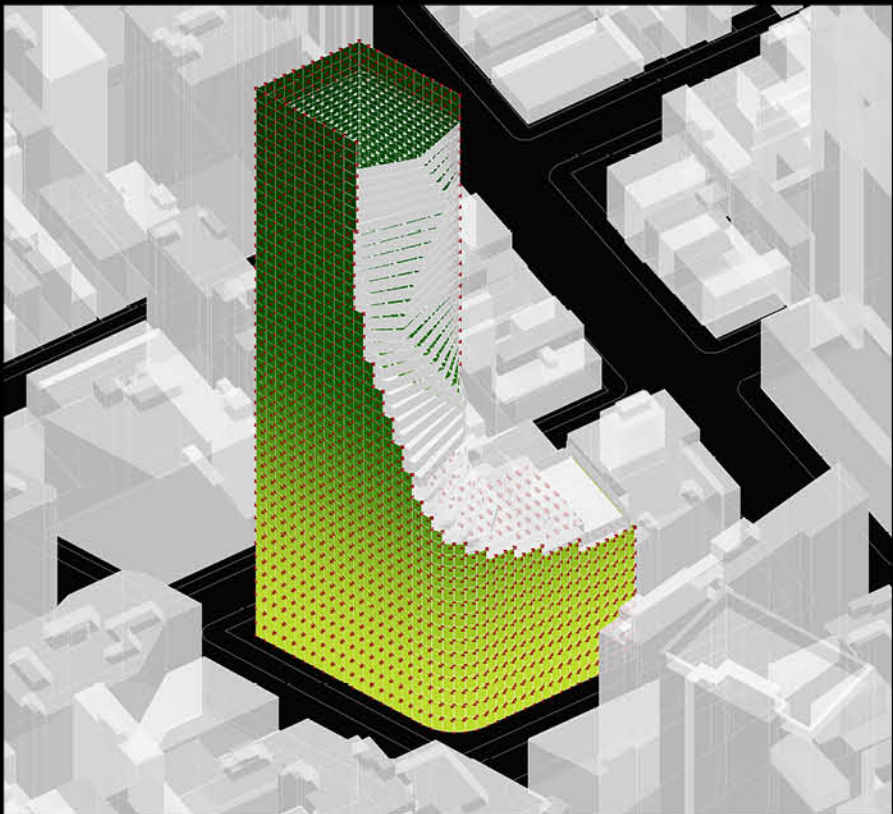
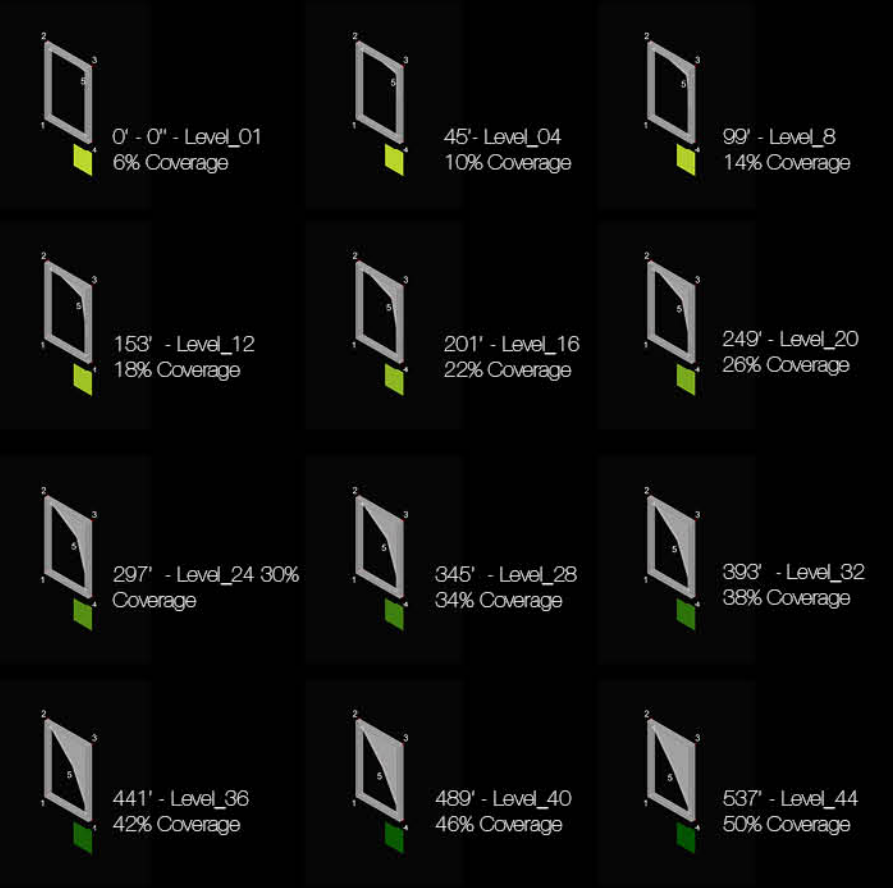


Residential - Level_40 Plan

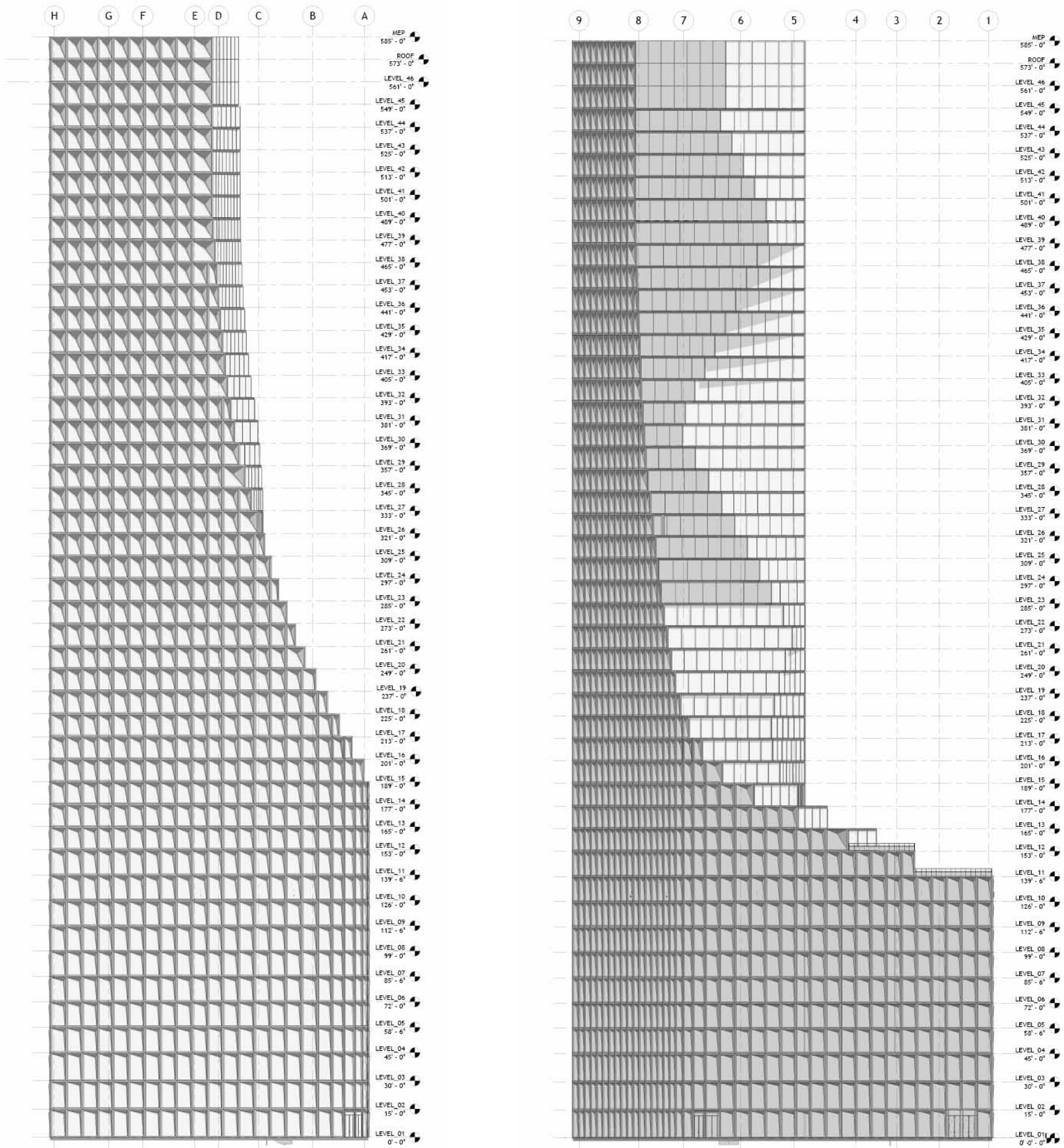
GENERATED PARAMETRIC GRIDS AND MULTI-TIER COLUMNS/BEAMS, EXPORTED TO REVIT.



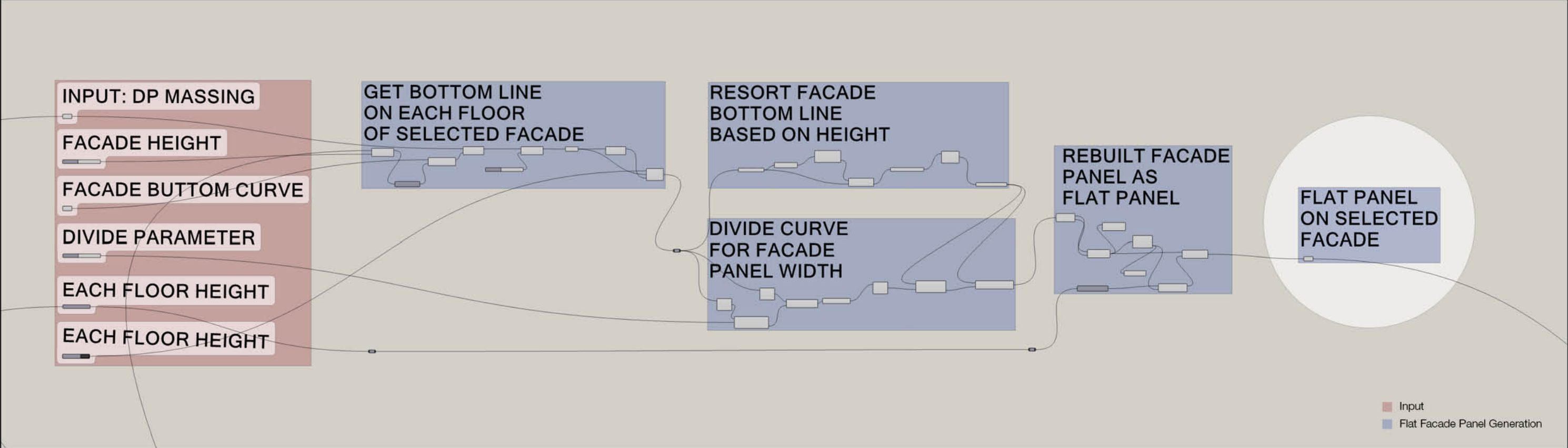
5 POINT ADAPTIVE FAMILY FOR FACADE PANEL (GH-REVIT)



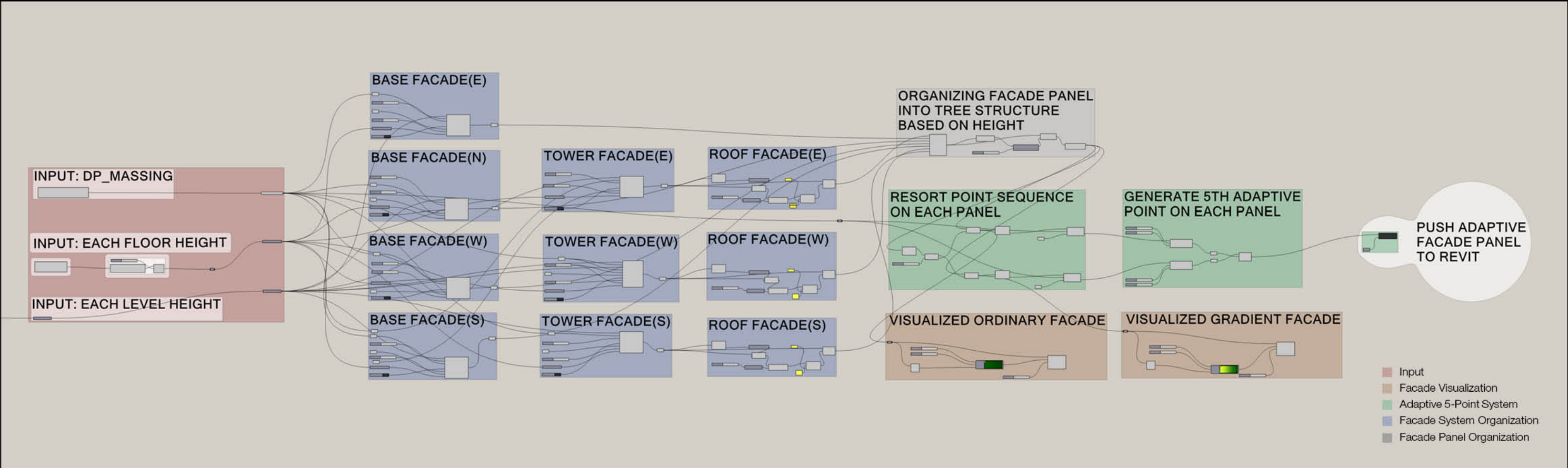
5 Point Adaptive Facade



EXTRACTED SLAB EDGES, REBUILT STRAIGHT SEGMENTS, EXTRUDED FLAT FAÇADE PANELS.



APPLIED PER-FAÇADE PANELS, REORDERED POINTS, ADDED 5TH ADAPTIVE CONTROL, EXPORTED TO REVIT.





RE-THINKING MICRO LIVING

AN AUTOMATED LAYOUT AND OPTIMIZATION SYSTEM

Generative Design

Computation

Critic: Danil Nagy

Spring 2025, GSAPP

Team: Yunhao Zhong, Krushi Saraiya, Janvi Patil,

Role: Script writing + system development

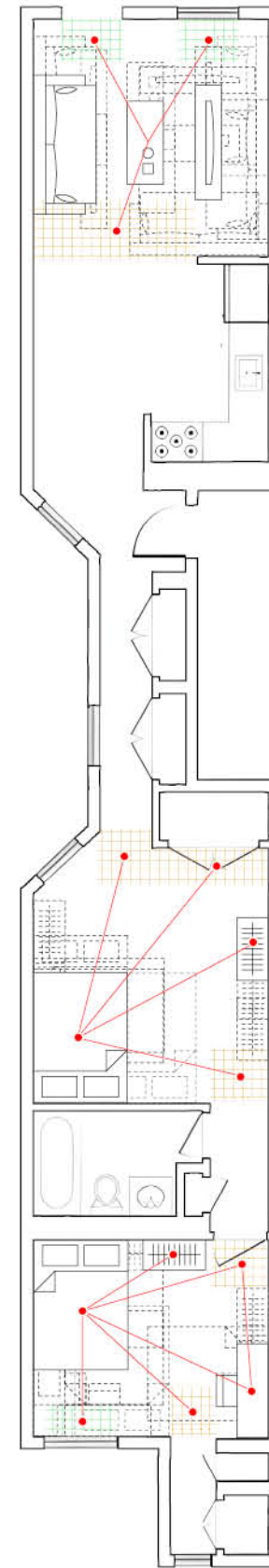
(Grasshopper), algorithm design, workflow integration, testing/iteration, publication writing. Authored all scripts shown in the portfolio. Optimization approach informed by studio guidance; teammates contributed market research and app UI/graphic design.

HIGH PASS

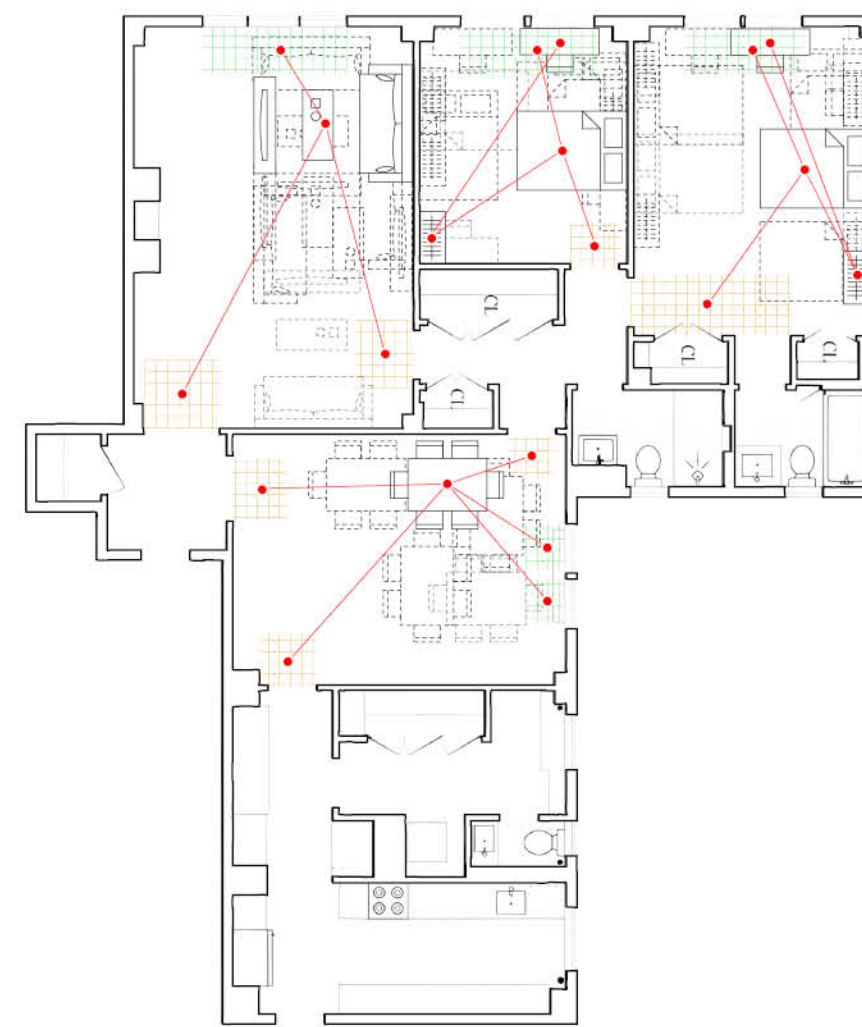
<https://medium.com/generative-design-course/re-thinking-micro-living-a-generative-design-system-for-adaptive-user-centric-living-in-urban-248c4a72b9e3>

This project reimagines the micro-apartment as a computational optimization problem rather than a constraint. In dense cities like New York, compact living is common—yet conventional layouts remain static, ignoring the diverse needs of urban residents. Built in Grasshopper, this generative tool enables automated layout generation based on apartment geometry, furniture sets, and lifestyle presets.

The system operates through two computational methods: exhaustive permutation with rule-based scoring, and evolutionary optimization via Galapagos. It scores layouts using quantifiable metrics—like daylight access and circulation efficiency—with user-defined criteria. A student, elder, or small family can all receive algorithmically optimized solutions tailored to their specific routines and needs.



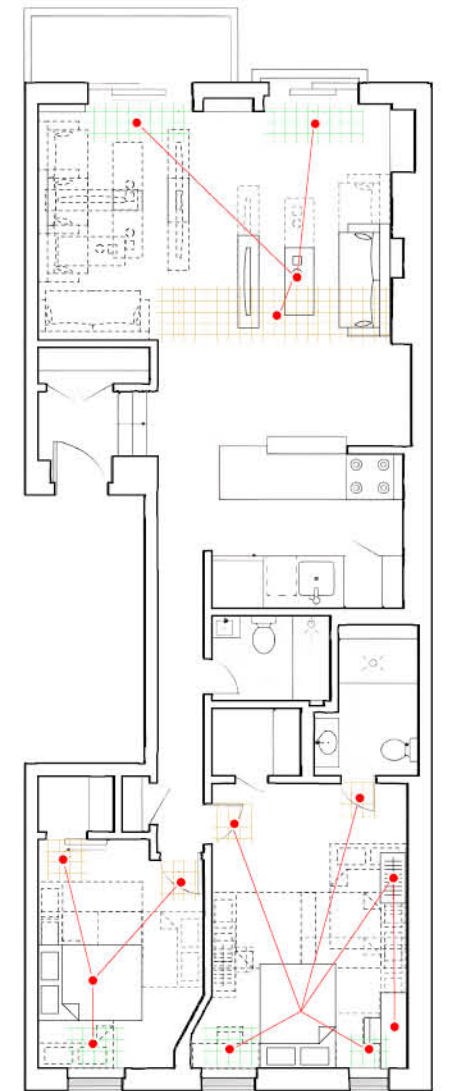
Railroad Apt Type



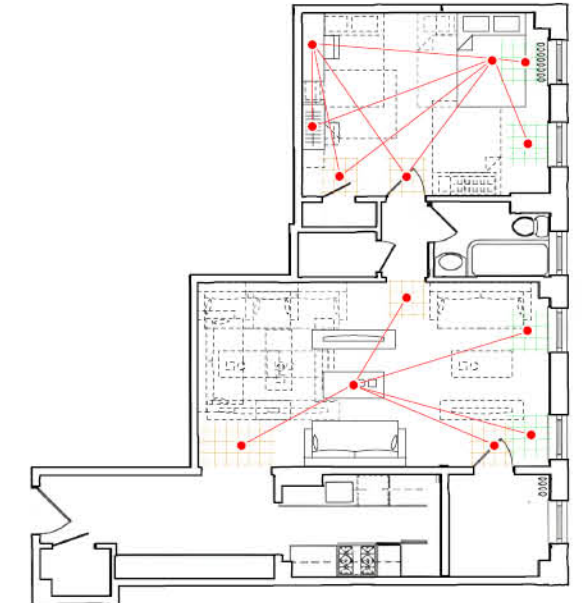
Classic Six Apt Type



Basement/Cellar Apt Type



Floor Through Apt Type



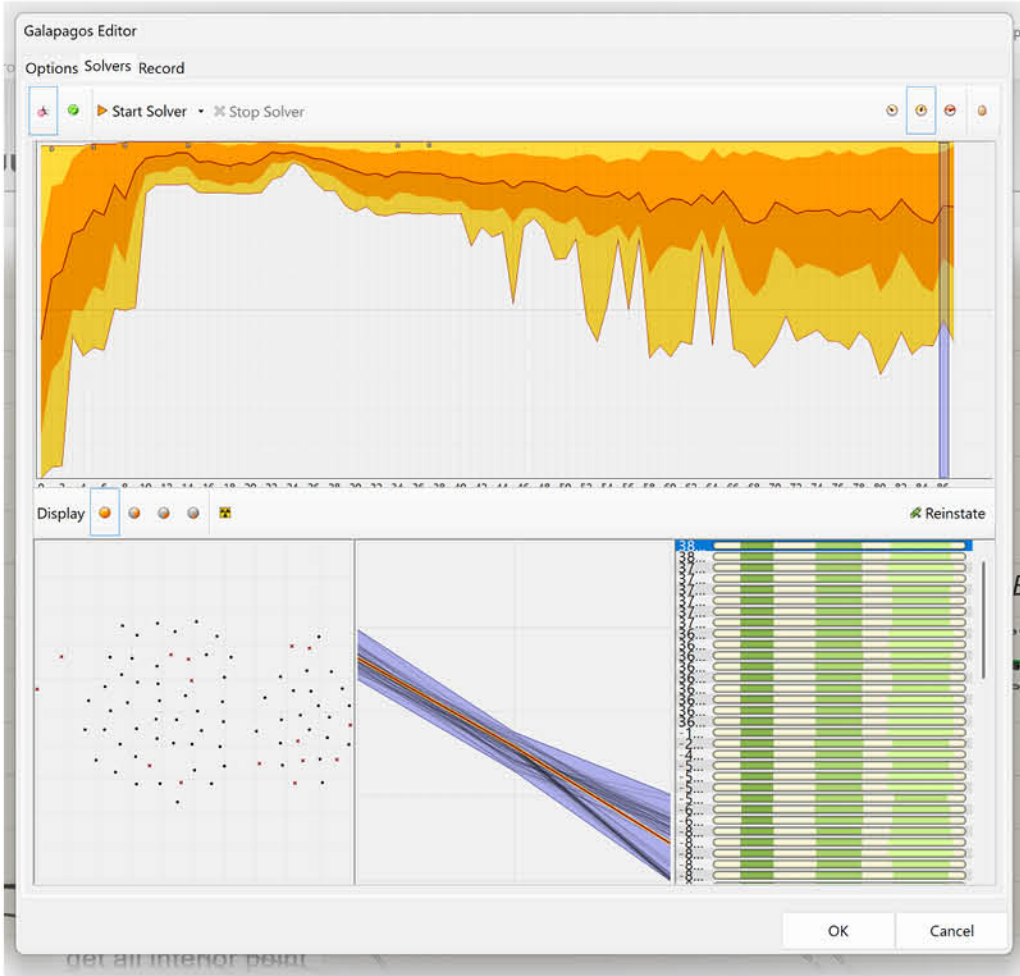
Junior Four Apt Type

AUTOMATED FURNITURE LAYOUT METHODS

The full permutation and rule-based scoring method explores the entire layout solution space but requires significant computation time. The Galapagos evolutionary optimization method rapidly finds good solutions but may miss the global optimum.

Feature	Method 1: Full Permutation	Method 2: Galapagos Optimization
Exhaustiveness	High	Low
Speed	Slow	Fast
Transparency (all options visible)	Yes	No
Scalability with item quantity	Poor	Excellent
Optimality Guarantee	Global Optimum	Not Guaranteed
Ideal Use Case	Exhaustive testing, research documentation	Early-stage iteration, real-time feedback

Approach Comparison - Full Permutation and Galapagos Optimization



Galapagos Optimization Interface

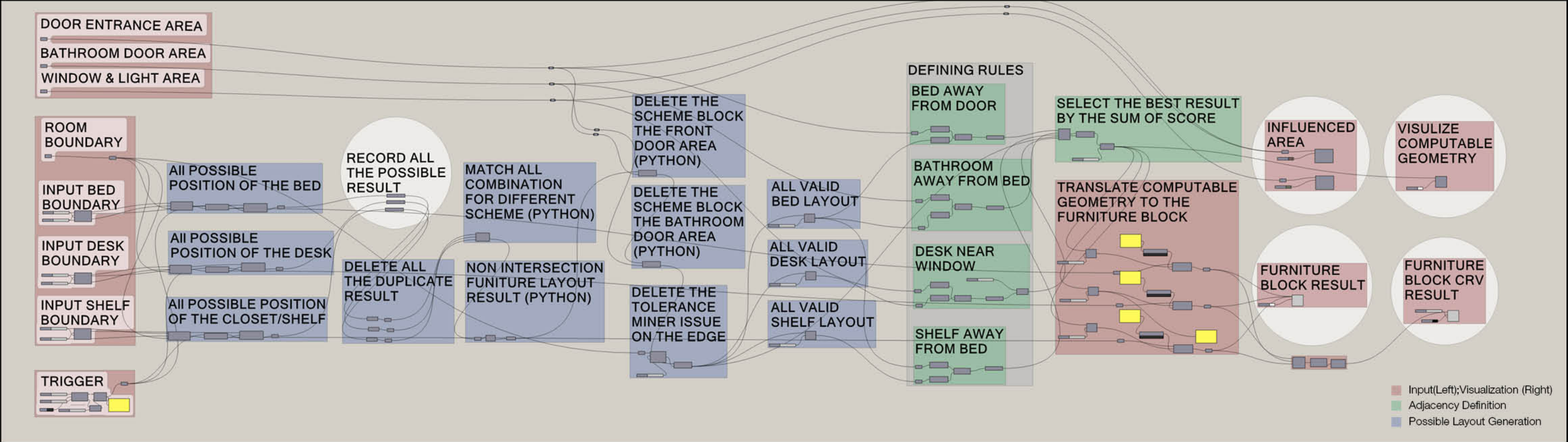


Full Permutation Approach

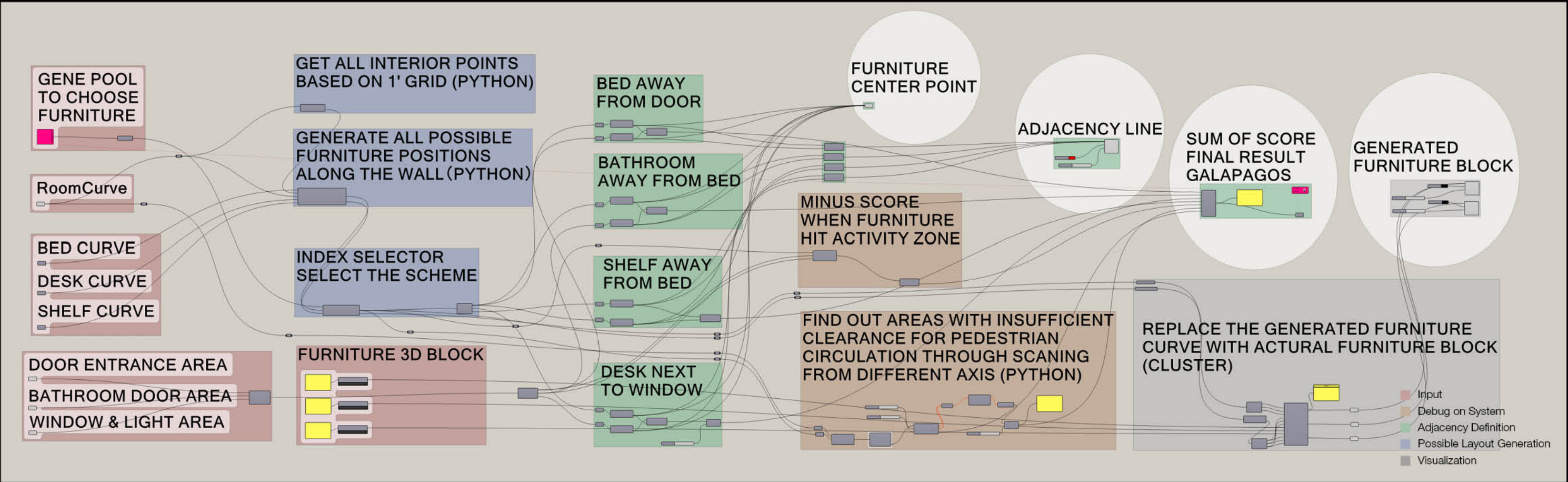
Galapagos Optimization with High Score

Galapagos Optimization with Low Score

FULL-PERMUTATION FURNITURE LAYOUTS, FILTERED COLLISIONS, SCORED ADJACENCY RULES, RANKED BEST.



GALAPAGOS-EVOLVED FURNITURE LAYOUTS, SCORED ADJACENCY RULES, FASTER SEARCH, NEAR-OPTIMAL.



INHABITING UNCERTAINTY

ELEVATING BRIDGEPORT'S FUTURE

Advanced Studio IV
Critics: Rachely Rotem
Spring 2025
Personal Project

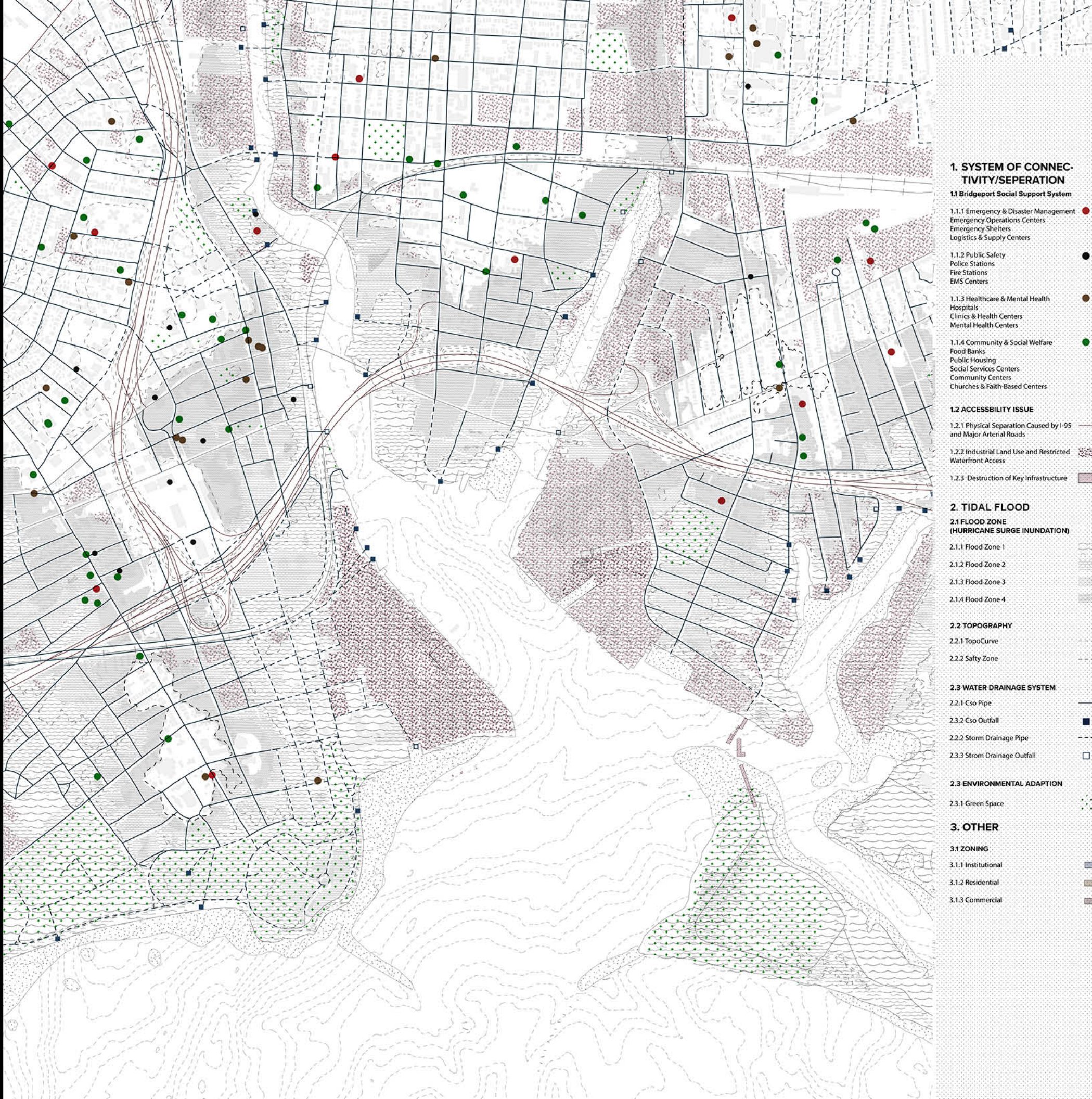
HIGH PASS

This project reimagines the overlooked interstitial spaces of Bridgeport's flood-prone East End—vacant lots, rooftop edges, and narrow alleys—into an elevated civic network. Inspired by a mathematical model from the University of York, it treats uncertainty not only as risk—of floods, neglect, and infrastructure failure—but also as a catalyst for spatial and social transformation.

The design introduces a modular kit of parts made from local materials: tires, washing machine drums, PVC pipes, and scrap metal. Lightweight platforms, supported by columns, connect second-floor windows to provide safe paths during floods and serve as outdoor extensions—kitchens, gardens, drying areas, and gathering zones—when dry.

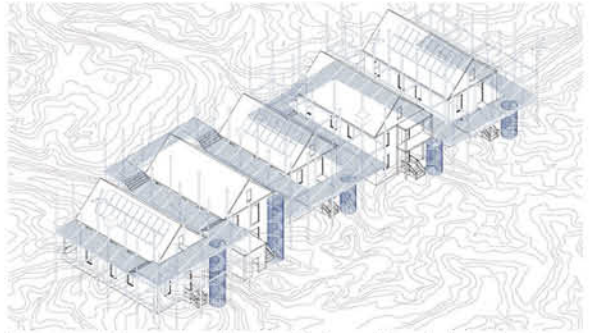
A mesh canopy above forms a breathable layer that supports plants, shades active spaces, and anchors emergency covers. Programs remain flexible and evolve with community needs. At the daycare, the system loops horizontally, allowing learning and play to extend outdoors while embedding resilience into daily life.

Rather than repairing a broken system from above, the project empowers residents to build a new one—gradually and collectively. It reframes architecture as an adaptive civic framework that sustains shared life through uncertainty.

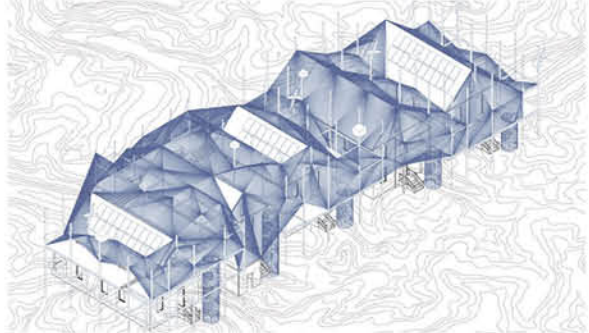




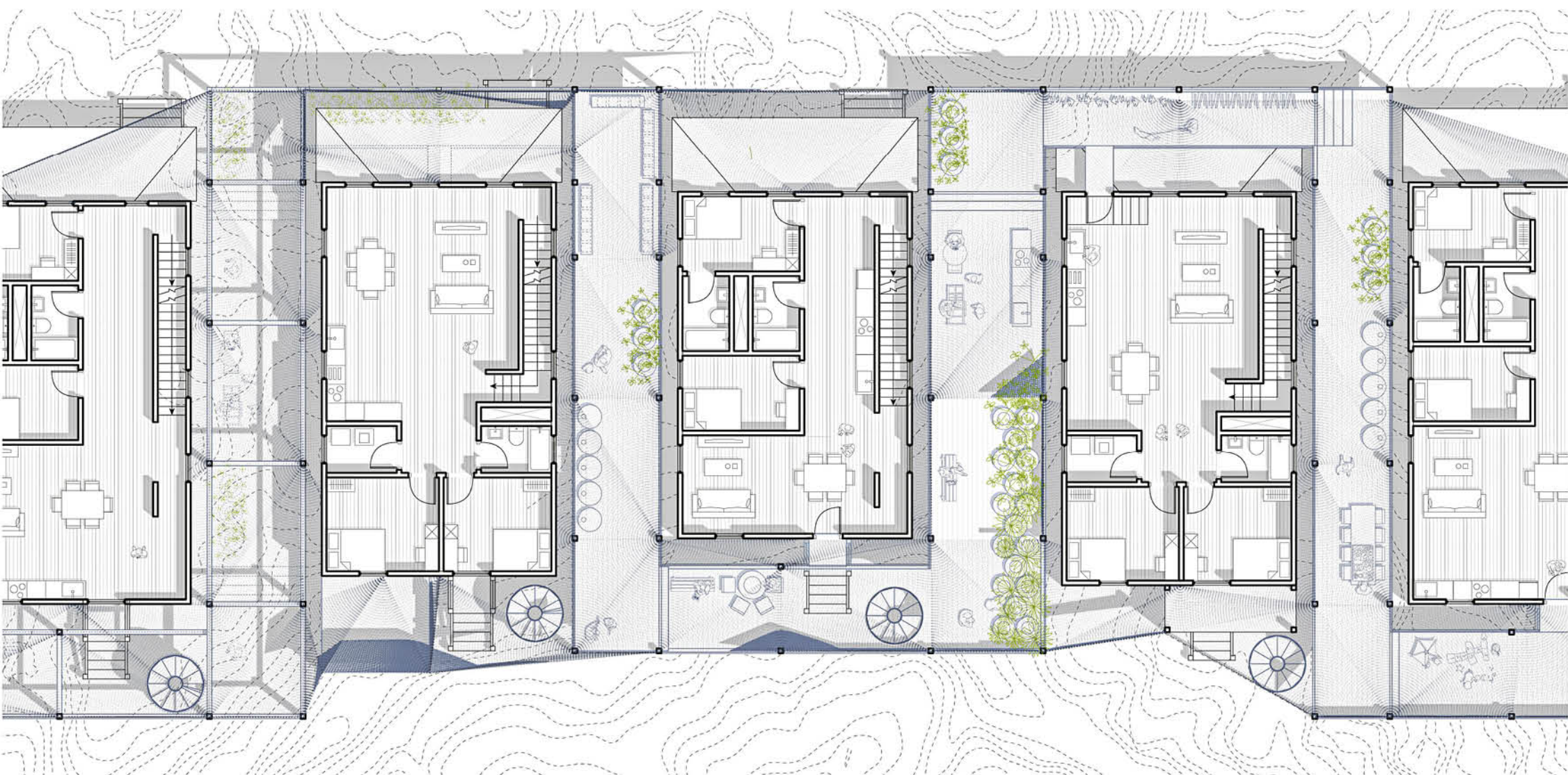
Minimum Solution: Platforms Between Buildings (Housing)



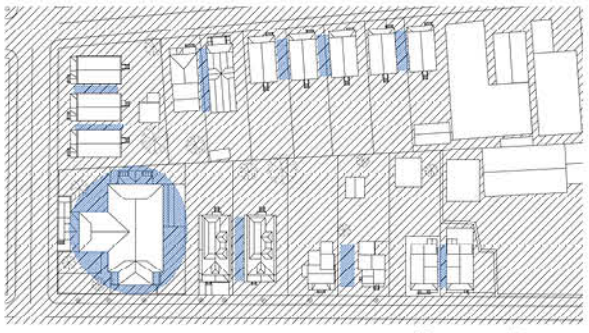
User - Led Expansion: Flexible Platform Growth (Housing)



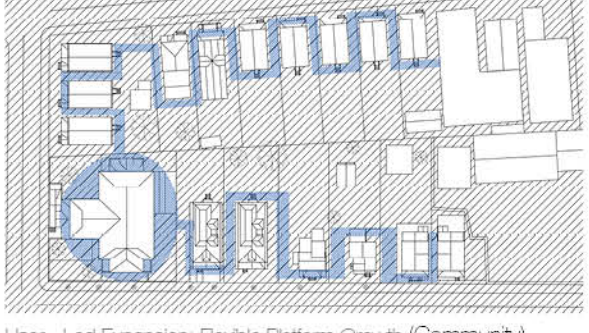
Mesh Envelope: Spatial Softness And Adaptation (Housing)



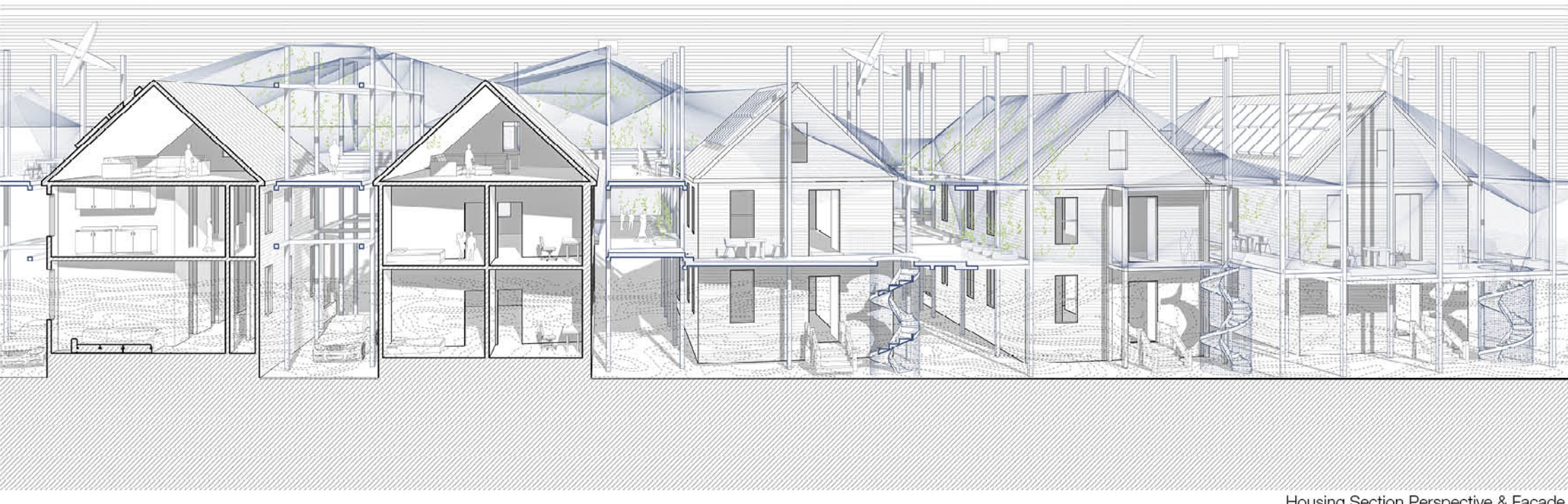
Housing Plan



Minimum Solution: Platforms Between Buildings (Community)

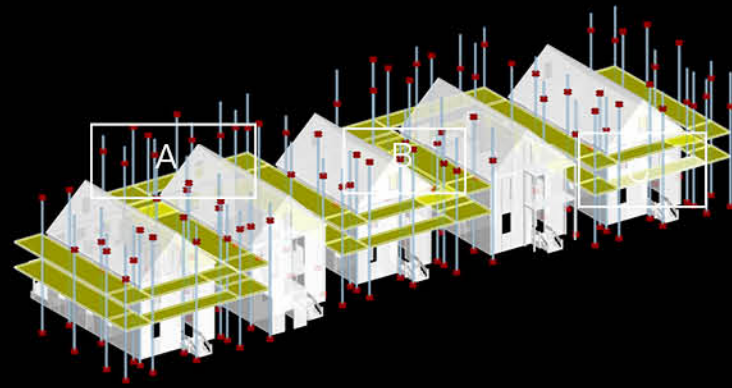


User - Led Expansion: Flexible Platform Growth (Community)

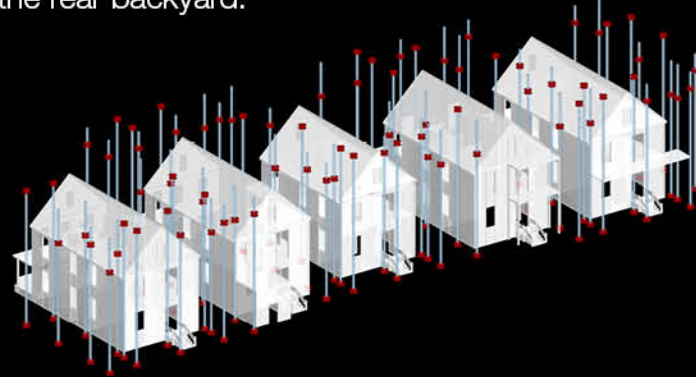


Housing Section Perspective & Facade

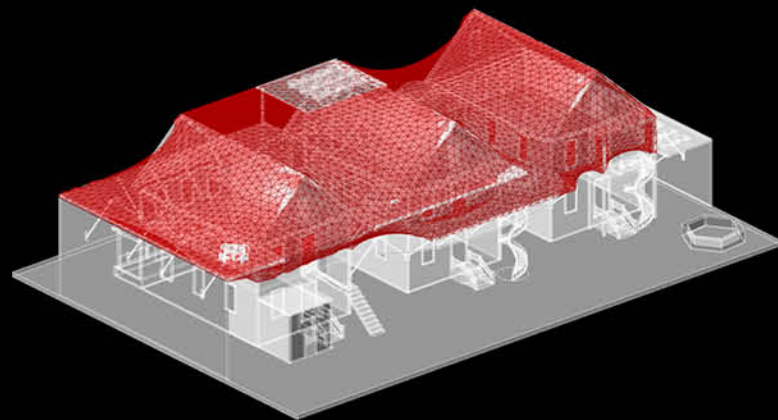
COMPUTATIONAL STEPS



1. The platform is computed as the front facade area, the in-between gap between houses, and the rear backyard.

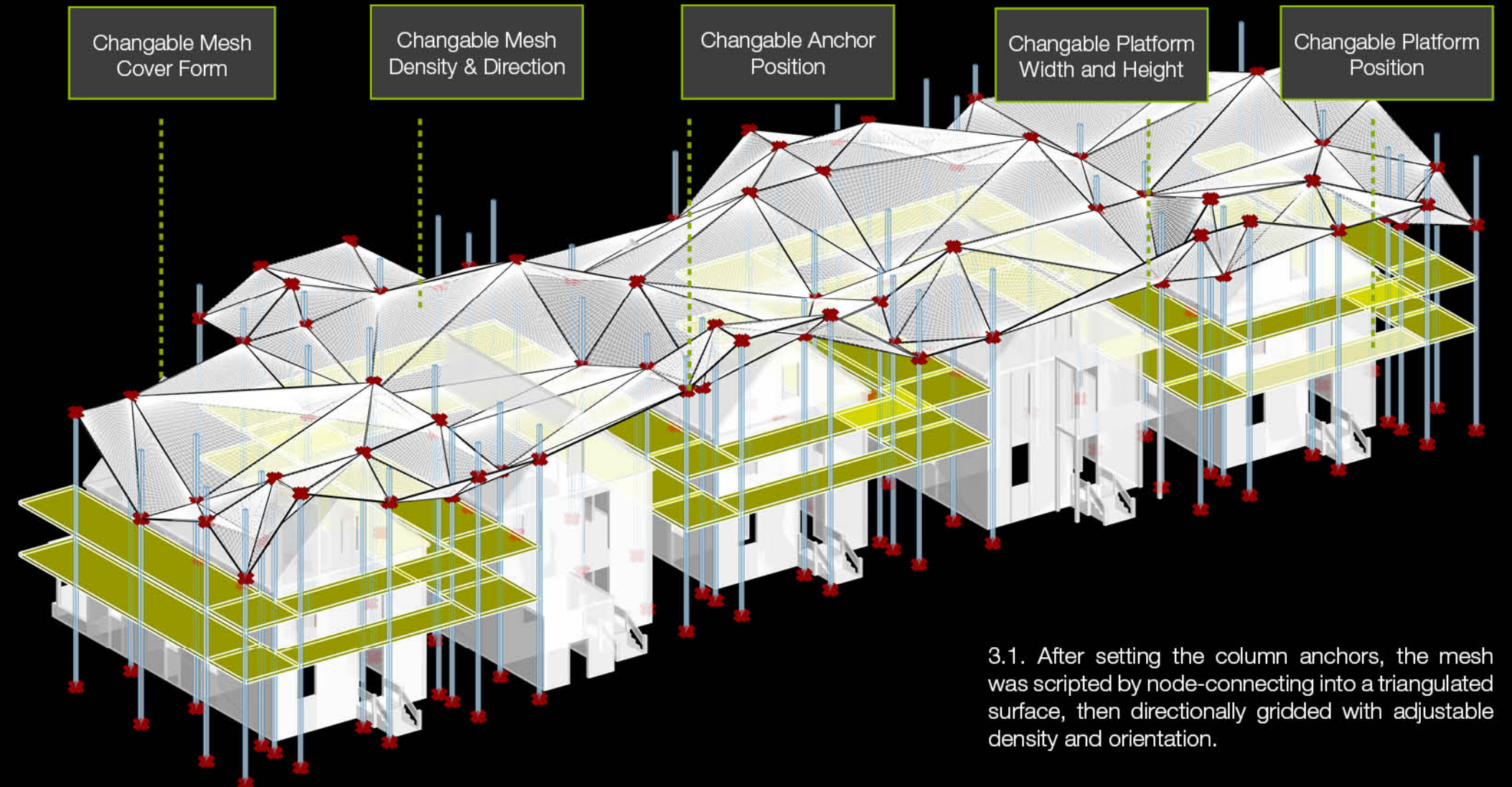


2. Once the platform location is set, the column layout and heights are generated, with mesh anchors placed on top and assigned randomized heights within a defined range.



3.2. To simulate material behavior, Kangaroo was used for physics-based mesh form-finding to achieve a more elastic, responsive geometry.

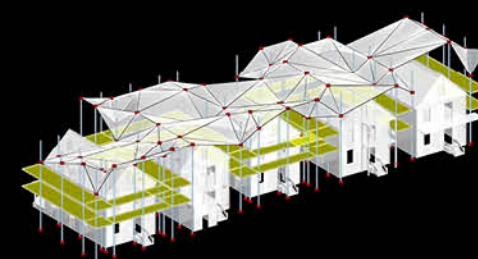
COMPUTATIONAL FEATURES



3.1. After setting the column anchors, the mesh was scripted by node-connecting into a triangulated surface, then directionally gridded with adjustable density and orientation.



SEED 15



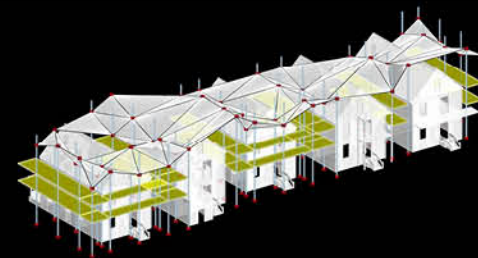
SEED 30



SEED 45



SEED 60



SEED 90



SEED 105

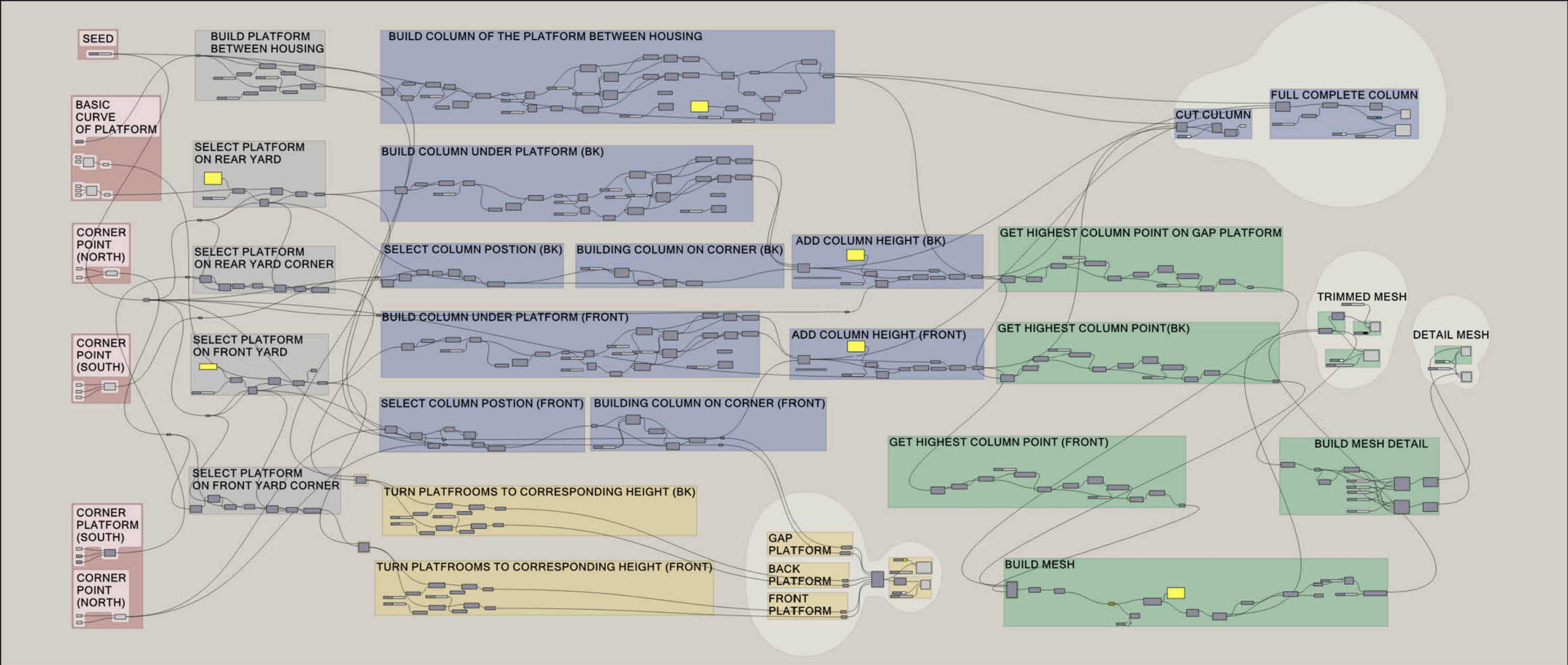


SEED 120

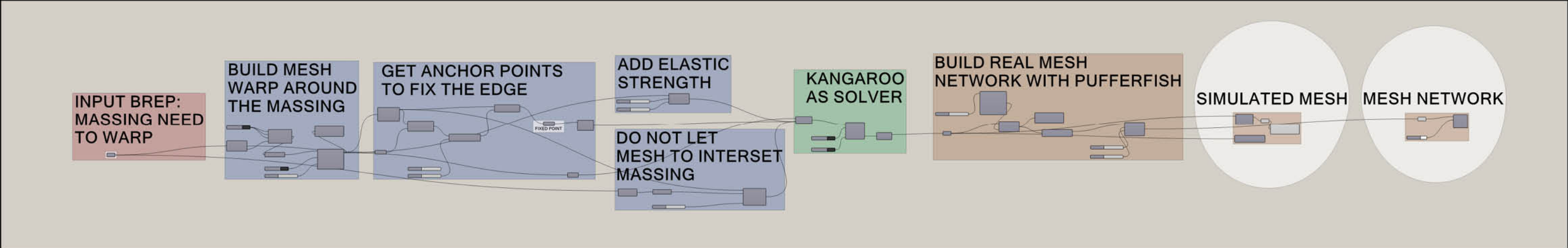


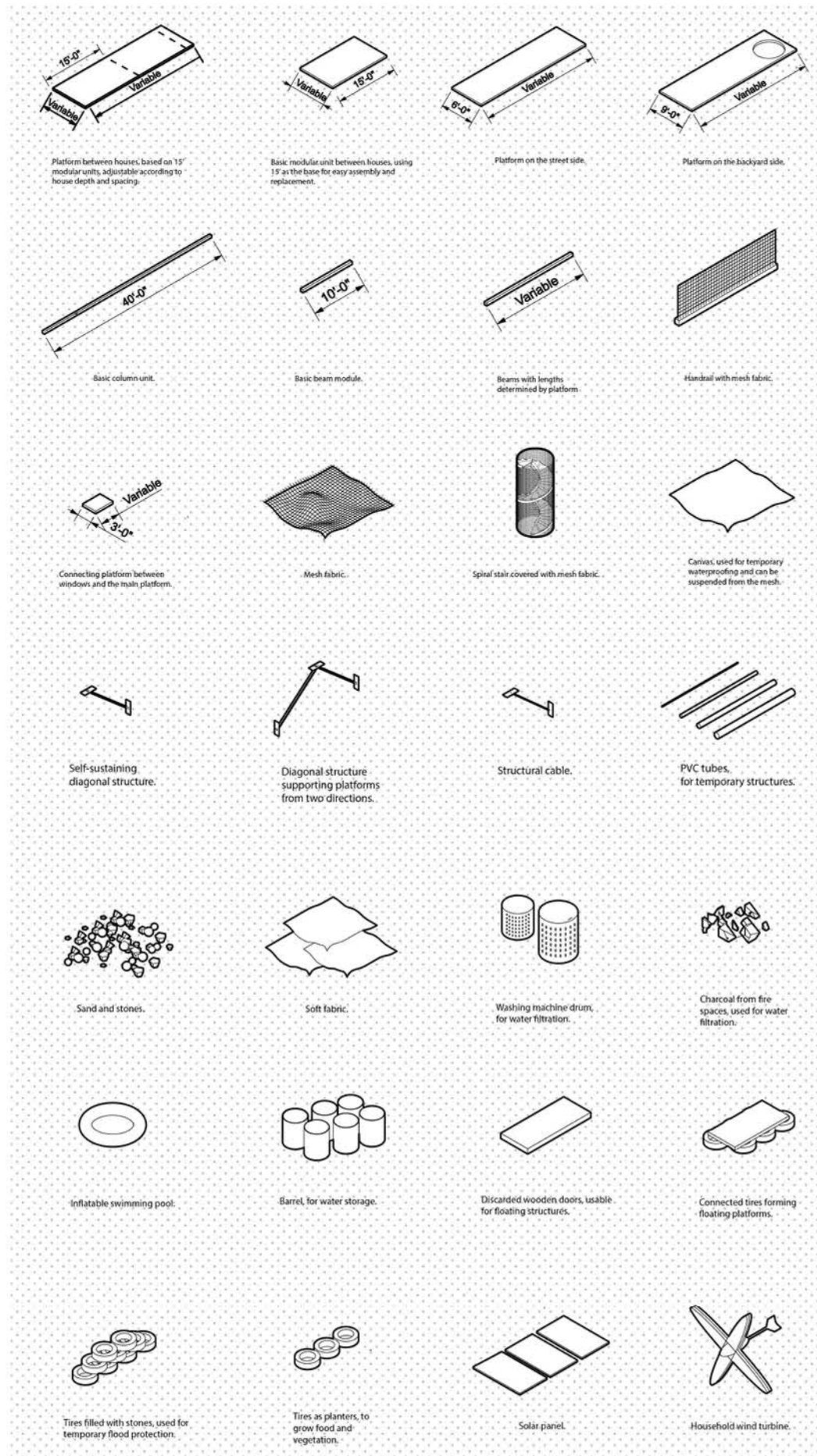
SEED 135

BUILT A RESPONSIVE PLATFORM-COLUMN-MESH SYSTEM WITH SELECTABLE OPTIONS, RANDOMNESS, VARIABLE ANCHORS, HEIGHTS, AND MESH DENSITY.

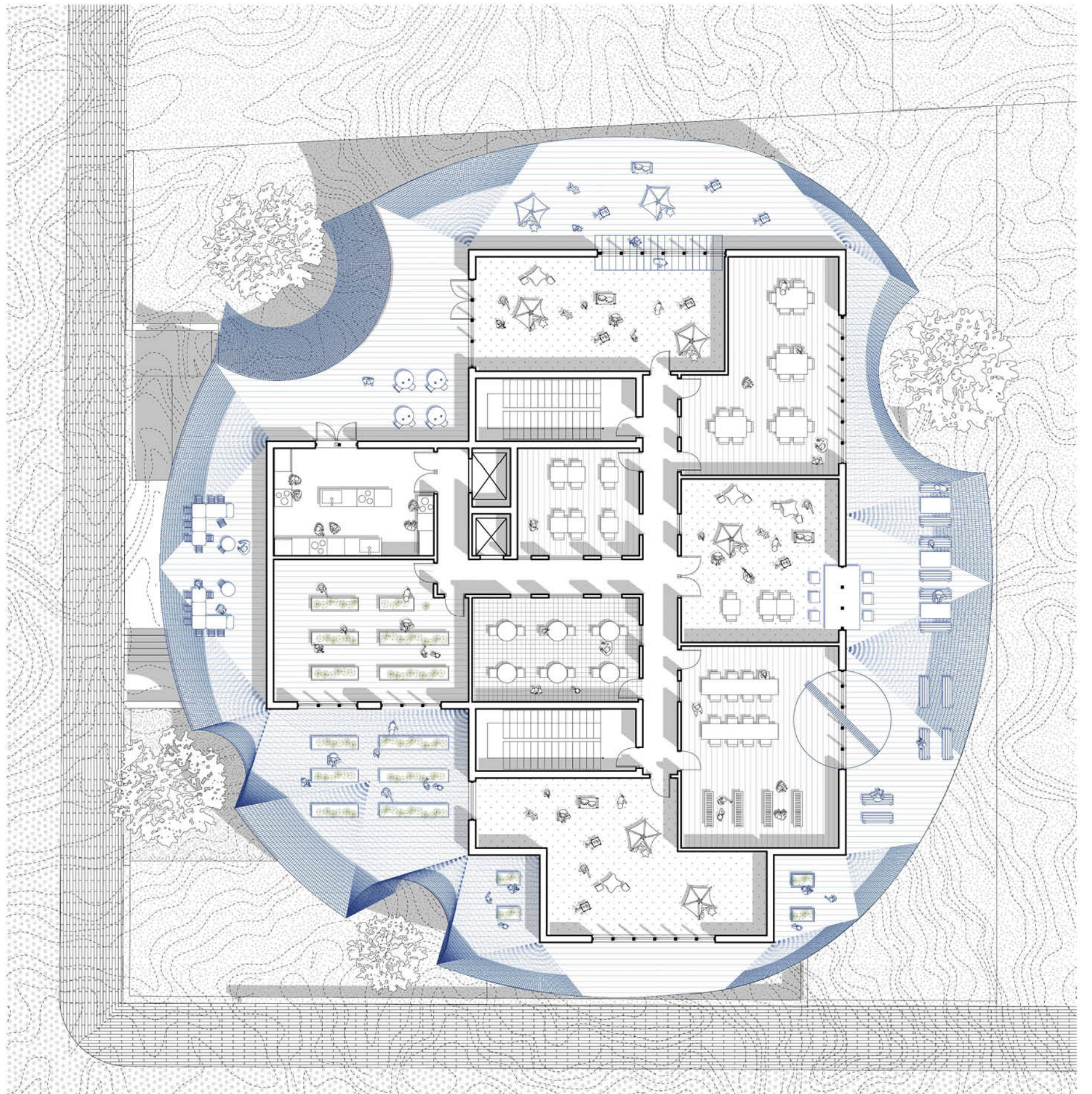


USED KANGAROO TO GENERATE AN ELASTIC WRAPPING MESH AROUND MASSING WITH ANCHORS, TENSION, AND COLLISION CONSTRAINTS.





Kits of Parts



Plan - Daycare

GSAPP CLOUD

REIMAGINING PUBLIC SPACE THROUGH LIGHTNESS AND COLLABORATION

The Outside in Project II
Building Science & Technology Elective
Fall 2024, GSAPP

Professors:

Galia Solomonoff, Laurie Hawkinson

Teaching Assistant:

Tristan Schendel, Syed Haseeb Amjad

Team:

Devyanshi Arya, Karim Baba, Qizhen Chen, Lula Chou, Daniel Hahn, Yun Jeong Han, Martina Hollmann, Laurent-Shixun Huang, Ka Heun Hyun, Lauren Jian, Adi Klein, Teymour Khoury, Leslie Li, Lucy Li, Lajja Mehta, Franco Daniel Nocioni, Matija Pogorilic, Maria Paula Rico, Khushi Rakesh Saraiya, Anna Maria Schmitz, Longjiu Sun, Nikoletta Zakynthinou Xanthi, Hanyin Zhang, Joe Zhang, Yunhao Zhong, Matilda Terolli

Role:

Form development, geometry modeling, parametric modeling, structural analysis, resolving connection details, sequencing assembly steps, coordinating structure and spatial use in DD Phase.

HIGH PASS

The Outside In Project is a two-semester, student-led inflatable pavilion designed under Professors Laurie Hawkinson and Galia Solomonoff. Suspended by 25 cables above Avery Plaza, the silver inflatable—titled Cloud—challenges spatial boundaries between interior and exterior, blending architecture and public participation. Initially conceptualized and fabricated in Spring 2024, and later installed during the Fall by a second student cohort, the project invites visitors into a floating structure anchored to Avery Hall's upper floor. Powered by electric blowers, the pavilion hosted GSAPP's Open House and remained active for events until October 30. It was documented through drawings and reflections to inform future inflatable designs. Cloud repositions the role of the built environment as both a stage and participant in collective experience.

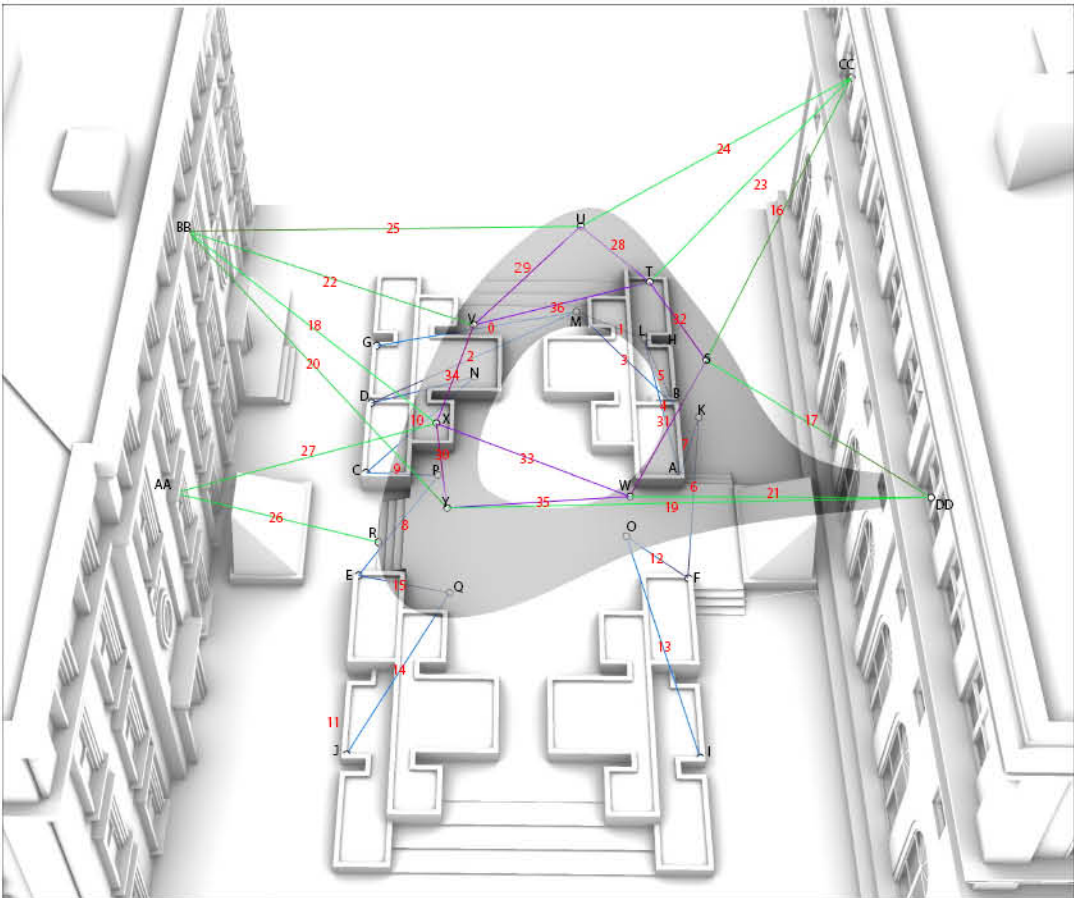


DD PHASE COORDINATION

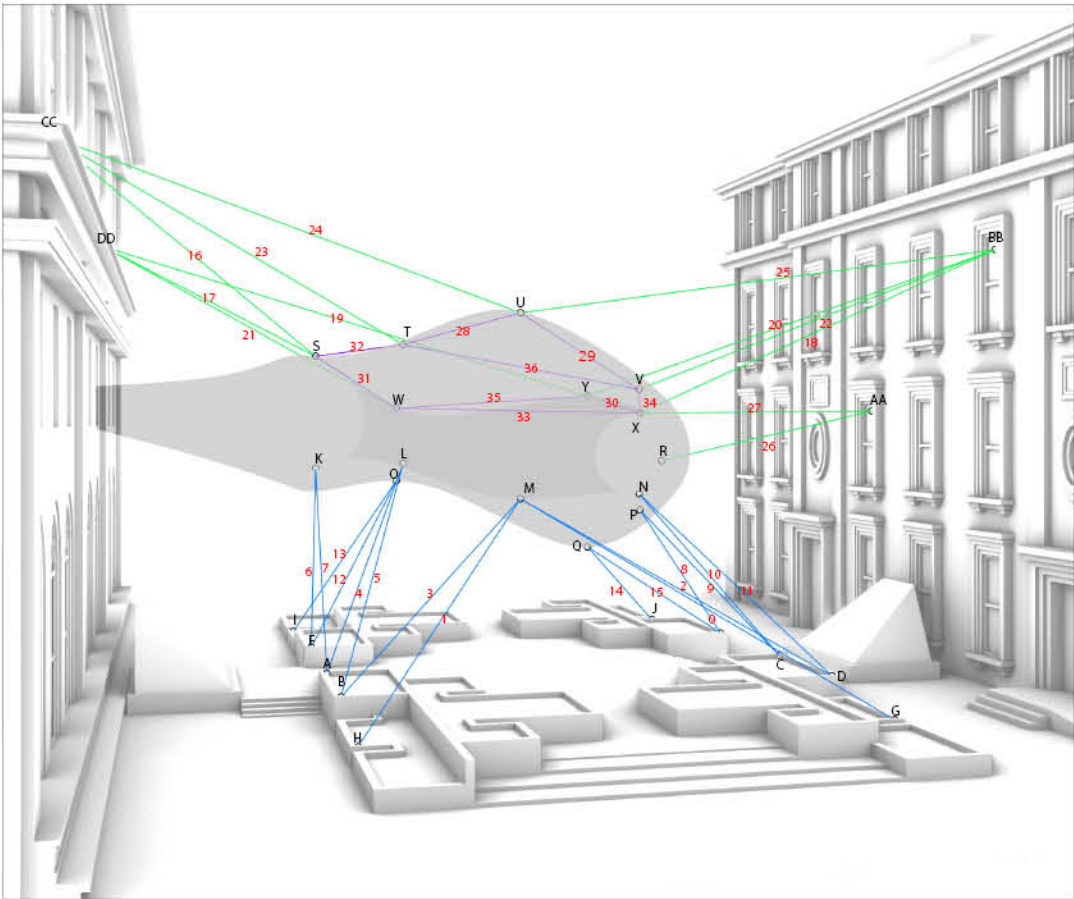
We developed a Grasshopper-based analysis and labeling system for the scissor-and-cable structure that calculated and tagged the required length of each cable for accurate procurement. The Rhino model was coordinated with CAD drawings to ensure dimensional accuracy and produce a clear, trackable assembly system that made the construction sequence and component relationships easy to follow.

0	G-M	38.8	46.6
1	H-M	27.8	33.4
2	D-M	36.1	43.3
3	B-M	23.9	28.7
4	A-L	23.2	27.8
5	B-L	22.6	27
6	F-K	23.8	28.6
7	A-K	21	25
8	E-P	19.9	23.9
9	C-P	22.9	27.5
10	C-N	24.2	29
11	D-N	26.3	31.6
12	F-O	21.7	26
13	I-O	31.2	37.5
14	J-Q	25.6	30.7
15	E-Q	19.5	23.4
16	CC-S	50.9	101.8
17	DD-S	44.2	88.4
18	BB-X	42.3	84.6
19	DD-Y	60.5	121
20	BB-Y	52.4	104.8
21	DD-W	41.3	82.6
22	BB-V	41.4	82.8
23	CC-T	43.5	87
24	CC-U	45.4	90.8
25	BB-U	55.2	110.4
26	AA-R	27.3	54.6
27	AA-X	36.1	72.2
28	T-U	13.1	26.2
29	U-V	21.1	42.2
30	X-Y	16.7	33.4
31	W-S	23	46
32	S-T	16.2	32.4
33	X-W	28.7	57.4
34	X-V	17.3	34.6
35	W-Y	23.9	47.8
36	T-V	25.3	50.6

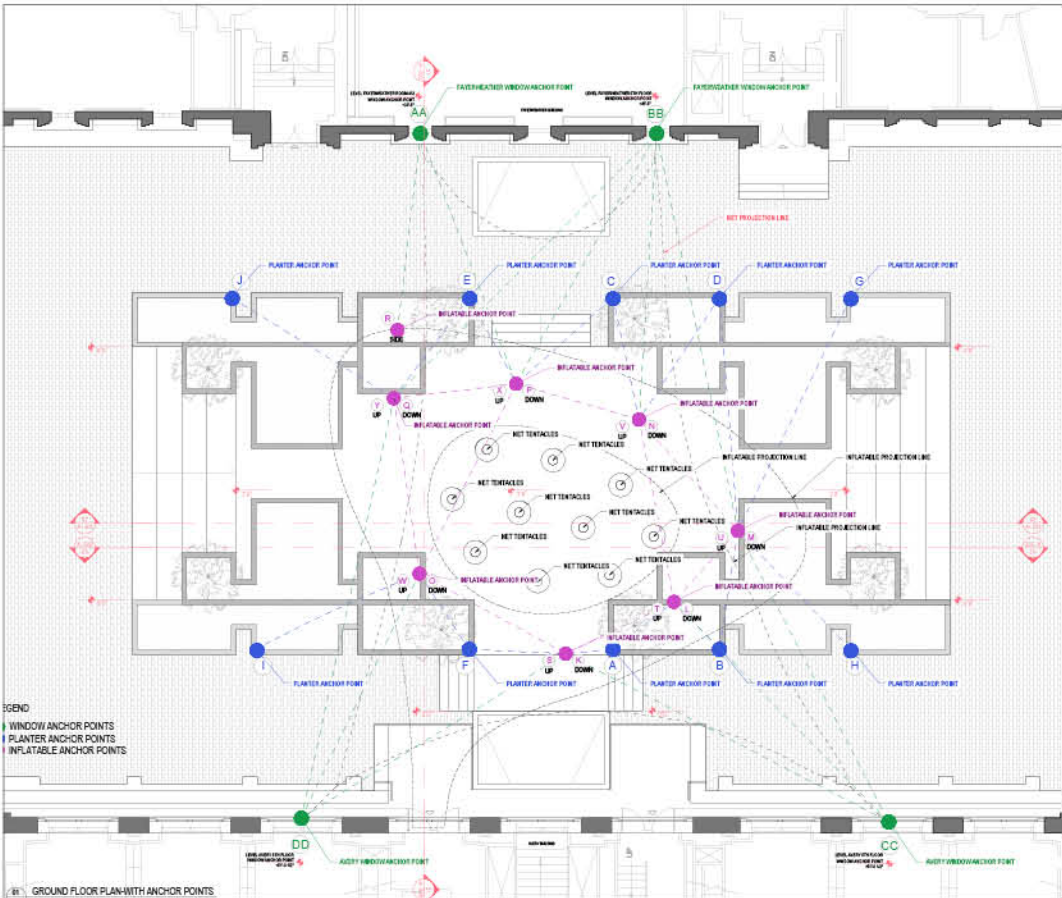
Anchor Point and Rope Data



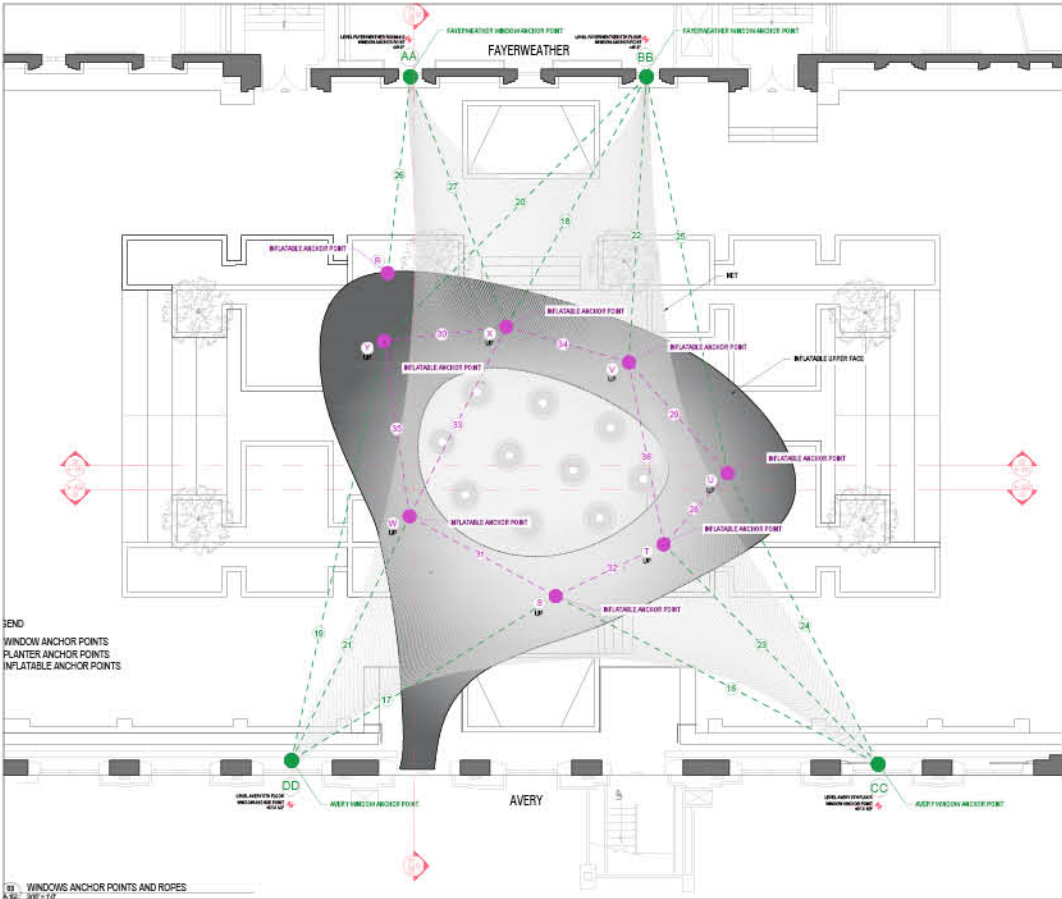
Perspective- Anchor Point and Rope Label



Perspective- Anchor Point and Rope Label



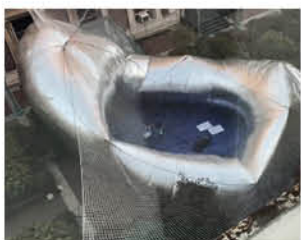
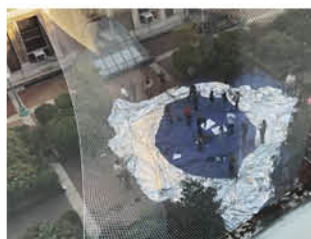
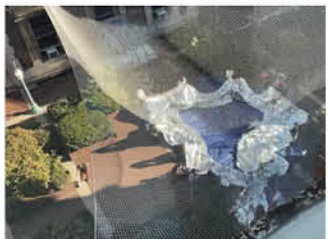
Plan - Ground Floor Anchor Point and Ropes



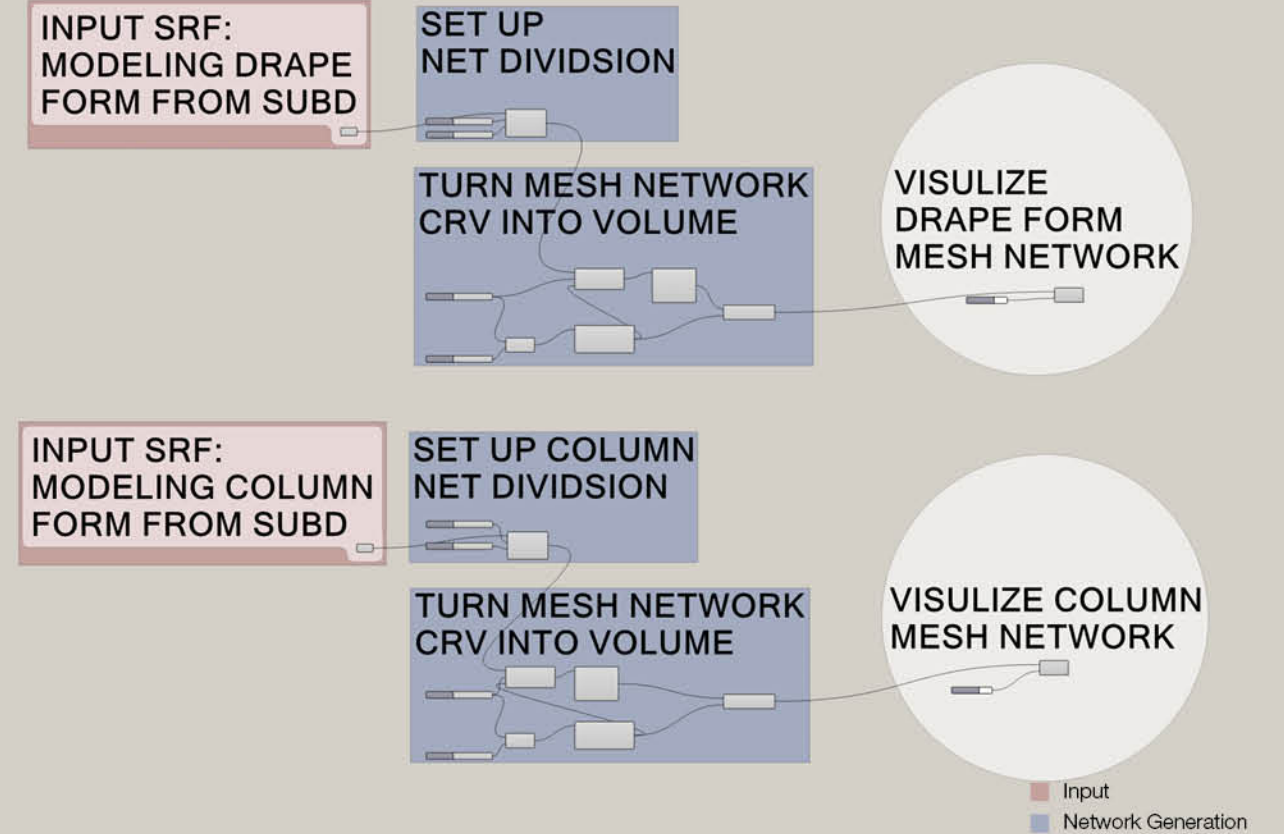
Plan - Window Anchor Point and Ropes



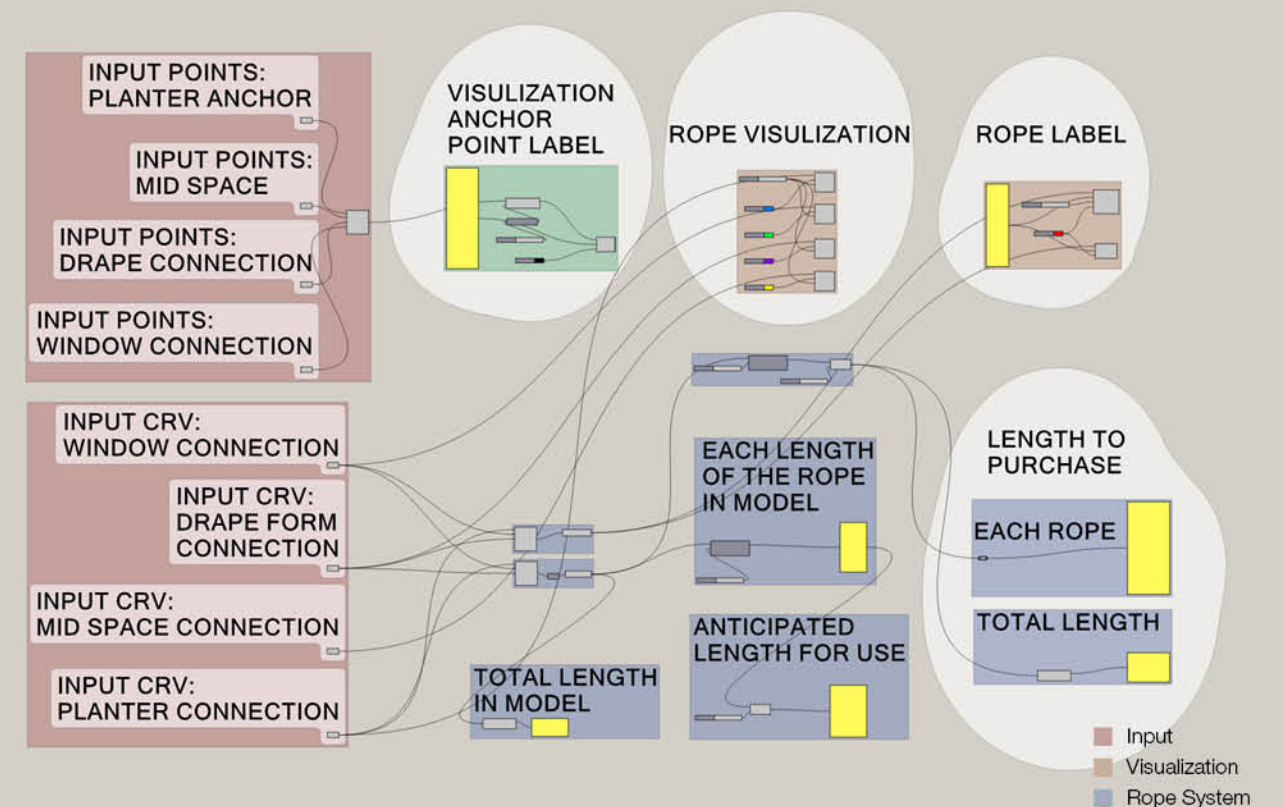
A Moment of Me Solving Real-Time Structural Issues on Site



PARAMETRIC GENERATION OF DRAPE AND COLUMN MESH VOLUMES



PARAMETRIC ROPE VISUALIZATION AND LENGTH CALCULATION WORKFLOW





The CAPTCHA Paradox: From Human Test to Algorithmic Governance

Yunhao Zhong

ARCHA4627: Final Paper
Prof. Ultan Byrne
05/09/2025

Abstract

CAPTCHAs were originally created to block bots. It assigns humans tasks such as recognizing distorted text or selecting images. However, the data produced through these tasks now trains AI to solve them, creating a self-defeating loop. This paper traces the evolution of CAPTCHA, comparing it to authentication systems like passwords and biometrics, and reflects on its unintended roles in AI training and invisible labor. Drawing on Turing’s imitation game and Deleuze’s theory of control, the paper argue that CAPTCHAs have shifted from simple verification tools to mechanisms of algorithmic governance. As AI advances, these systems increasingly blur the line between human and machine, raising critical questions about surveillance, labor, and power in digital infrastructures.

Chapter 1:Introduction

In today’s increasingly automated digital world, much of internet traffic is generated by bots, such as crawlers, scrapers, and fraud programs, rather than human users. In response, websites rely on CAPTCHAs: quick tests asking users to read distorted text, identify objects in images, or click “I’m not a robot” to prove their humanity. This is actually based on a simple idea, that certain visual or behavioral tasks are still easier for people to complete than for machines.

However, this mechanism is so paradoxical. Solving a CAPTCHA also generates training data for the AI that it meant to block. Over time, the defense lose the effect, and it feeds the threat it self. This paper also explores how CAPTCHA has changed over time. It shows how AI has made many CAPTCHAs less effective. Today, CAPTCHAs are not just security tools. They also collect user data and make people do small tasks for free. These ideas are also analyzed using Turing’s imitation game and Deleuze’s theory of control. This shows how a simple tool to stop bots has quietly become part of larger systems of power. CAPTCHA is no longer just about security. It reflects how technology decides who belongs online. But what if, in fact, machines are the ones scoring our behavior, how do we know what version of “human” they are being taught to recognize? We are no longer just users. We are also test subjects. Each click isn’t just a test. It is training the system to decide what “being human” even looks like.

Chapter 2: The Evolution of CAPTCHA

The word “CAPTCHA” means “Completely Automated Public Turing test to tell Computers and Humans Apart.” Researchers at Carnegie Mellon University introduced it in the early 2000s. It was a kind of automated Turing Test. The goal was to tell humans and bots apart.¹ This idea builds on Turing’s 1950 proposal of the “imitation game.” In this test, a machine attempts to pass as human by producing convincing written responses to an interrogator. ² However, unlike the Turing Test, CAPTCHA reverses the roles. A machine now tests a human. It asks the user to prove they are not a bot. This change made CAPTCHA a useful tool to stop bots.

2.1 Text-Based CAPTCHAs

CAPTCHA systems initially emerged in the late 1990s. It often using distorted text images to differentiate human users from automated programs. Luis von Ahn and collaborators formalized the concept of CAPTCHA in 2003 to 2004, framing it as a test designed to distinguish humans from

¹ Luis von Ahn, Manuel Blum, and John Langford, "Telling humans and computers apart automatically," *Communications of the ACM* 47, no. 2 (2004): 58, <https://doi.org/10.1145/966389.966390>.
² Alan M Turing, *Computing machinery and intelligence* (Springer, 2009).

machines. Major platforms such as Yahoo! and Hotmail soon implemented it to prevent automated account creation and curb spam.³

Text-based CAPTCHAs were soon undermined by advances in image processing and computer vision, which enabled machines to segment characters, remove noise, and decode distorted text once meant to fool OCR systems.^{4,5}

2.2 Image-Based CAPTCHAs

In a 2014 blog post, Google reported that its AI could solve even the most complex distorted-text CAPTCHAs with an accuracy of 99.8%, making such tests unreliable for distinguishing humans from bots.⁶ As a result, websites switched to image-based CAPTCHAs. Users were asked to find things like traffic lights or crosswalks, such as in the Google's reCAPTCHA 2, which came out at 2014.^{7,8} These tasks also cleverly used human visual skills but also helped label data for AI. What originally started as a security test became a way to train the computer vision systems. This means users were helping to train AI without knowing it. The line between helping the system and being used by the system becomes very blurry.

2.3 Behavioral and Invisible CAPTCHAs

In 2014, Google introduced NoCAPTCHA, using behavioral cues to assess humanness.^{9,10} In 2018 reCAPTCHA v3 removed visible interaction altogether, silently scoring users in the background based on behavior.¹¹ This evolution aimed to minimize user friction, while maintaining protection. And I would like to ask, what if your behavior doesn't match what the algorithm expects? Are you still human enough to pass?

Other CAPTCHA forms also emerged. Audio CAPTCHAs were designed for accessibility but proved vulnerable to voice recognition software. Recent experimental formats explore visual illusions¹², but as AI improves on the computer vision to mimic human, how can we know it will not be defeated.

So, CAPTCHA continue becoming different forms, text, images, or behavior, but AI soon catches up. And they are often trained on the data users provide while solving them. In this way, CAPTCHA works like a test that always tries to stay one step ahead of machines. And it constantly updating the question: "What can a human still do that a machine can't?". This question becomes harder and harder. At some point, it may no longer be possible to tell who is testing whom. It becomes a game of control, not of safety. The question is no longer about what we can do better than machines, but whether we are teaching them to do everything we once called human.

Chapter 3: The Loop of Defeat

³ Ahn, Blum, and Langford, "Telling humans and computers apart automatically."

⁴ Andrew Searles, Renascence Tarafder Prapty, and Gene Tsudik, "Dazed & Confused: A Large-Scale Real-World User Study of reCAPTCHA v2," *arXiv preprint arXiv:2311.10911* (2023).

⁵ Suphannee Sivakorn, Iasonas Polakis, and Angelos D Keromytis, "I am robot:(deep) learning to break semantic image captchas" (paper presented at the 2016 IEEE European Symposium on Security and Privacy (EuroS&P), 2016).

⁶ "Are you a robot? introducing no captcha recaptcha," Google Security Blog, 2014, 3, <https://developers.google.com/search/blog/2014/12/are-you-robot-introducing-no-captcha> (12).

⁷ Shet, "Are you a robot? introducing no captcha recaptcha."

⁸ "Google reCAPTCHA v2 vs v3: Key Differences and Selection Guide," 2025, accessed May 7th, 2025, <https://blog.geetest.com/en/article/recaptcha-v2-vs-v3>.

⁹ Shet, "Are you a robot? introducing no captcha recaptcha."

¹⁰ "How 'I'm Not a Robot' by reCAPTCHA Works," 2024, accessed May 8th, 2025, <https://medium.com/@vishalbarvaliya/how-im-not-a-robot-by-recaptcha-works-347f618fd1ab>.

¹¹ Wei Liu, "Introducing reCAPTCHA v3: the new way to stop bots," *Google Webmaster Central Blog* (2018).

¹² Ziqi Ding et al., "IllusionCAPTCHA: A CAPTCHA based on visual illusion," *arXiv preprint arXiv:2502.05461* (2025).

CAPTCHAs are always being updated, but AI always finds a way to get past them. At first, a new CAPTCHA can stop the bots. But after some time, AI learns how to solve it by using the answers people gave. Then the CAPTCHA becomes useless. This happens again and again. People make new tests, AI learns, and the tests stop working.

Text CAPTCHAs were the first one to be ineffective. Though once effective, they were broken by smarter segmentation algorithms and deep learning. By 2014, Google actually reported its AI could solve its own hardest text CAPTCHAs with 99.8% accuracy.¹³ Also in the same year, it launched NoCAPTCHA, which used behavioral signals instead of distorted text, showing the going down of traditional methods.¹⁴

Image-based CAPTCHAs then came. But what is quite interesting is that the bots used Google's own tools, such as reverse image search, to solve them.^{15,16} Additionally, Audio CAPTCHAs were cracked using Google's speech program.¹⁷ Then In 2018, reCAPTCHA v3 removed visible challenges altogether, silently scoring users by their clicks, scrolls, and movements.¹⁸ But even this method didn't really work for long. In 2019, some bots learned to act like real people and passed the test.¹⁹ CAPTCHA-solving farms and malware that hijacks real user sessions further weakened the system by allowing bots to appear human.^{20,21}

This has become a never-ending back-and-forth fight. As Von Ahn and colleagues said, a CAPTCHA is "only as secure as the AI problem it relies on." Once that problem is solved, it must be replaced.²² A clear example is reCAPTCHA's role in training self-driving AI.²³ Tasks like "click all the traffic lights" were not just tests, and they were data labeling systems for road scenes. Google's CAPTCHAs have helped label storefronts, addresses, and signs. It has taught bots to navigate the world. Observers have noted how these CAPTCHAs "look suspiciously like methods for collecting training data for improving self-driving cars".²⁴

Even high-level logic tasks like the Winograd Schema have been solved by GPT models.²⁵ So CAPTCHA has become a feedback loop: each challenge strengthens the AI it was meant to block. And it also use unpaid human to input. The more we try to prove we are human, the better machines become at copying us. In a way, each CAPTCHA helps the machine get closer to replacing human action.

In the end, the fight between CAPTCHA and AI is like a cycle. AI keeps getting better and beats each new test. This makes people question if humans really have special thinking skills or recognition skills. CAPTCHA was originally made to stop bots, but now it may be training them to take over the tasks it once defended. This also raises a critical question: is CAPTCHA still about protection, or has it become a disguised form of data extraction? Each time we try to test if someone is human, we help

¹³ Shet, "Are you a robot? introducing no captcha recaptcha."

¹⁴ Shet, "Are you a robot? introducing no captcha recaptcha."

¹⁵ Sivakorn, Polakis, and Keromytis, "I am robot:(deep) learning to break semantic image captchas."

¹⁶ "Why CAPTCHAs have gotten so difficult," 2019, accessed May 7th, 2025, <https://www.theverge.com/2019/2/1/18205610/google-captcha-ai-robot-human-difficult-artificial-intelligence>.

¹⁷ Dzieza, "Why CAPTCHAs have gotten so difficult."

¹⁸ GeeTest, "Google reCAPTCHA v2 vs v3: Key Differences and Selection Guide."

¹⁹ I Akrou, A Feriani, and M Akrou, "Hacking google recaptcha v3 using reinforcement learning. arXiv," (1903).

²⁰ "CAPTCHA Farms: What are they and how can they be stopped?," 2025, accessed May 7th, 2025, <https://www.verifiedvisitors.com/threat-research/captcha-farms>.

²¹ "Behind the CAPTCHA: A Clever Gateway of Malware," McAfee, 2024, accessed May 7th, 2025, <https://www.mcafee.com/blogs/other-blogs/mcafee-labs/behind-the-captcha-a-clever-gateway-of-malware/>.

²² Luis Von Ahn et al., "CAPTCHA: Using hard AI problems for security" (paper presented at the International conference on the theory and applications of cryptographic techniques, 2003), 296.

²³ "Forget security – Google's reCAPTCHA v2 is exploiting users for profit," 2024, accessed May 7th, 2025, https://www.theregister.com/2024/07/24/googles_recaptchav2_labor/.

²⁴ Claburn, "Forget security – Google's reCAPTCHA v2 is exploiting users for profit."

²⁵ Vid Kocijan et al., "The defeat of the Winograd schema challenge," *Artificial Intelligence* 325 (2023).

machines learn to copy human behavior. CAPTCHA no longer separates humans from machines. It makes the difference less clear. If machines can mimic human actions to pass these tests, does it still make sense to ask who the real user is? The border between human and algorithm has become unclear.

Chapter 4: CAPTCHA vs. Passwords (and Other Authentication)

4.1 CAPTCHAs Only Care If You Are Human.

CAPTCHAs are actually different from passwords and biometrics. Passwords and biometrics confirm who you are, based on what you know or what you look like. CAPTCHAs don't care about your identity. They only check if you're a human or not. CAPTCHAs are often used in simple tasks like blog comments or sign-up pages. In these cases, it is more important to stop bots than to know who the user is. So using passwords or biometrics in those situations sometimes is not necessary.

CAPTCHAs act like small checkpoints. They do not ask who you are but decide what you can do at that moment. It's like soft control. People are being watched, even if they don't feel like it. In societies of control, access isn't granted once and for all. Instead of static identification like a signature, it depends on dynamic "codes" like passwords, things that track and regulate behavior over time, keeping access open or closed based on constant modulation.²⁶ So CAPTCHA sort of stands somewhere in between. It does not fully track people like surveillance, but it still controls what people can do for a short time. This kind of subtle, small control may seem harmless, but it shows how access is shaped by hidden systems we do not understand. But this also clearly shows a shift: access is no longer based on trust or identity, but on behavior that can be measured. I want to ask, should access to public digital space depend on invisible scores we never get to see?

4.2 CAPTCHAs Make Life Harder for Humans Too

CAPTCHAs often cause trouble for human users. Unlike passwords, CAPTCHAs cannot be saved or backed up. They often very suddenly interrupt people by suddenly asking people to solve a puzzle or click blurry pictures, which is honestly very annoying and also hard for people with disabilities.

They also push bots to become smarter. To avoid being blocked, developers now teach bots to move the mouse slowly or click in ways that look human.²⁷ So instead of stopping bots completely, CAPTCHAs often just make them better at pretending to be human. People don't know they are being tested, their actions are recorded. The test may be hidden, but the impact is definitely real. Besides, the data can also be used to train AI or track people online, raising concerns about privacy. So, CAPTCHAs not only make life harder for real users, but also help bots improve and collect data in ways most people don't notice.

Chapter 5: How CAPTCHAs Serve Companies and Use people's Time

5.1 How Companies Use CAPTCHAs to Protect Their Business

CAPTCHAs not only block bots but also help protect some companies' business interests. As noted, they prevent automated account creation and ad fraud, which cost companies over \$84 billion in 2023.²⁸ Google offers reCAPTCHA for free because it protects its advertising network.²⁹ Websites like

²⁶ Gilles Deleuze, "Postscript on the Societies of Control," in *Surveillance, crime and social control* (Routledge, 2017), 5.

²⁷ Jiahua Liu et al., "DMTG: A Human-Like Mouse Trajectory Generation Bot Based on Entropy-Controlled Diffusion Networks," *arXiv preprint arXiv:2410.18233* (2024).

²⁸ "Click Bots 101: 10 Must-Know Tips for Effective Prevention and Detection," 2024, accessed May 9th, 2025, <https://www.wisegrowthmarketing.com/click-bots/>.

²⁹ "What is reCAPTCHA?," 2025, accessed May 9th, 2025, <https://developers.google.com/recaptcha>.

JSTOR also use it to stop bots from quickly copying large amounts of data.³⁰ In these cases, CAPTCHAs help slow down bots and let real people go through more easily.

5.2 Millions Work for Free Without Knowing It

Humans also played a role in labeling data. For example, in reCAPTCHA v1, users unknowingly did a huge amount of work to help digitize printed books. Within one year, they had transcribed over 440 million words.³¹ For the reCAPTCHA v2, Prompts like "select all buses" not only verify users but also train AI for applications such as self-driving and mapping. In 2019, users spent 819 million hours solving reCAPTCHA, equivalent to \$6.1 billion in free labor.³² A 2024 study from UC Irvine said reCAPTCHA v2 is not really about security. Instead, it lets companies collect free image labels and track users to make money from ads and data.³³ Other firms such as hCaptcha monetize this labor openly, offering payment or donations in exchange for CAPTCHA hosting, then selling labeled data to machine learning clients.³⁴ What at first looks like security is also hidden work. Platforms make it seem like helping the public, but it is unpaid labor. In fact, this raises a deeper question. Why are people working for free to train machines that might one day replace them? To pass a CAPTCHA, we're asked to click traffic lights, but behind that, we're teaching AI how to see the world. The system says it's for security, but to be honest, it's collecting data to improve commercial technologies. And we don't get any money or even told what our work is being used for. And this is actually very strange. We perform tasks to prove we're not robots, but those tasks make robots more like us. It's like a test human can never win. We're unpaid workers helping machines get smarter.

Chapter 6: Control and Algorithmic Power

6.1 People are the One Being Tested Now

While Alan Turing proposed that machines should imitate humans, today's CAPTCHAs flip that idea. Now, machines test users by watching how they move the mouse, scroll the page, and click. Each action gets scored quietly in the background. You become a data point, not a person. But what if, for some reason, your performance changes, because you're sick, distracted, or just different? Does that mean you're no longer human enough? This seems to mean that humanity is actually being judged by a nonhuman now, and that our behavior is also being shaped by this mechanism. Is that fair?

With reCAPTCHA v3, there are no questions, just silent judgment.³⁵ There was even a case where GPT-4 asked a real person on TaskRabbit to help it solve a CAPTCHA, meaning it passed the test by getting help from a human.³⁶ This shows a bigger change: as the philosopher Deleuze described, today's systems don't care who you are. They care how you behave.³⁷ Access is now, quite literally, given not based on your name or identity, but on how your actions look to a machine. In the end, you're judged not by what you is, but by how you move.

6.2 CAPTCHA Makes People Obey

³⁰ "eAccess Troubleshooting Guide: JSTOR," 2024, accessed May 9th, 2025, <https://researchguides.smu.edu.sg/c.php?g=944224&p=6839136>.

³¹ Luis Von Ahn et al., "recaptcha: Human-based character recognition via web security measures," *Science* 321, no. 5895 (2008): 1465.

³² Claburn, "Forget security – Google's reCAPTCHA v2 is exploiting users for profit."

³³ Searles, Prapty, and Tsudik, "Dazed & Confused: A Large-Scale Real-World User Study of reCAPTCHA v2."

³⁴ "Suspicious of Google's reCaptcha? Here's a popular alternative," 2019, accessed May 7th, 2025, <https://www.fastcompany.com/90377406/suspicious-of-googles-recaptcha-heres-a-popular-alternative>.

³⁵ Liu, "Introducing reCAPTCHA v3: the new way to stop bots."

³⁶ "Chat-GPT Pretended to Be Blind and Tricked a Human Into Solving a CAPTCHA," 2023, accessed May 7th, 2025, <https://gizmodo.com/gpt4-open-ai-chatbot-task-rabbit-chatgpt-1850227471>.

³⁷ Deleuze, "Postscript on the Societies of Control," 5.

Each CAPTCHA task, such as clicking traffic lights or storefronts, creates training data. This unpaid micro-labor is often overlooked. Scholars such as Couldry and Mejias call this "data colonialism," meaning companies take human behavior and use it for profit under corporate control.³⁸ In this system, users work not because they choose to, but because they have to. If they refuse, they cannot move forward.

By 2019, CAPTCHAs had generated over 800 million hours of invisible work.³⁹ The system is necessary because users must complete the task to continue. As these tests become less visible and turn into behavior tracking, the imbalance grows. You can't say no, because saying no means getting locked out. That's not a choice. It's control. What used to feel like just a quick step has now become a way to watch and measure you. You are paying with your time just to stay online.

Chapter 7: Conclusion

CAPTCHAs used to be simple tests to block bots. But today, they do much more. Each time we click, we help train AI, often without knowing it, without getting anything in return. Over time, these tools have quietly turned into systems that collect data, shape access, and control how we move online. As machines get better at copying us, we need to pause and ask: Are we really still in charge of the internet, or are we just helping it run? And if machines are learning from us, shouldn't we at least be told, or even credited? This is about privacy, fairness, and what it means to be part of a digital world.

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³⁸ Nick Couldry and Ulises A Mejias, "The costs of connection: How data is colonizing human life and appropriating it for capitalism," in *The costs of connection* (Stanford University Press, 2019), ix-xxiii.

³⁹ Claburn, "Forget security – Google's reCAPTCHA v2 is exploiting users for profit."

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“Architecture is no longer built. It is computed, contested, and collectively enacted. In an age where intelligence is automated and governance is algorithmic, the last critical act of the architect is to decide — not what to build, but what systems to set in motion, and for whom.”