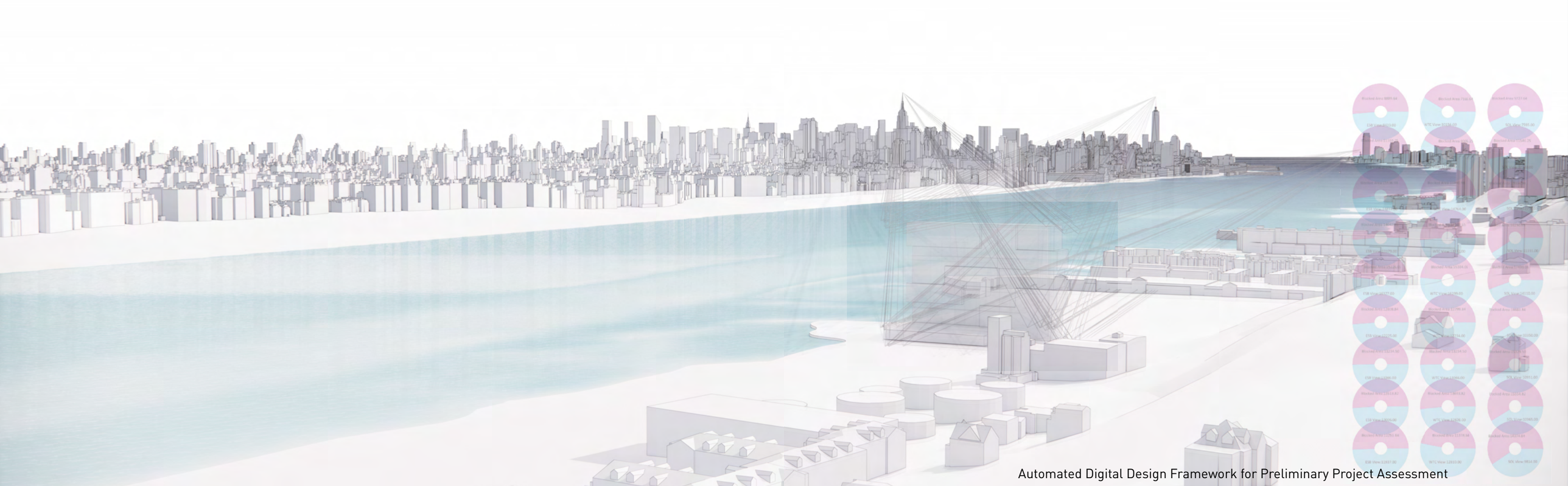


Automated Digital Design Framework for Preliminary Project Assessment

DIGITAL WORKFLOW IN ARCHITECTURAL PRACTICE VOL.01

SEMI-AUTOMATION IN ARCHITECTURE

3D Framework to Support Data Driven Decision Making in Preliminary Project Assessment

H Architecture

This research paper was written and edited by Dongil Kim, Jake Jaekyung Han, John Hanghyun Cho at H Architecture, 2022.

H Architecture

Automated Digital Design Framework for Preliminary Project Assessment

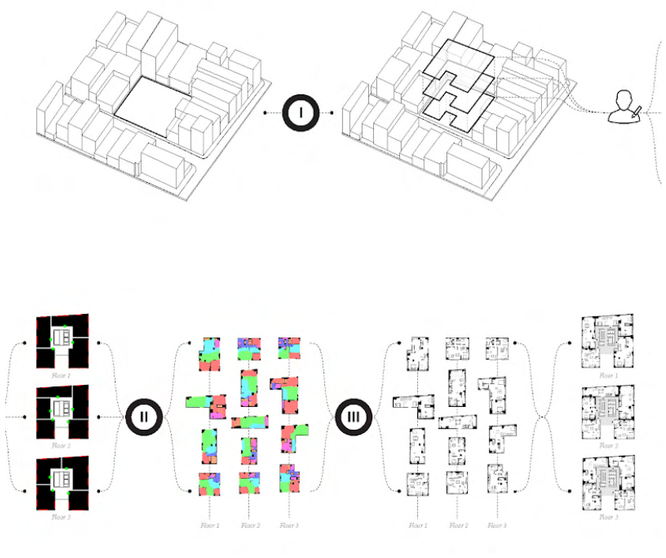
DIGITAL WORKFLOW IN ARCHITECTURAL PRACTICE VOL.01

H Architecture

CONTENTS

INTRODUCTION

Apartment building generation pipeline, ArchiGAN: a Generative Stack for Apartment Building Design, Stainslas Chaillous, Nvidia, USA



Introduction

Automated Digital Workflow In Architectural Practice

The preliminary project assessment in architectural practice is to establish a framework and requirements regarding both tangible and intangible context in Pre-design Phase(PD). A Pre Design Phase document often includes; the project goal, site selection, site analysis, zoning analysis, programming, cost analysis, and pro forma, establishing a general guideline and the entire project scope.

The preliminary project assessment, however, requires meticulous numerical data analysis and calculation since these numbers directly affect the project feasibility. Compared to other architectural design phases, the PD phase requires a proportionally substantial amount of time to derive necessary data and tabulate those numbers for a pro forma.

This research investigate automatic data tabulation and visualization methods with simple geometric and numerical inputs, The proposed process requires less time and effort on repetitive manual data extraction and input processing, resulting architects and designers can focus their effort on more creative works.

OBJECTIVE

Semi-automated Preliminary Project Assessment

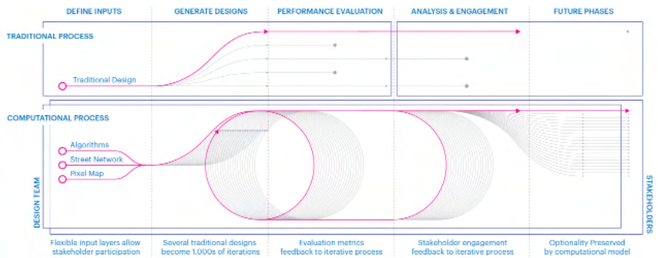
Comparison of traditional master planning process (top) with CUrbD methodology (bottom), How to Generate a Thousand Master Plans: A Framework for Computational Urban Design, Luc Wilson, Jason Danforth, Carlos Cerezo Davila, and Dee Harvey, KPF, New York, USA

SEMI-AUTOMATED PRELIMINARY PROJECT ASSESSMENT

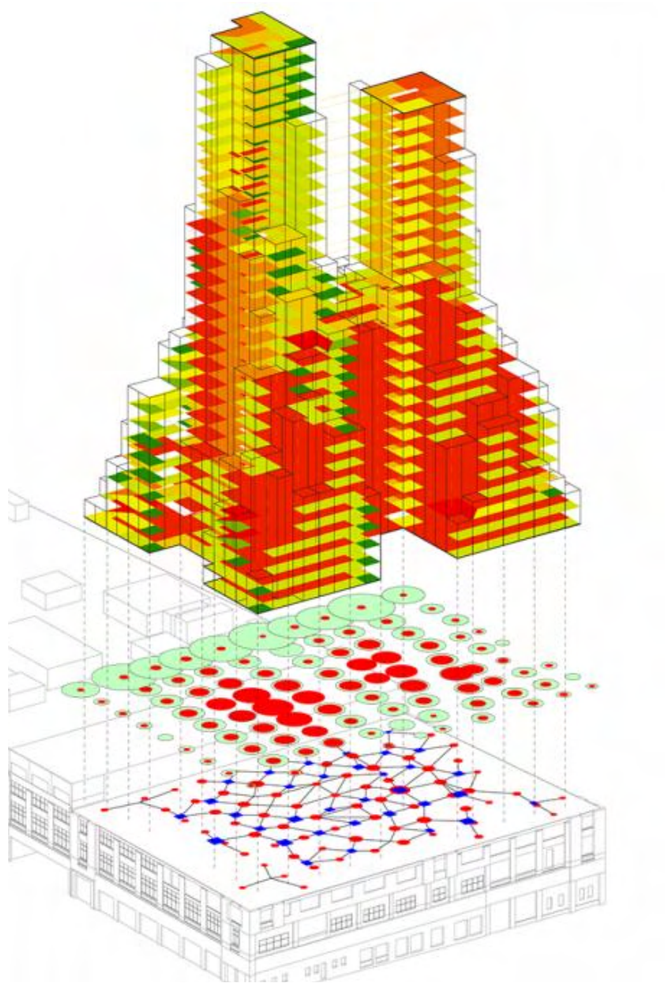
Automation in Architecture

The advancement in Building Information Modeling (BIM) has drastically transformed the architecture discipline; design process, information exchange, product delivery, and construction. While the previous Computer-Aided Design (CAD) model only included geometric information, a BIM model includes many other data associated with the geometry.

The BIM model enabled designers to adjust the design that meets required standards with instantaneous data feedback during the course of the design process. The development of artificial intelligence (AI) and BIM data encourages the diverse range of CAD-CAM software and recently many different diciplines such as architect, designer, and software engineer introduce wide range of analysis and design platform. For example, ‘Flexity’ by Edit Collective, South Korea, provides volumetric suggestions and corresponding cost/profit analysis; ‘Landbook’ by Spacewalk, South Korea, provides potential investment cost and profit of properties currently for sale, or new constructions especially mid-rise building development. While the above-mentioned products focus on investment opportunities, some products focus more on design. ‘ArchiGAN: a Generative Stack for Apartment Building Design’ by Stanislas Chaillou, NVIDIA, USA, utilizes machine learning to mimic an architect’s design. ‘KPFui’ by KPF, USA, is a set of evaluation tools and data analytics to resolve competing objectives and facilitate the design.



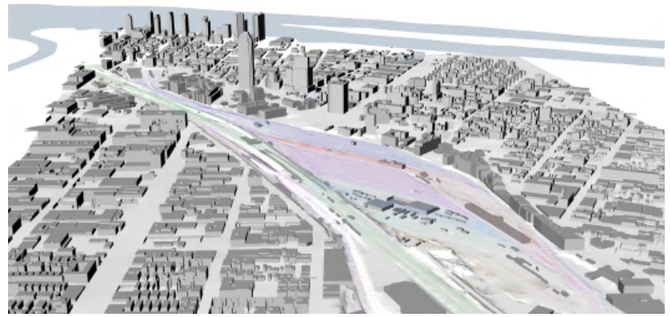
TT Toolbox by Thornton Tomasetti, Core Studio

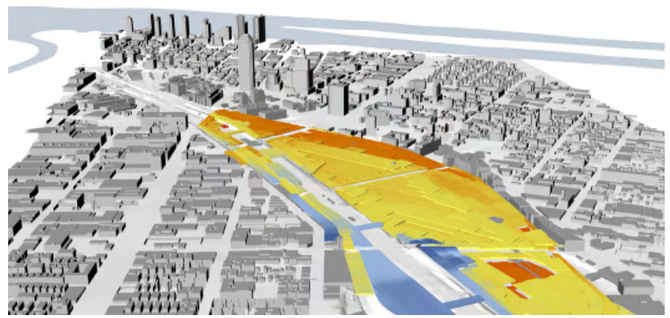


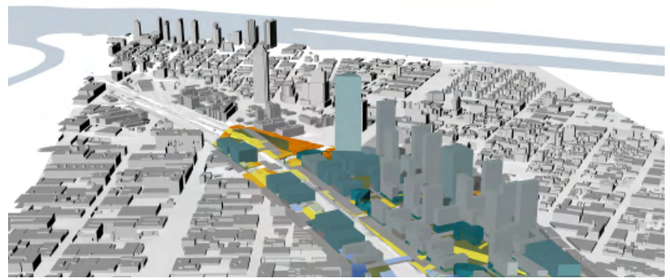
The software first extracts relevant information/parameters from a pool of available data such as site context, zoning regulation, and topography. Then, the AI engine generates design solutions based on those parameters. The resulting design options are analyzed to determine the optimal solution for the project. Although AI in architecture enhances the speed and efficiency of the design process, the the sole use of the AI based design automation has limited to the complexity of software and allowable quantifiable data set.

The objective of this research is semi-automated design methods, which combine human intuition and machine processing. A designer provides simple input data such as building volume model and lot boundary. Simultaneously, the proposed custom tool set computes those inputs, generates corresponding data, and visualizes a set of applicable information for initial design decision-making.

Top: Rail line locations were inherited from local authorities, Yards Modeling, CORE Studio
Middle: Heat map showing structural span and depth, Yards Modeling, CORE Studio
Bottom: Overbuild proposal, Yards Modeling, CORE Studio







METHODOLOGY

01. Area Tabulation
02. Parking Solution
03. Contextual Analysis
04. Visualization

Methodology

Semi-automated Preliminary Project Assessment

The pre-requisite for this research is volumetric models created based on multiple criteria; regulations, preferences, environmental data analysis, and many more. The methods introduced in this research are tools for adjusting the options and decision-making. This research contains four categories: Area Tabulation, Parking Solution, Environmental Analysis, and Data Visualization. There is no specific order between each set beside the visualization, which comes last.

Area Tabulation utilizes Rhinoceros, Grasshopper, Microsoft (MS) Excel, and 'TT Toolbox,' a Grasshopper plugin, which allows data exchange between Grasshopper and Microsoft Excel. Rhinoceros is an excellent tool for creating and adjusting a volumetric model, Grasshopper is a great tool for parametric data management, and MS Excel is an intuitive tool for input data management. Designers can manage input data using the most intuitive software, and a set of Grasshopper codes automatically tabulates corresponding data.

Parking solution utilizes Rhinoceros, Grasshopper, and Grasshopper plugins- 'Parking Solver' and 'Galapagos'. Parking Solver generates parking solutions based on simple geometric and numerical input. The combination of Galapagos, a one-dimensional optimization tool, and Parking Solver generates parking layouts with the most stall counts. While Parking Solver excels at surface parking solutions. Yet, it requires some improvement for indoor parking solutions. For PD phase purposes, however, Parking Solver is suitable software to generate general parking strategies and the approximate number of parking stalls.

The contextual analysis is to investigate indoor view conditions utilizing Rhinoceros, Grasshopper, and Grasshopper plugins-'Ladybug' and 'Honeybee.' 'Ladybug' and 'Honeybee' generate View analysis, Radiation analysis, and Shadow analysis Based on the input geometry. The view analysis is comprise of two parts; the broad view range and the view range toward specific landmarks.

Lastly, Data Visualization in last chepter of the research utilizes 'Conduit', a Grasshopper plugin, to visualize all of the simulations and analyses of the research. Conduit allow designers to graphically compare the numeric data for decision-making in effective way.

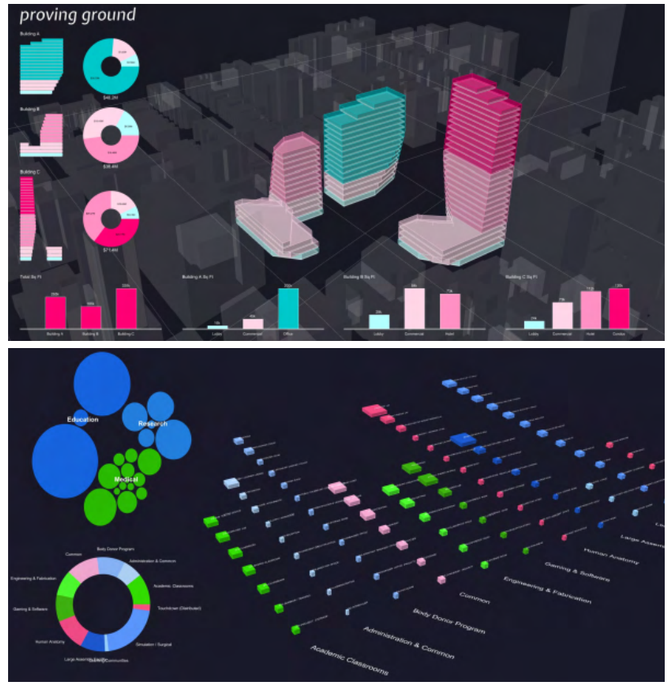
Area Tabulation

Area tabulation is one of the crucial products in a preliminary project assessment. Generally, an area tabulation includes but is not limited to Floor, Height, Level, Gross Floor Area (GFA), Deduction Area, Zoning Floor Area (ZFA, GFA-Deduction Area), and Program. The information included in an area tabulation is the basis for project feasibility analysis. After establishing project requirements and objectives, Clients, architects, and sometimes other consultants spend many hours and efforts reviewing and updating Preliminary Design Options and corresponding Area Tabulation for decision-making processes as the design changes. While Building Information Modeling (BIM) software such as Autodesk Revit can simultaneously update area tabulation based on geometric data, BIM software is limited to those who can afford it and has some expertise in the BIM process. Often, designers spend many hours on the repetitive task of updating the area tabulation

On the other hand, Rhinoceros and Excel are more affordable and intuitive tools for initial design stage. Designing a volumetric model in Rhinoceros and tabulating in Excel are prevalent methods to create a wide range of preliminary area based tabulation. The Major absent of the definition is no simultaneous update due to the limit of interoperability.

This chapter introduces a Grasshopper plug-in, TT Toolbox, which enables data exchange between Rhinoceros, Grasshopper, and Excel, to intuitively manage input geometry and numerical data to semi-automatically generate an area tabulation as an open source framework during design update.

Top & Bottom - Conduit, open source custom data representation tool developed by Proving Ground



EXCEL INPUT FACTORS

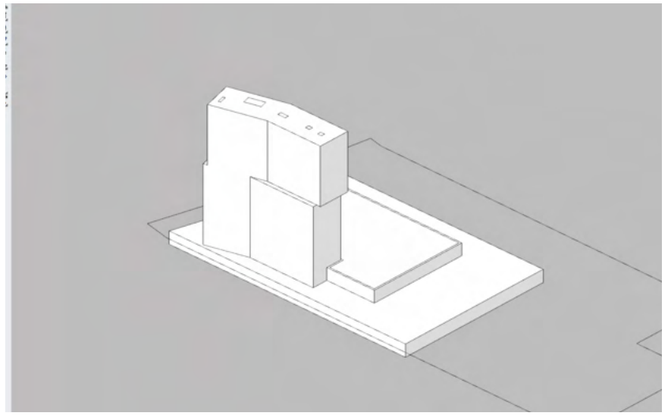
	A	B	C	D	E	F	G	H
1	Floor	Height	Level	Type		Floor	Height	Level
2	1	20	0	Lobby		B1F	10	-10
3	2	10	20	Lobby		B2F	10	-20
4	3	20	30	Common				
5	4	12	50	Mech				
6	5	20	62	Common				
7	6	20	82	Common				
8	7	15	102	Residential				
9	8	12	117	Residential				

RELATED REGULATIONS

New Jersey State Housing Code, NJAC 5:28, 2017

Dwelling unit	any room or group of rooms or any part thereof located within a building and forming a single habitable unit with facilities which are used, or designed to be used for living, sleeping, cooking, and eating.
Occupant	any person or persons in actual possession of, and living in the building or dwelling unit, including the owner.
	(a) Every dwelling unit shall contain at least 150 square feet of floor space for the first occupant thereof and at least 100 additional square feet of floor space for every additional occupant thereof, the floor space to be calculated on the base of total habitable room area. (b) Every room occupied for sleeping purposes by one occupant shall contain at least 70

PRE-DEFINED BUILDING VOLUME



Input for semi-automated area tabulation

1) Floors, Heights, Programs in Excel raw

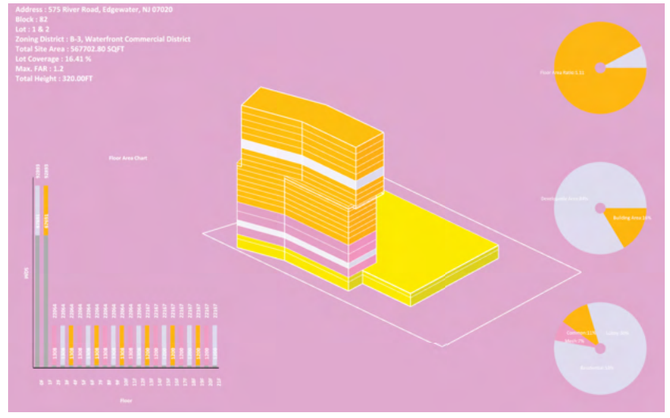
2) Pre-designed building volume in GH environment

3) Related regulations for Floor area calculation

DATA FACT SHEET - EXCEL

	A	B	C	D	E	F	G	H
1	Floor	Height (ft)	Level (ft)	Program	G.F.A. (sqft)	Core Area (sqft)	Deduction Area (sqft)	Z.F.A. (sqft)
2	B2F	10 ft	-20 ft	Parking	226269 sqft	-	-	-
3	B1F	10 ft	-10 ft	Service	226269 sqft	-	-	-
4	1F	20 ft	0 ft	Lobby	87550 sqft	1019 sqft	75860 sqft	11689 sqft
5	2F	10 ft	20 ft	Lobby	110534 sqft	1019 sqft	75860 sqft	34673 sqft
6	3F	20 ft	30 ft	Common	45959 sqft	1019 sqft	288 sqft	45670 sqft
7	4F	12 ft	50 ft	Mech	45959 sqft	1019 sqft	288 sqft	45670 sqft
8	5F	20 ft	62 ft	Common	45959 sqft	1019 sqft	288 sqft	45670 sqft
9	6F	20 ft	82 ft	Common	45959 sqft	1019 sqft	288 sqft	45670 sqft
10	7F	15 ft	102 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
11	8F	12 ft	117 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
12	9F	12 ft	129 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
13	10F	12 ft	141 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
14	11F	12 ft	153 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
15	12F	12 ft	165 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
16	13F	12 ft	177 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
17	14F	12 ft	189 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
18	15F	12 ft	201 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
19	16F	12 ft	213 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
20	17F	20 ft	225 ft	Mech	44330 sqft	911 sqft	288 sqft	44041 sqft
21	18F	15 ft	245 ft	Residential	44330 sqft	911 sqft	288 sqft	44041 sqft
22	19F	15 ft	260 ft	Residential	44330 sqft	911 sqft	288 sqft	44041 sqft
23	20F	15 ft	275 ft	Residential	44330 sqft	911 sqft	288 sqft	44041 sqft
24	21F	15 ft	290 ft	Residential	44330 sqft	911 sqft	288 sqft	44041 sqft
25	22F	15 ft	305 ft	Residential	44330 sqft	911 sqft	288 sqft	44041 sqft
26					1560037 sqft	21132 sqft	157500 sqft	949998 sqft

DESIGN FACT SHEET - RHINO VIEWPORT



Output

1) Data Fact Sheet - Excel output sheet

2) Design Fact Sheet - Custom representation over Rhino viewport

2018 International Building Code, New Jersey Edition, 2nd Ver. Oct 2019

Building Area	The area included within surrounding exterior walls, or exterior walls and fire walls, exclusive of vent shafts and courts. Areas of the building not provided with surrounding walls shall be included in the building area if such areas are included within the horizontal projection of the roof or floor above.
Gross Floor Area	The floor area within the inside perimeter of the exterior walls of the building under consideration, exclusive of vent shafts and courts, without deduction for corridors, stairways, ramps, closets, the thickness of interior walls, columns or other features. The floor area of a building, or portion thereof, not provided with surrounding exterior walls shall be the usable area under the horizontal projection of the roof or floor above. The gross floor area shall not include shafts with no openings or interior courts.
Net Floor Area	The actual occupied area not including unoccupied accessory areas such as corridors, stairways, ramps, toilet rooms, mechanical rooms and closets.
Gross Leasable Area	The total floor area designed for tenant occupancy and exclusive use. The area of tenant occupancy is measured from the centerlines of joint partitions to the outside of the tenant walls. All tenant areas, including areas used for storage, shall be included in calculating gross leasable area.
Habitable Space	A space in a building for living, sleeping, eating or cooking. Bathrooms, toilet rooms, closets, halls, storage or utility spaces and similar areas are not considered habitable spaces.

New Jersey Zoning Land Use Codes

Zoning Floor Area	The area of all floors computed by using the dimensions of the outside walls of each floor of a building. Only those areas having completed floors, ceilings generally (not always) may be considered in computing the second floor area of a one-and-one-half-story house and at least 1/2 of the included second floor area shall have a minimum ceiling height of seven feet six inches. Cellars (but not basements), porches, balconies, patios, terraces, breezeways, enclosed pedestrian walkways, carports, verandas and garages are excluded, as is enclosed parking for nonresidential use except that enclosed porches and patios which are heated and used year-round shall be counted in computing the floor area.
Floor Area Ratio (FAR)	The sum of the area of all floors of buildings or structures compared to the total area of the site.
Lot Coverage	The portion of the lot covered by impervious surfaces and expressed as a percentage in which the numerator is the area of the lot covered by impervious surfaces, and the denominator is the gross area of the lot.

Municipal Code Of The Borough of Edgewater, Ner Jersey

Gross Floor Area (GFA)	The sum of the gross horizontal areas of the several floors of a building measured from the exterior walls of the building, but not including interior parking spaces.
Floor Area	The sum of the gross horizontal areas of the several floors of a building. "Floor area," for the purposes of imposing parking calculations, shall not include areas devoted to mechanical equipment serving the building, stairways and elevators, interior areas devoted exclusively to parking and loading for motor vehicles or to any space where the floor-to-ceiling height is less than seven feet, provided that no more than 15% of the gross area may be reduced for these common area calculations.
Floor Area Ratio (FAR)	The sum of the area of all floors of buildings or structures compared to the total area of the site.

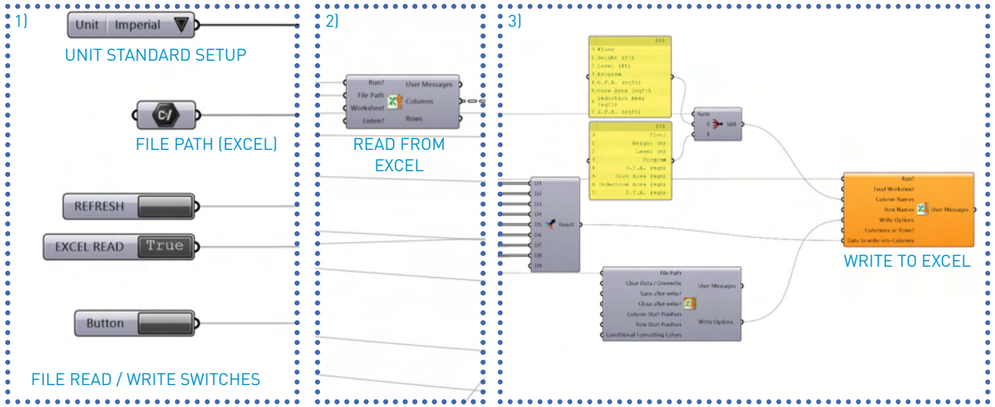
New Jersey State Housing Code, NJAC 5:28, 2017

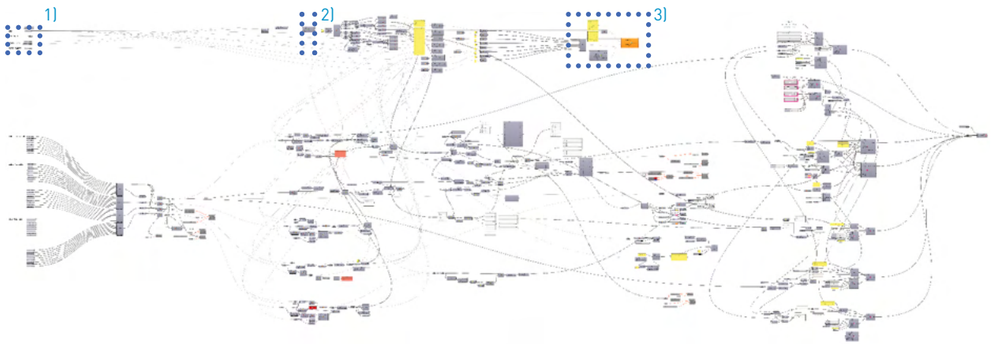
Dwelling unit	any room or group of rooms or any part thereof located within a building and forming a single habitable unit with facilities which are used, or designed to be used for living, sleeping, cooking, and eating.
Occupant	any person or persons in actual possession of, and living in the building or dwelling unit, including the owner.
Use and occupancy of space	(a) Every dwelling unit shall contain at least 150 square feet of floor space for the first occupant thereof and at least 100 additional square feet of floor space for every additional occupant thereof, the floor space to be calculated on the base of total habitable room area. (b) Every room occupied for sleeping purposes by one occupant shall contain at least 70 square feet of floor space, and every room occupied for sleeping purposes by more than one occupant shall contain at least 50 square feet of floor space for each occupant thereof. (c) At least one-half of the floor area of every habitable room shall have a ceiling height of at least seven feet. The floor area of that part of any room where the ceiling is less than five feet shall not be considered as part of the floor area in computing the total floor area in the room for the purpose of determining the maximum permissible occupancy thereof. (d) A room located in whole or in part below the level of the ground may be used for sleeping provided that the walls and floors thereof in contact with the earth have been damp-proofed in accordance with a method approved by the Administrative Authority; and provided that all requirements otherwise applicable to habitable rooms generally are satisfied.

Area Definition Standard

1) Check area definition in accordance to the relevant regulation

2) Check gross and deduction area for legally acceptable floor area





Set units

1) Set units to metric or imperial, depending on the locale of the project

2) Create excel file with assigned unit

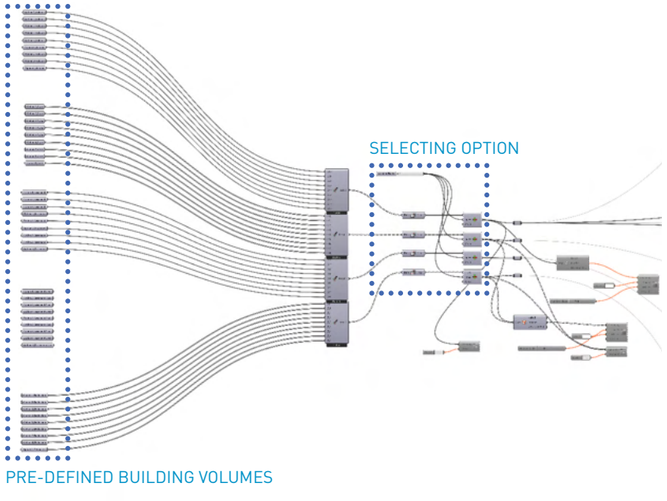
	A	B	C	D	E	F	G	H
1	Floor	Height	Level	Type		Floor	Height	Level
2	1	20	0	Lobby		B1F	10	-10
3	2	10	20	Lobby		B2F	10	-20
4	3	20	30	Common				
5	4	12	50	Mech				
6	5	20	62	Common				
7	6	20	82	Common				
8	7	15	102	Residential				
9	8	12	117	Residential				
10	9	12	129	Residential				
11	10	12	141	Residential				
12	11	12	153	Residential				
13	12	12	165	Residential				
14	13	12	177	Residential				
15	14	12	189	Residential				
16	15	12	201	Residential				
17	16	12	213	Residential				
18	17	20	225	Mech				
19	18	15	245	Residential				
20	19	15	260	Residential				
21	20	15	275	Residential				
22	21	15	290	Residential				
23	22	15	305	Residential				
24								
25								

INPUT (from EXCEL to GH)
NUMBER OF FLOORS
HEIGHTS
PROGRAMS

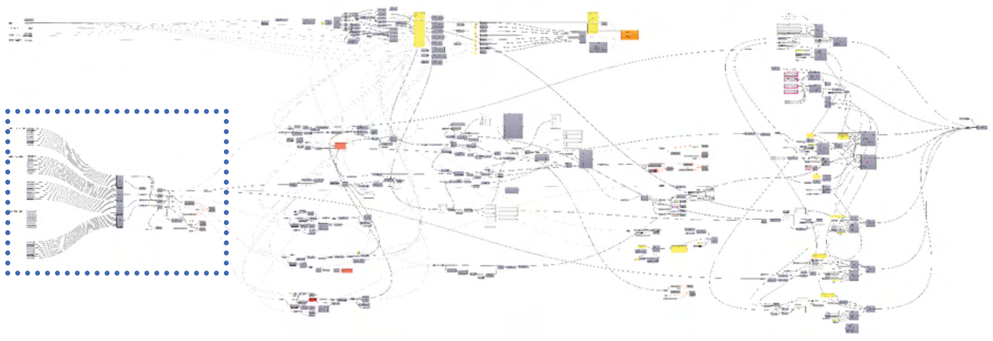
Import data from Excel

1) Create Excel file with input for representation

2) Read pre-defined Excel file to GH



PRE-DEFINED BUILDING VOLUMES



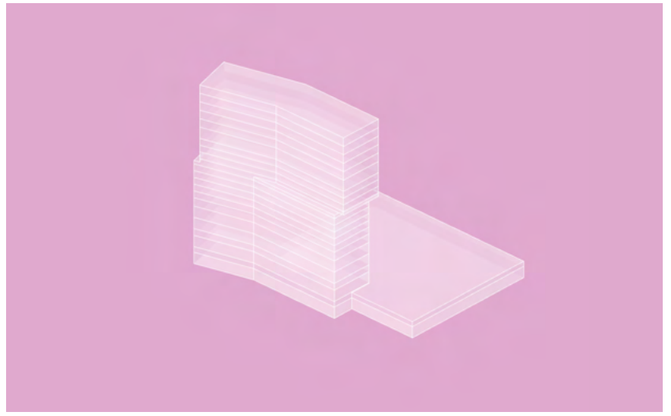
Connect Excel file to Pre-defined

1) Create Excel file with two distinctive sheets - Input / Output

2) Connect input factors to the building volume through TT toolbox

	A	B	C	D	E	F	G	H
1	Floor	Height	Level	Type		Floor	Height	Level
2	1	20	0	Lobby		B1F	10	-10
3	2	10	20	Lobby		B2F	10	-20
4	3	20	30	Common				
5	4	12	50	Mech				
6	5	20	62	Common				
7	6	20	82	Common				
8	7	15	102	Residential				
9	8	12	117	Residential				
10	9	12	129	Residential				
11	10	12	141	Residential				
12	11	12	153	Residential				
13	12	12	165	Residential				
14	13	12	177	Residential				
15	14	12	189	Residential				
16	15	12	201	Residential				

INPUT PARAMETERS IN EXCEL

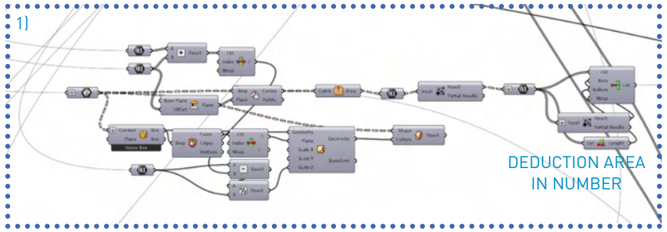


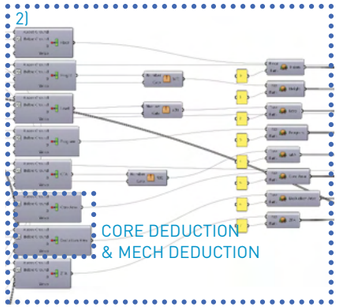
IMPORTED HEIGHT/LEVEL DATA FROM EXCEL

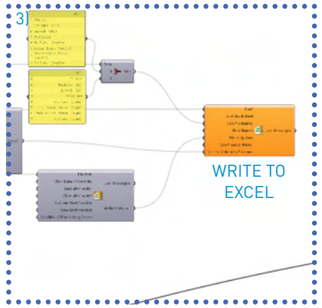
Assign Floor Geometry based on Excel

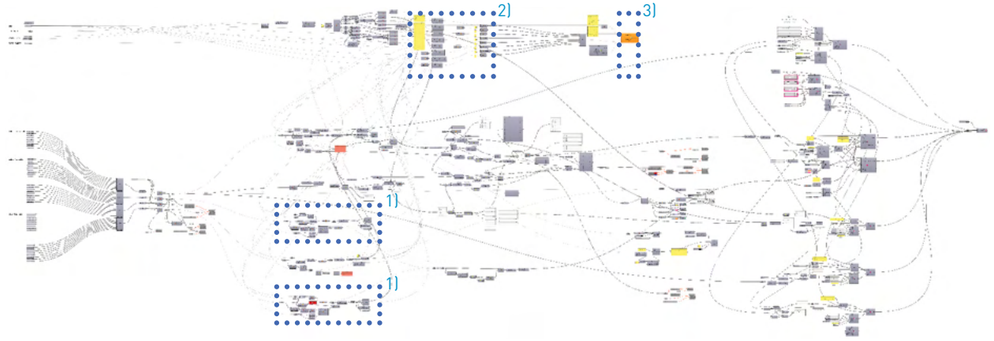
1) Connect height values in excel to the building volume by contouring

2) Extrude and sort floors using level & type value





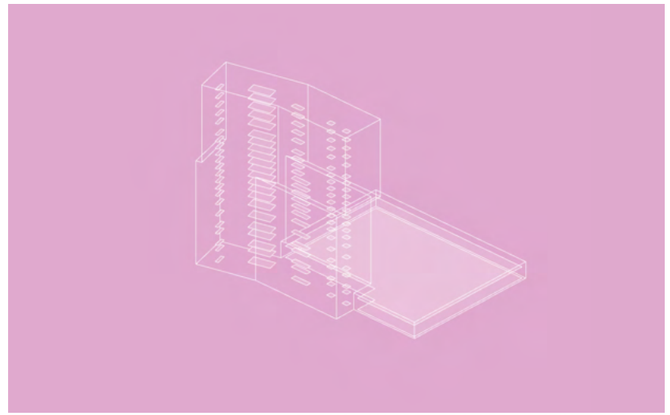




Assign deduction & core area

1) Create deduction volume for area calculation (in accordance to the regulations)

2) Connect height and level to the deduction volume



DEDUCTION AREA FROM PRE-DEFINED VOLUME

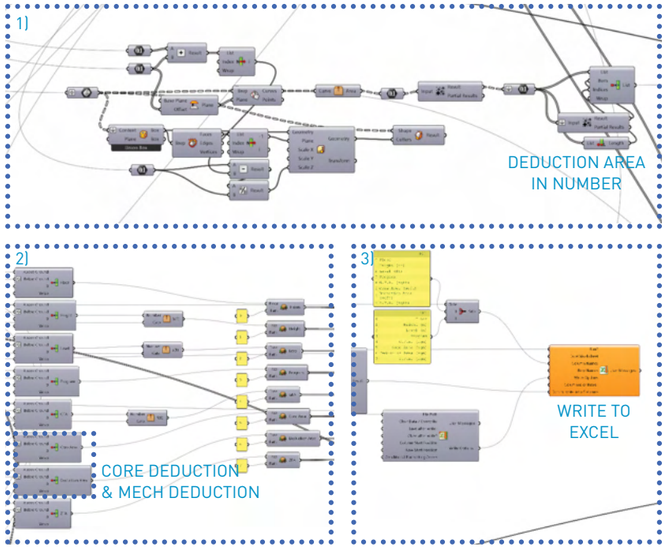
	A	B	C	D	E	F	G	H
1	Floor	Height (ft)	Level (ft)	Program	G.F.A. (sqft)	Core Area (sqft)	Deduction Area (sqft)	Z.F.A. (sqft)
2	B2F	10 ft	-20 ft	Parking	226269 sqft	-	-	-
3	B1F	10 ft	-10 ft	Service	226269 sqft	-	-	-
4	1F	20 ft	0 ft	Lobby	87550 sqft	1019 sqft	75860 sqft	11689 sqft
5	2F	10 ft	20 ft	Lobby	110534 sqft	1019 sqft	75860 sqft	34673 sqft
6	3F	20 ft	30 ft	Common	45959 sqft	1019 sqft	288 sqft	45670 sqft
7	4F	12 ft	50 ft	Mech	45959 sqft	1019 sqft	288 sqft	45670 sqft
8	5F	20 ft	62 ft	Common	45959 sqft	1019 sqft	288 sqft	45670 sqft
9	6F	20 ft	82 ft	Common	45959 sqft	1019 sqft	288 sqft	45670 sqft
10	7F	15 ft	102 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
11	8F	12 ft	117 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
12	9F	12 ft	129 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
13	10F	12 ft	141 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
14	11F	12 ft	153 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
15	12F	12 ft	165 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
16	13F	12 ft	177 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
17	14F	12 ft	189 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
18	15F	12 ft	201 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
19	16F	12 ft	213 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
20	17F	20 ft	225 ft	Mech	44330 sqft	911 sqft	288 sqft	44041 sqft
21	18F	15 ft	245 ft	Residential	44330 sqft	911 sqft	288 sqft	44041 sqft
22	19F	15 ft	260 ft	Residential	44330 sqft	911 sqft	288 sqft	44041 sqft
23	20F	15 ft	275 ft	Residential	44330 sqft	911 sqft	288 sqft	44041 sqft

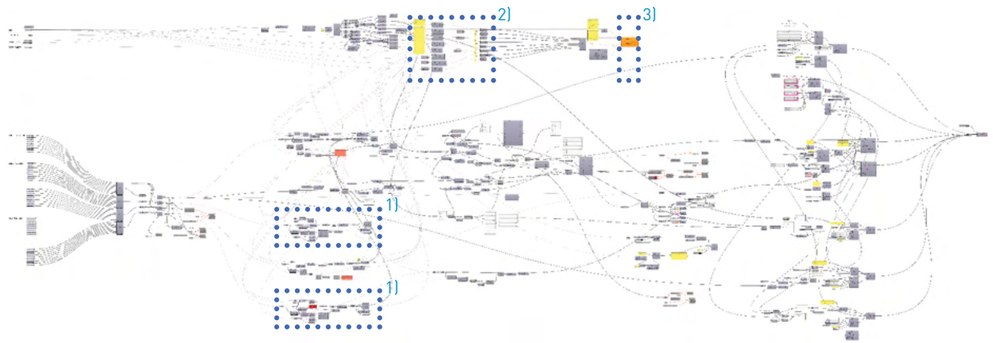
EXPORTED DEDUCTION AREA IN EXCEL

Export deduction & core area to the Excel

1) Create deduction volume for area calculation (in accordance to the regulations)

2) Connect height and level to the deduction volume

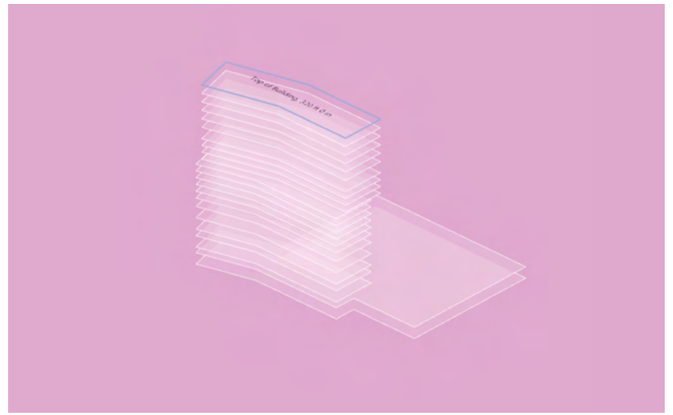




Import building height

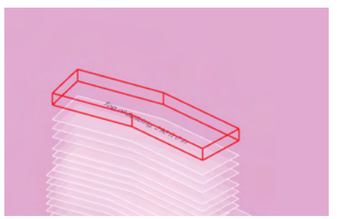
1) Subtract deduction area from the gross floor area

2) Check the overall height is under top of the building volume (Blue box)



VOLUME & EXCEL IS HAVING IDENTICAL TOTAL HEIGHTS

VOLUME IS HIGH ENOUGH

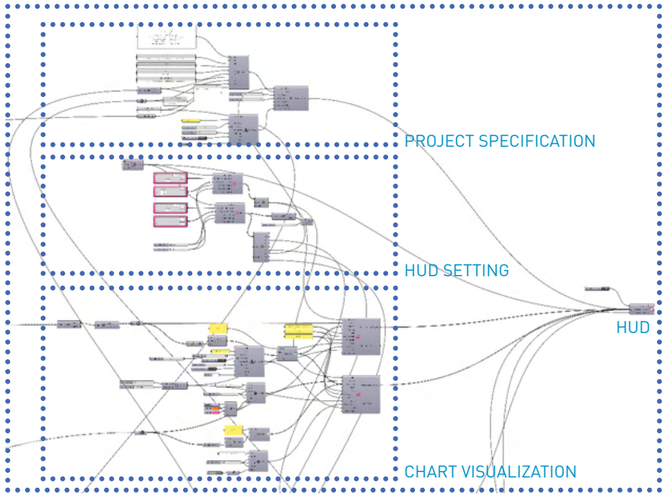


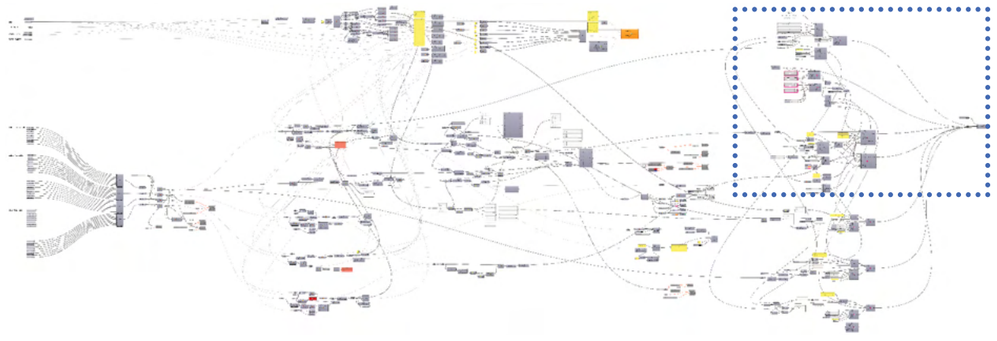
VOLUME REQUIRES MORE HEIGHTS

Check total building height

1) Create text message with total building height

2) In case the Red box appears, adjust the building volume

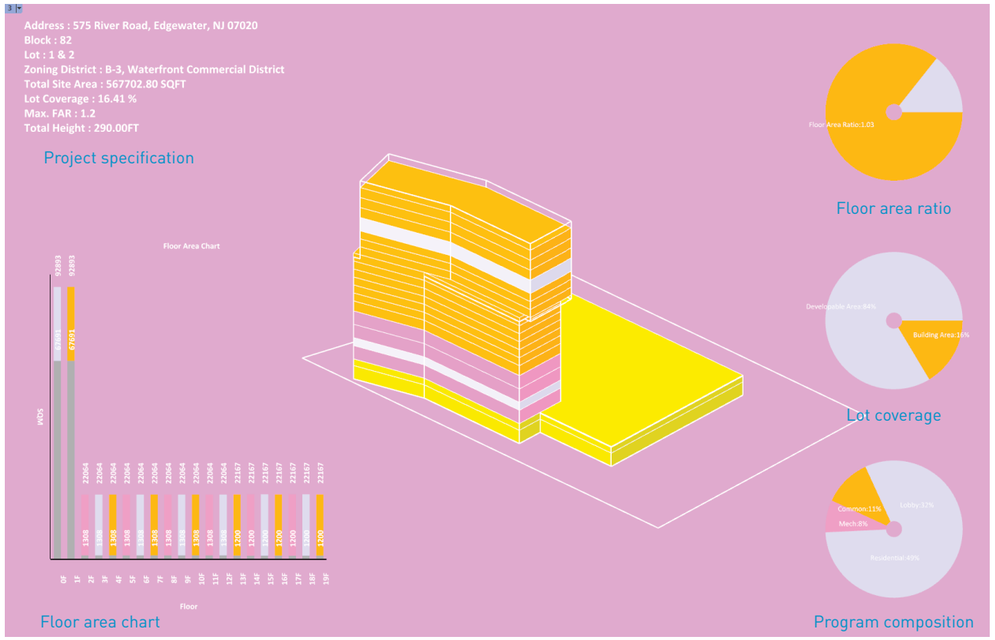




Writing data on Excel sheet

1) Connect numbers to the Excel output sheet

2) Transfer the area data to the excel for the calculation

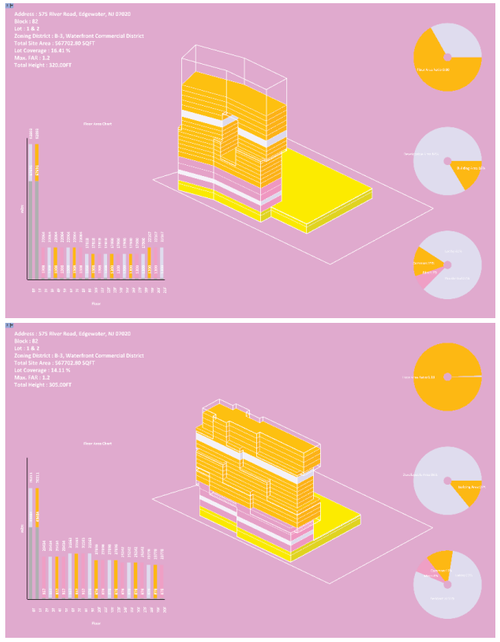


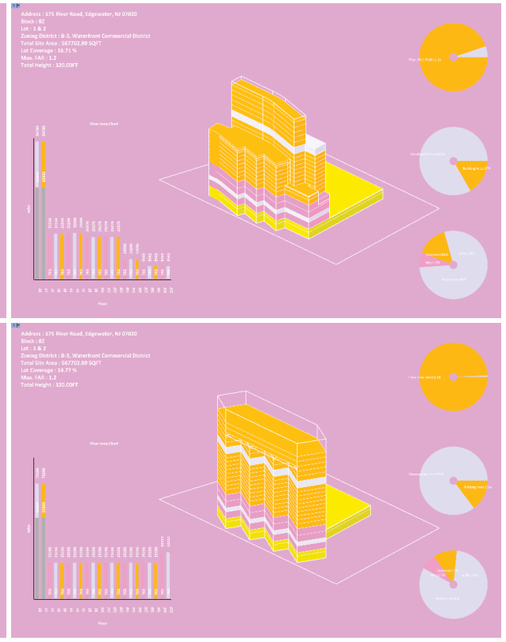
CUSTOM USER INTERFACE

Parsing and compiling data into visual project specification

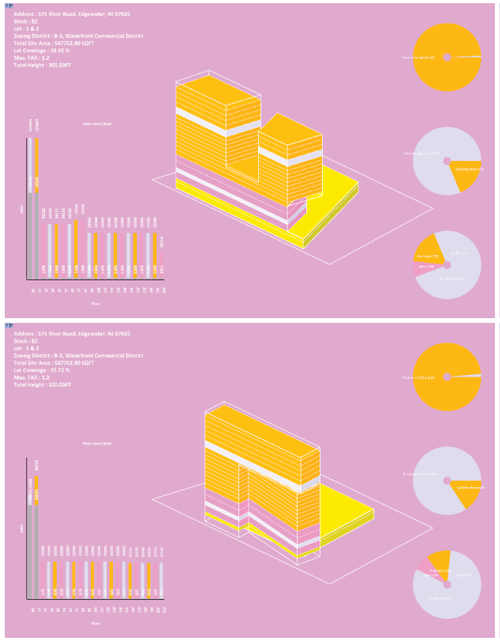
1) Categorize the numbers for floor area, FAR calculation, or program percentage

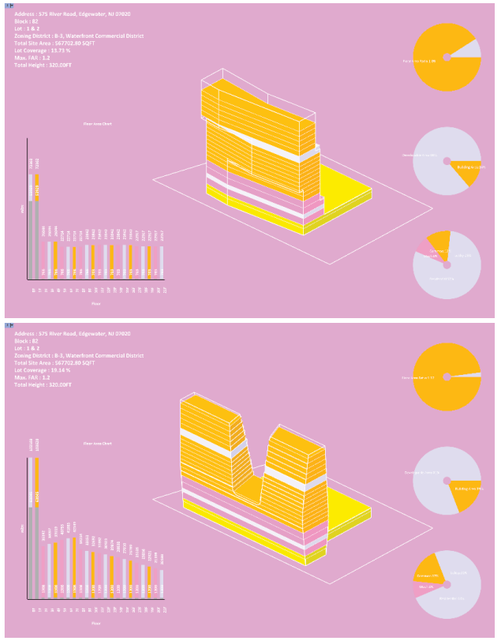
2) Compiling numerical data into the conduit





COMPARISON OF DESIGN OPTIONS





COMPARISON OF DESIGN OPTIONS

Repeat on other design options

1) Change building volume connected and create new visual fact sheet

2) repeat on other options for comparison

METHODOLOGY.02

Parking Solution

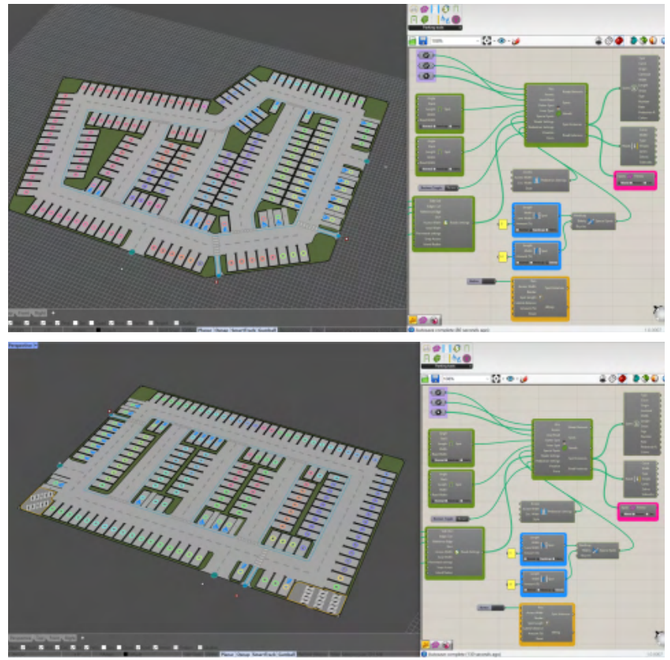
Parking Solution

In New York City, especially in Manhattan, parking layout is often irrelevant to the project. However, depending on the project criteria such as program and jurisdiction, the parking layout can be critical to the project. During the preliminary project assessment, architects calculate the required parking stalls and iterate several options to decide on an appropriate parking strategy. However, many factors such as expertise level and time affect the quality of parking layouts.

This chapter inroduce artifitial intelligent aided parking layout optimization utilizing; Galapagos, a single objective optimization solver; Grasshopper plug-ins and; Parking Solver developed by Christian Karl Silveira Siebje, to quickly generate a set of potential parking layout strategies with minimal input data. Parking Solver generates parking layouts based on curves, points, and numerical input. The combination of Parking Solver and Galapagos can generate many potential parking layouts and select an appropriate solution within a limited time.

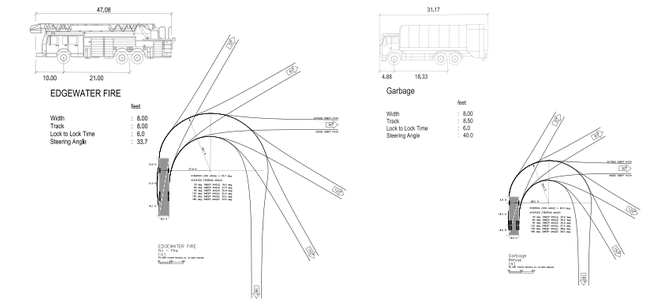
Parking Solver is optimal to use an approximate number of parking stalls for preliminary project assessment. However, the solver requires improvement for indoor parking applications.

Top & Bottom: Parking Solver, developed by Christian Karl Silveira Siebje

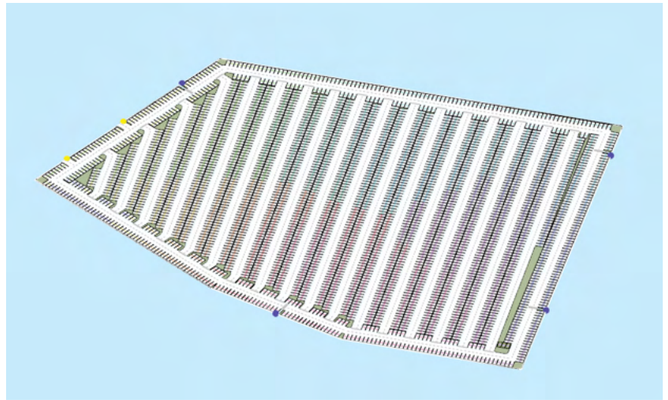


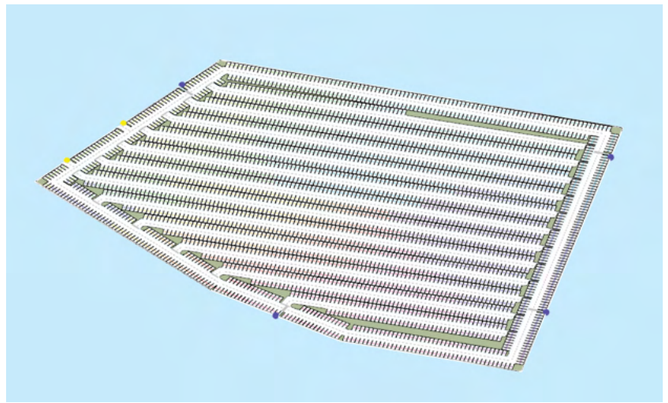
PRE-DEFINED GEOMETRY

REGULATIONS



ANGLE





OPTIMIZED LAYOUT IN DESIGNATED BOUNDARY

Input for semi-automated parking layout

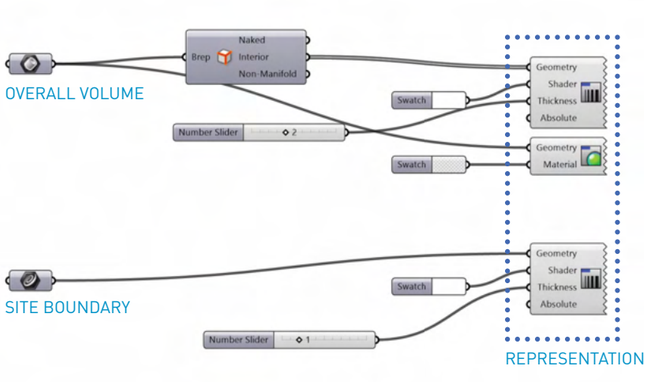
1) Boundary of the parking space

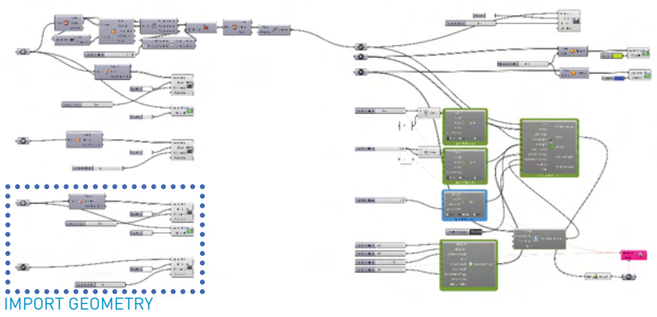
2) Related regulations

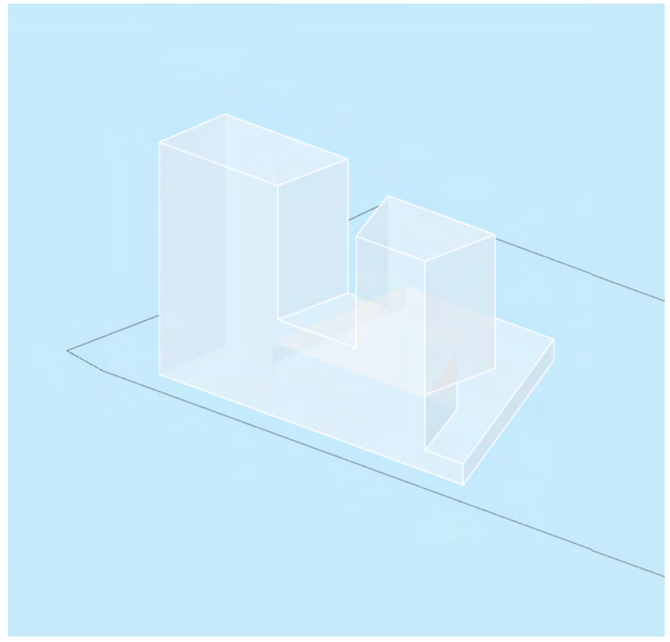
3) Access, Axis, Angle of the parking stalls

Output

1) Multiple parking options with optimized numbers

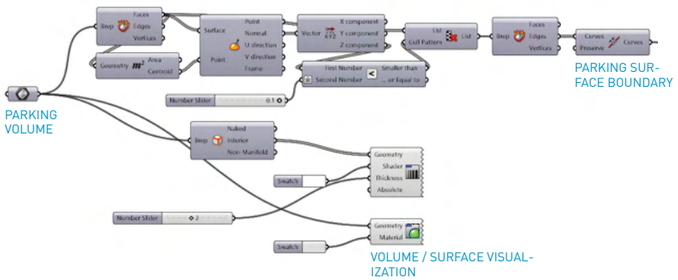






Define Building volume

1) Create or import building volume in Grasshopper environment

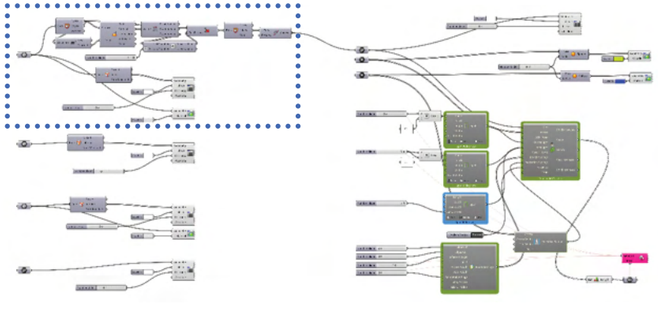


PARKING VOLUME

PARKING SUR-
FACE BOUNDARY

VOLUME / SURFACE VISUAL-
IZATION

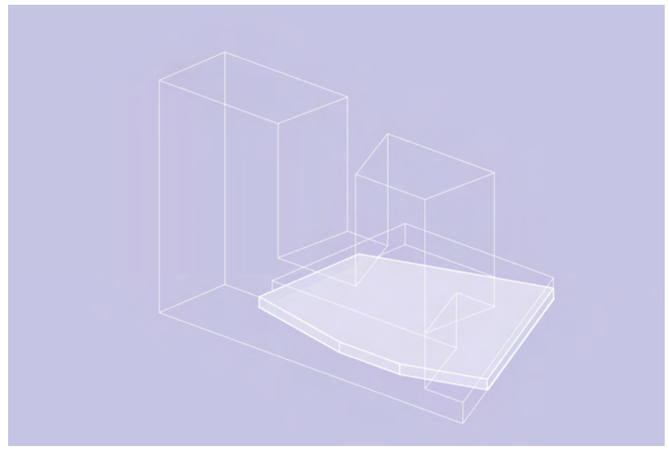
PARKING BOUNDARY SETUP



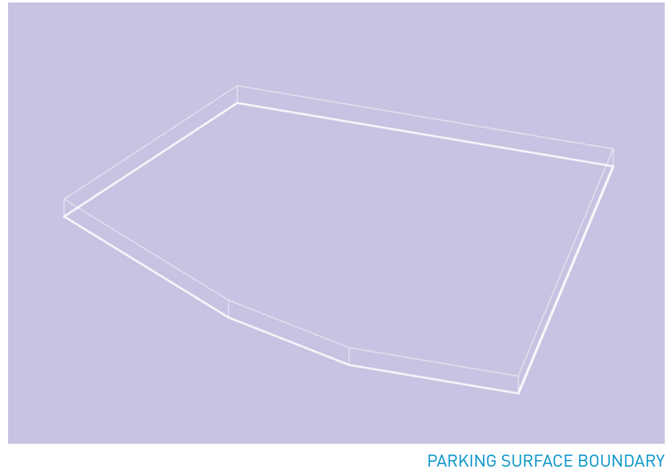
Define portion for parking layout

1) Set up parking portion

2) Sort floor area as brep surface for the layout



PARKING VOLUME

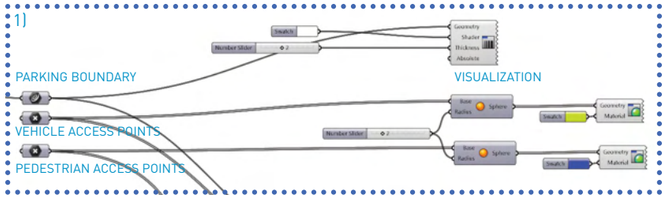


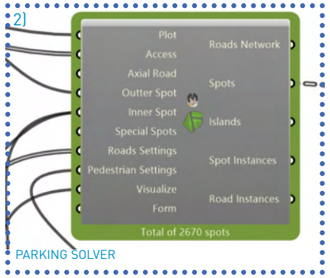
PARKING SURFACE BOUNDARY

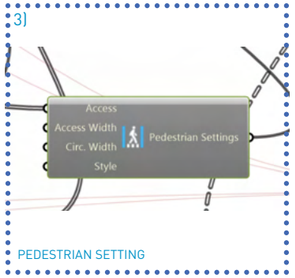
Define portion for parking layout

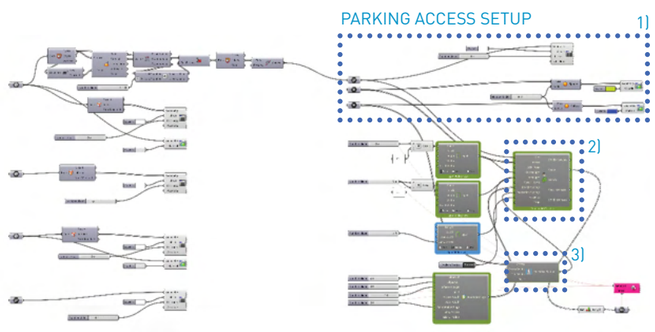
1) Set up parking portion

2) Sort floor area as brep surface for the layout







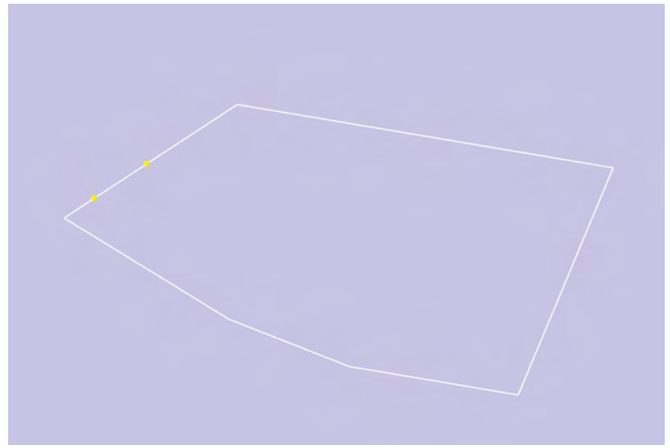


Adjust base dimensions on regulation

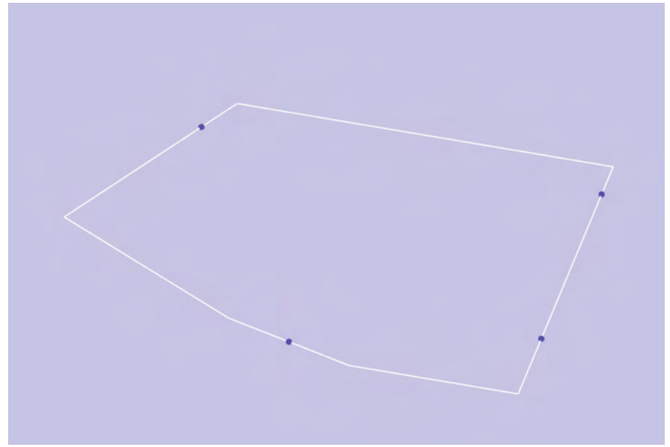
1) Check dimensions on regulations

2) Input the dimensions as base numbers in component

3) Create base calculation/ simulation set



VEHICLE ACCESS



PEDESTRIAN ACCESS

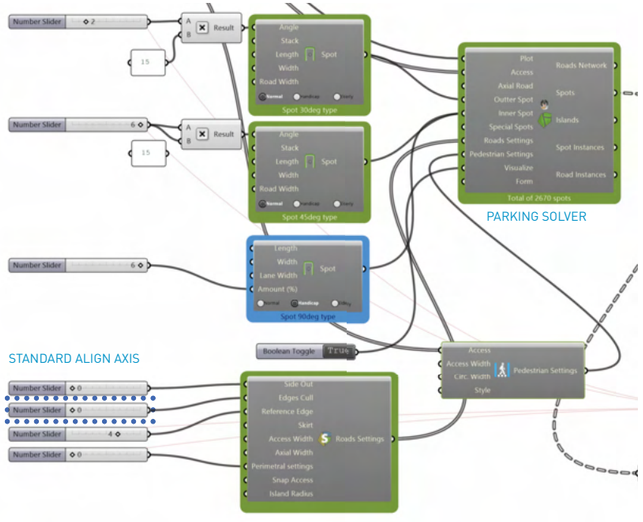
Define access point for vehicle and pedestrian

1) Check plan and in/out access point for vehicles & pedestrian

2) Set access and circulation width in accordance to the regulation

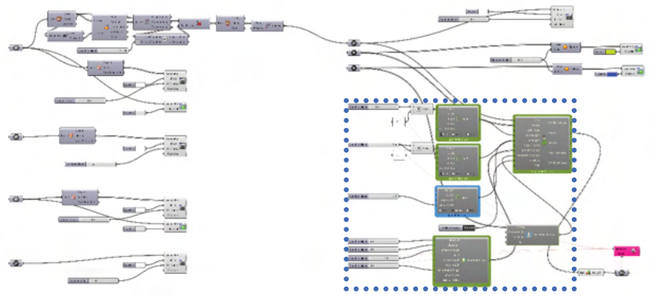
3) Connect 'Axial Road', if needed.

4) Set style of the pedestrian road (roadside vs sidewalk)



PARKING SOLVER

STANDARD ALIGN AXIS

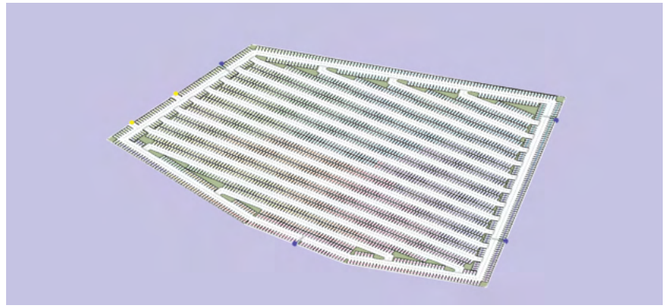


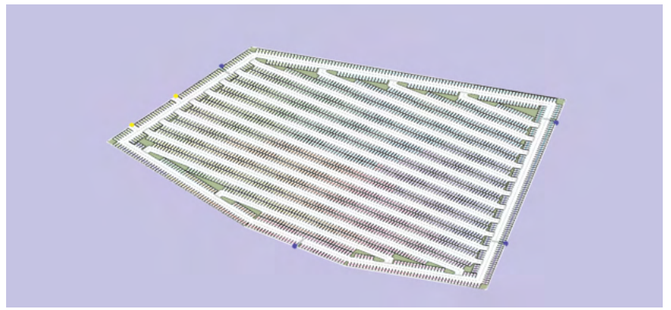
LAYOUT DETAIL SETUP

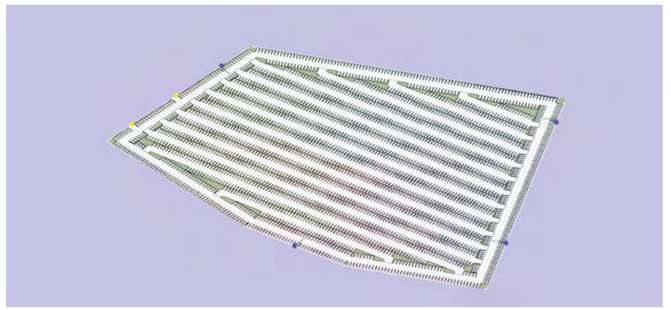
Initial parking layout setup

1) Connect all the settings to parking solver component

2) Check every spots are not trapped island or not overlaps with others





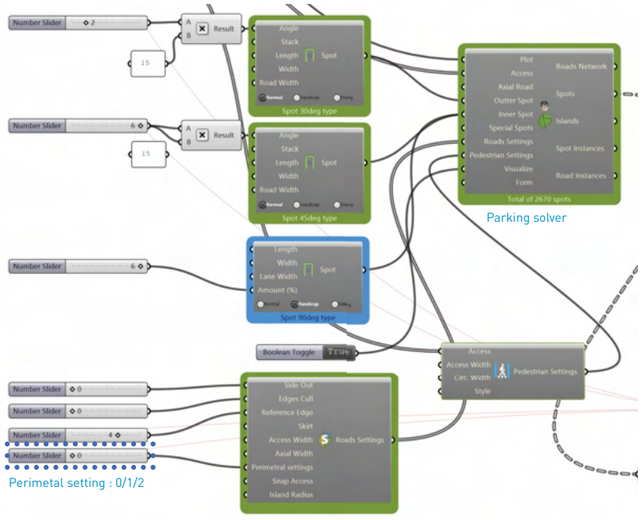


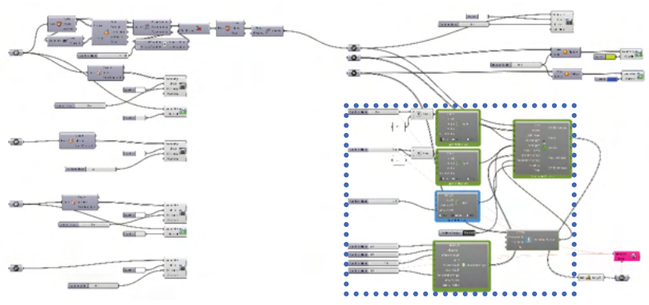
LAYOUT OPTIONS WITH DIFFERENT ALIGN AXIS

Adjust axis of the parking layout in accordance to the edges

1) Connect each edges to check proper parking axis

2) Compare overall composition, road/stall ratio and stall numbers



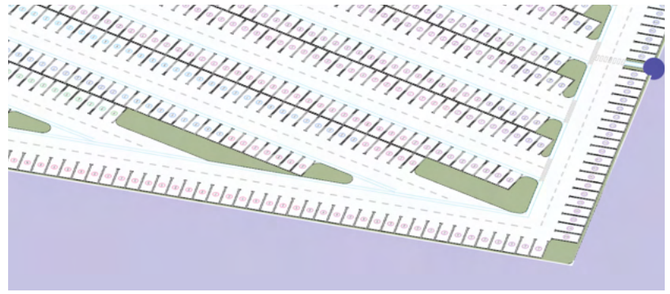


Check surrounding condition of the parking boundary

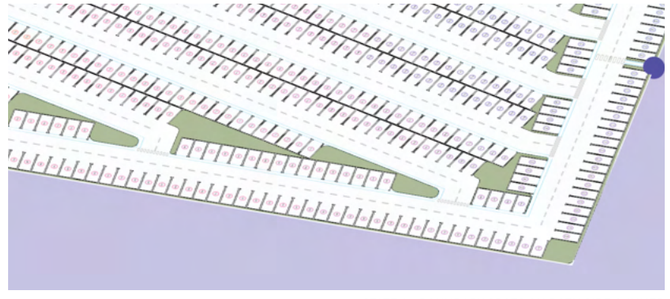
1) Check whether surrounding of the parking requires cleaned up boundaries

2) In case of specific perimeteral setting is required, check options

STATE 0 - ONLY INNER SPOTS



STATE 1 - BOUNDARY SPOTS ON ONE SIDE & INNER

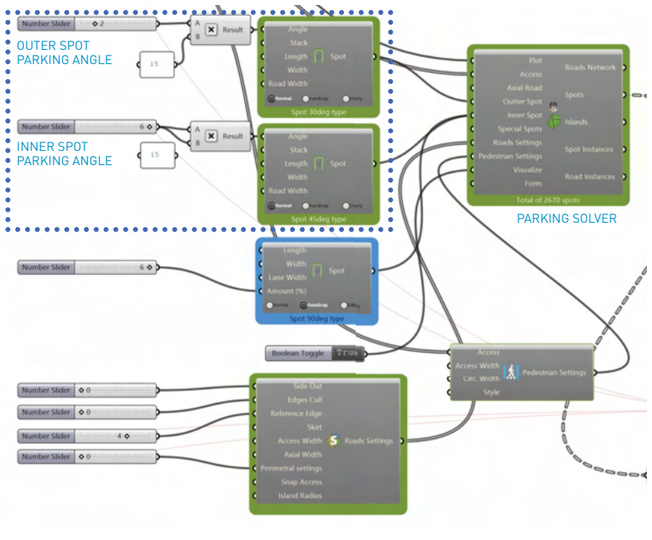


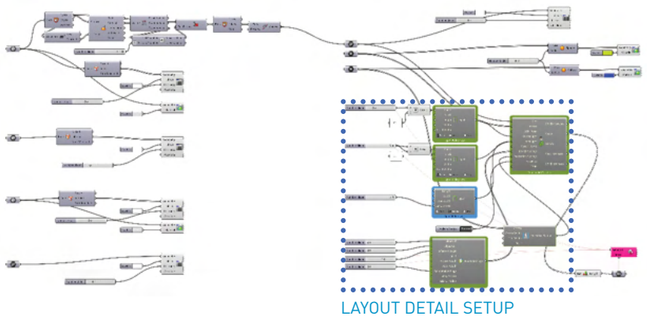
STATE 1 - BOUNDARY SPOTS ON BOTH SIDE & INNER

Adjust perimetral settings

1) Check perimetral settings

2) Connect numerical value from 0 to 3, as described above





Angle of the parking layout

1) Default setting is 90 degree standard parking

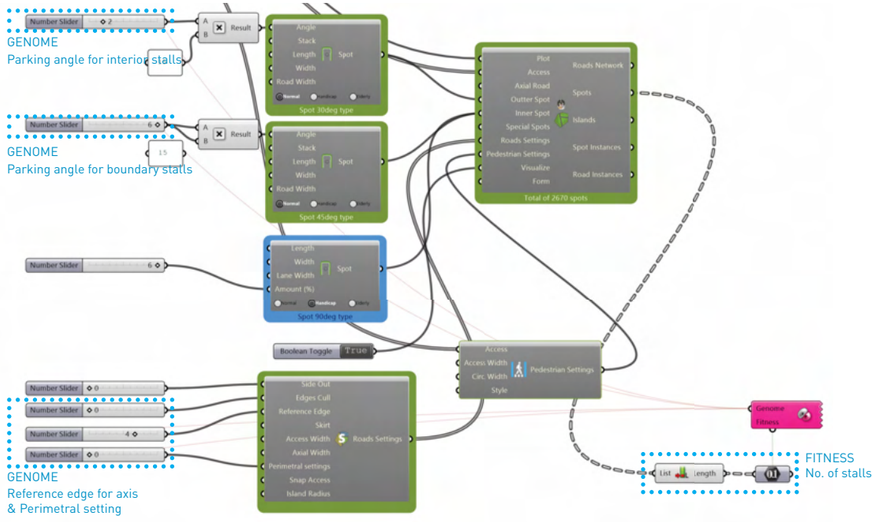
2) In rare case, 30/45/60 degree parking is needed, Adjust angle options

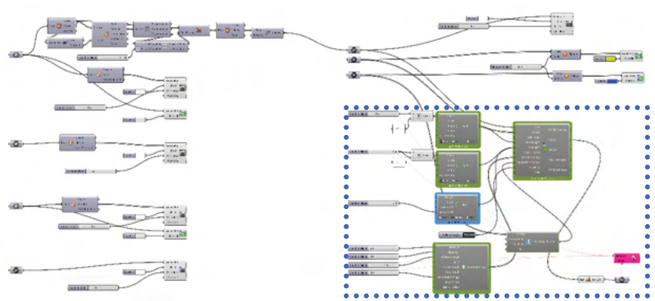
PARKING ANGLE

Adjust parking angles

1) angle to be set to 15/30/45/60/90 degree with modified composition

2) Interior and perimetral parking angle will be adjusted separately





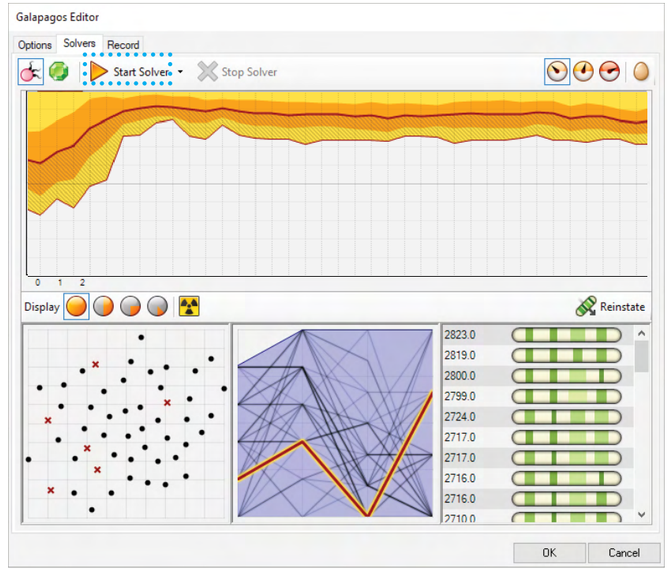
EVOLUTIONARY SOLVER SETUP

Connecting variable values to Galapagos

1) Sorting the fixed and variable numerical values

2) Connect the variables to the galapagos as Genome

3) Connect number of the parking spots to the galapagos as Fitness

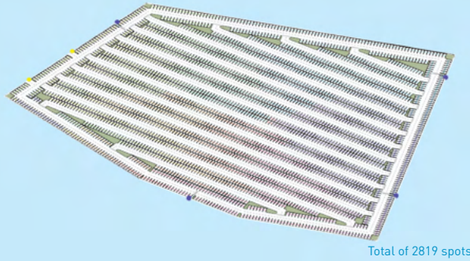


Run Galapagos for layout optimization

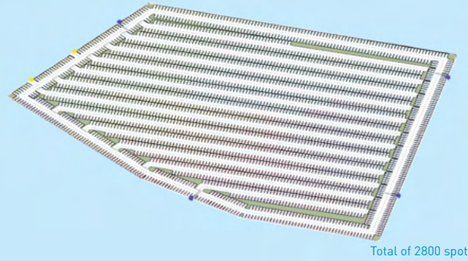
1) Set the fitness to be maximized

2) Run the solver and compare the layout options

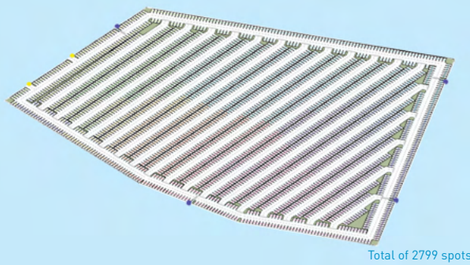
Top tier layout options



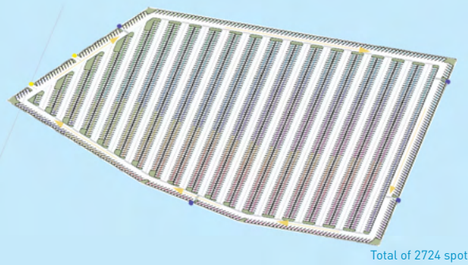
Total of 2819 spots



Total of 2800 spots

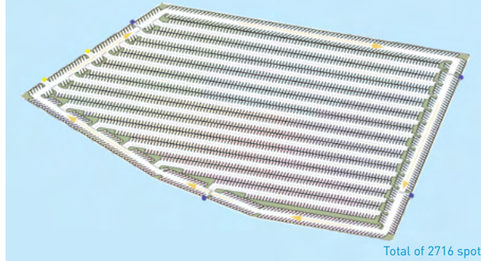


Total of 2799 spots

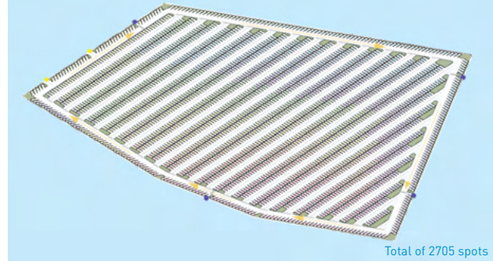


Total of 2724 spots

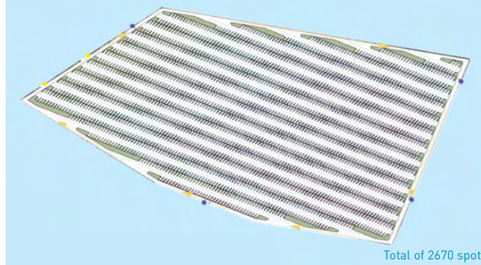
COMPARISON OF LAYOUT OPTIONS



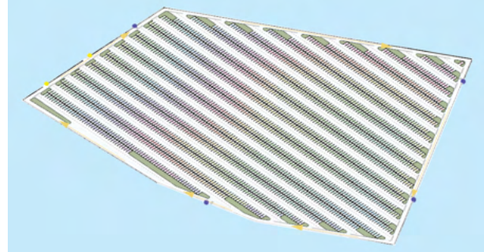
Total of 2716 spots



Total of 2705 spots



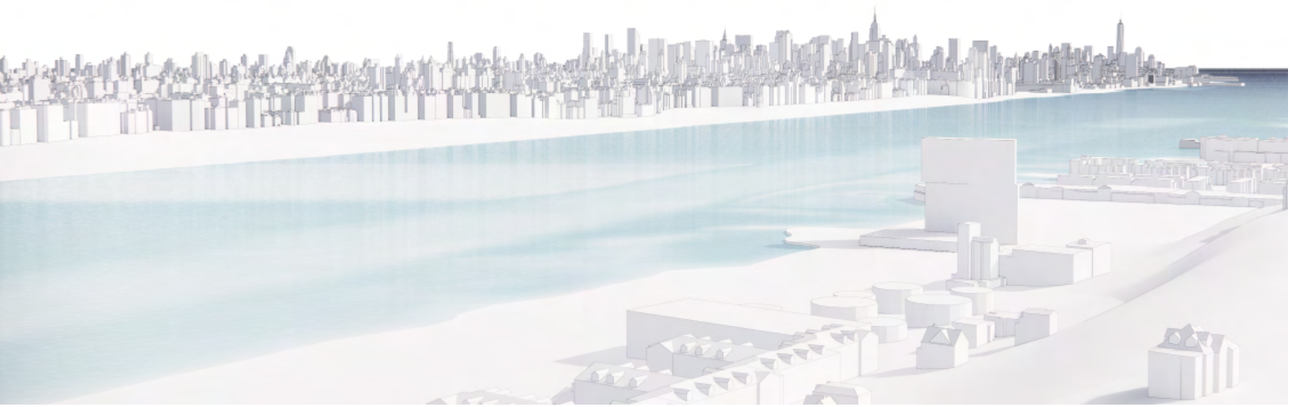
Total of 2670 spots



COMPARISON OF LAYOUT OPTIONS

METHODOLOGY.03

Contextual Analysis



Contextual Analysis

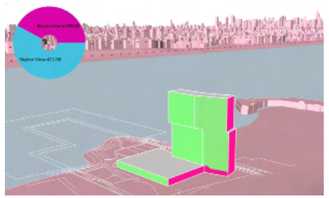
Depending on the project, contextual data such as Quality of the View, Amount of the Radiation, Hours of Sunlight, Structural rigidity or Wind direction can be a main design driver. This information can vary depending on design options and quality of the criteria may contribute to the decision making in selecting optimal design options.

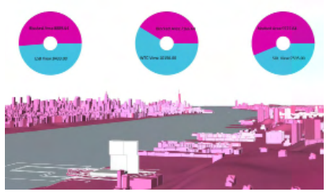
This chapter is to explore view criteria via Ladybug view analysis to simulate the building's visibility towards City's iconic skyline and several specific landmarks. The statistics calculated through simulation will be juxtaposed with scoring factors, and will be dedicated to the design decision making.

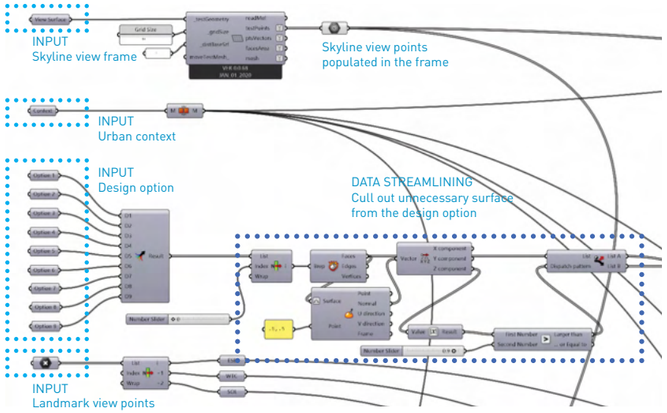
Ladybug is major tools for environmental data simulation for this chapter. Although this chapter is limiting its capability to the visibility analysis, The same process illustrated in this chapter can be processed with altered simulation such as radiation, glare effect, wind, etc.

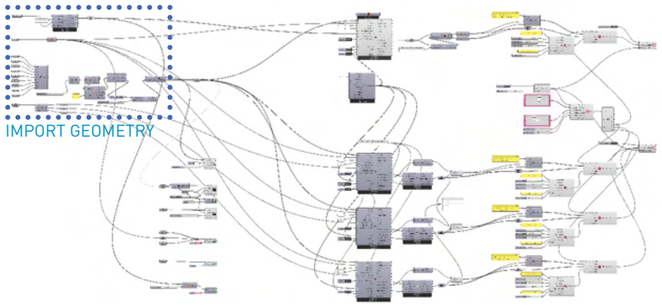
INPUT FACTORS - GIS DATA

RESULT - VIEW SCORING









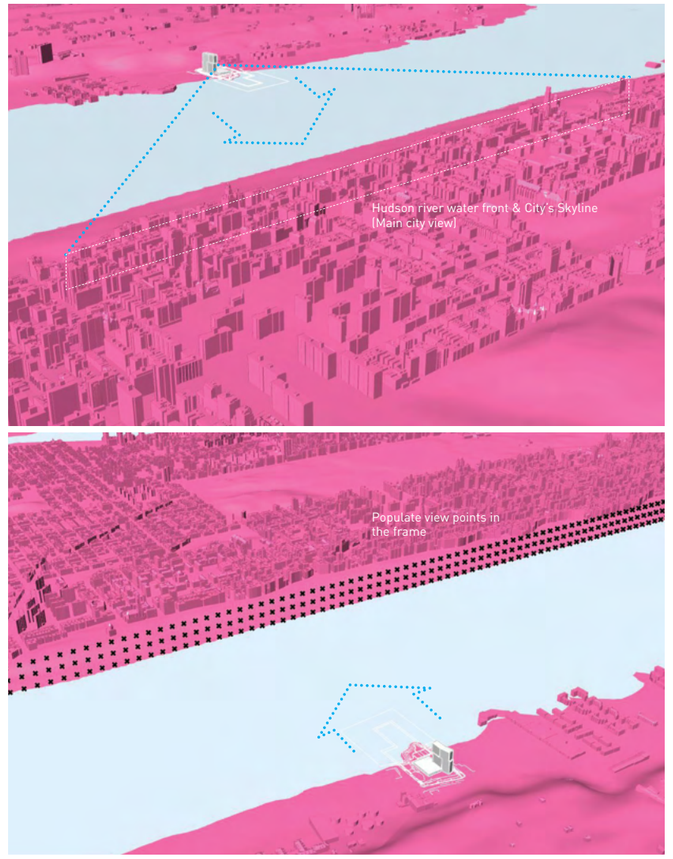
Importing urban context & Set focal points

1) Import the Geological and building data from related authority or open source data.

2) Transfer the context to grasshopper environment with mesh or brep form

3) Create imaginary frame of view from the building as a surface

4) Import surface to grasshopper as brep

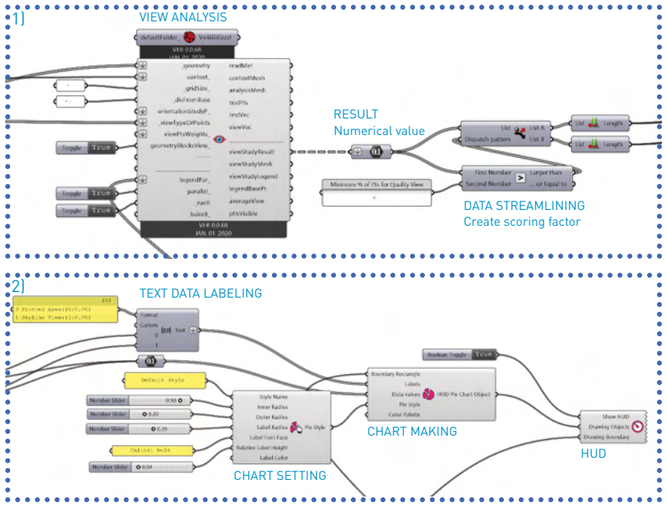


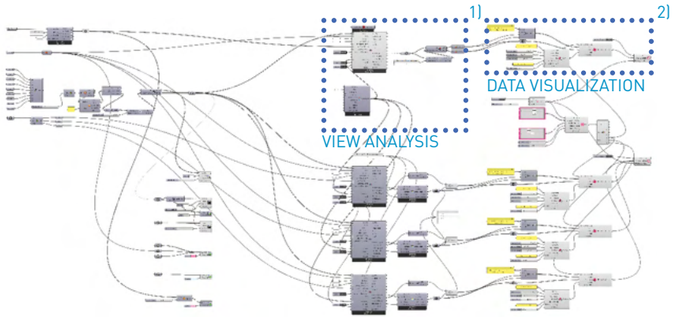
VIEW TOWARD CITIES SKYLINE

Focal points set up

1) populate focal points in imported brep

2) Connect the points in view analysis component for simulation

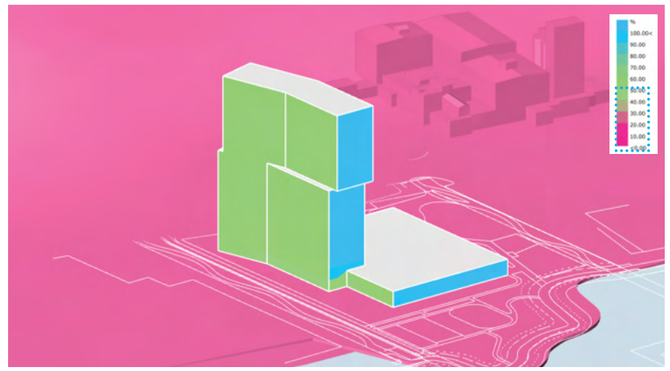




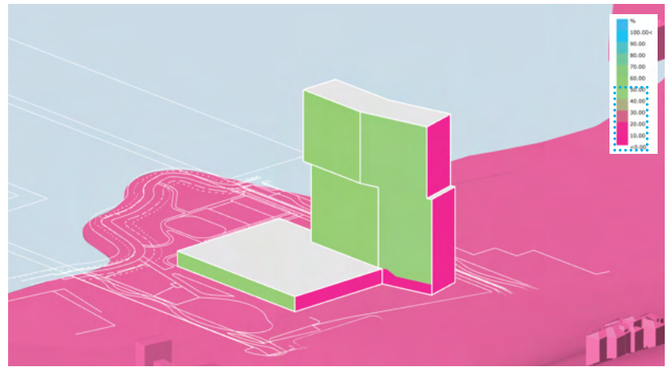
View analysis

1) Run simulation by connecting building volume and context

2) Check the result and connect it to conduit for visualization



VIEW ANALYSIS - S/W FACADE



VIEW ANALYSIS - N/E FACADE

View analysis scoring & representation

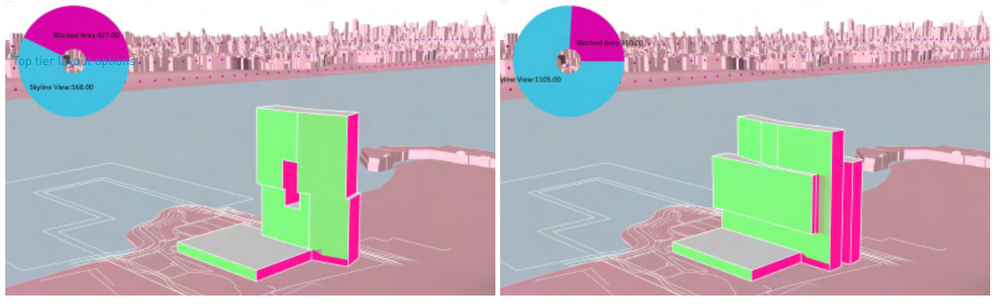
1) Set percentage of focal points visivle from each area of the building volume

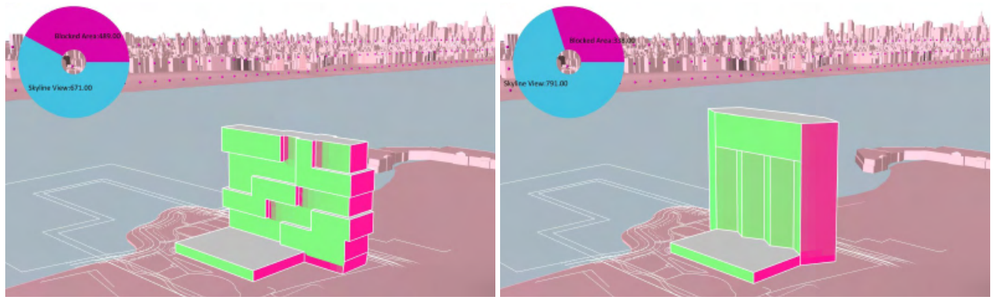
2) In this project, standard percentage is 50% of focal points

3) Sorting the score of each area and connect it to conduit

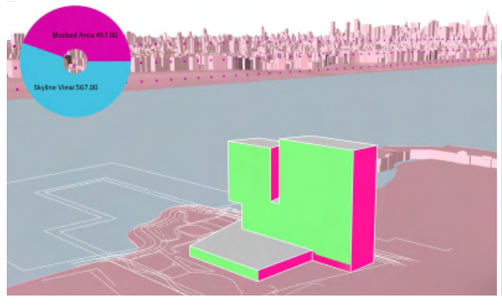
4) Create Pie chart for each portion of view quality

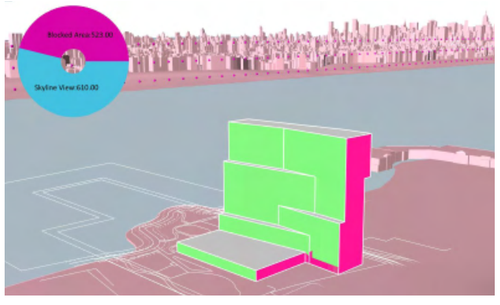
Top tier option

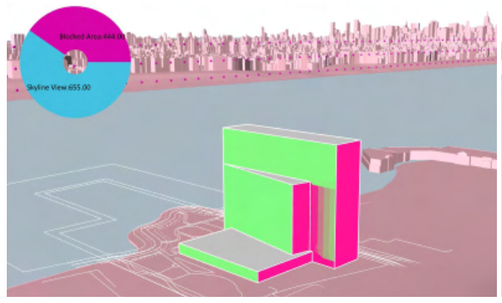


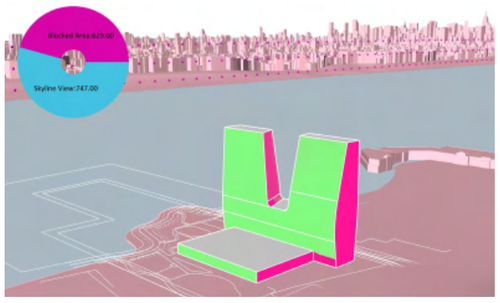


COMPARISON OF WATERFRONT / CITY VIEW ANALYSIS

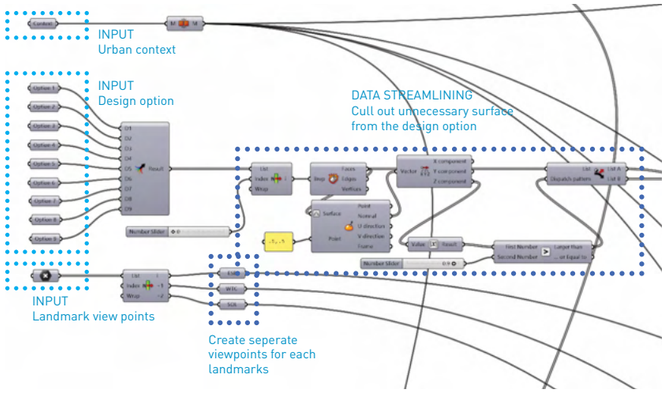


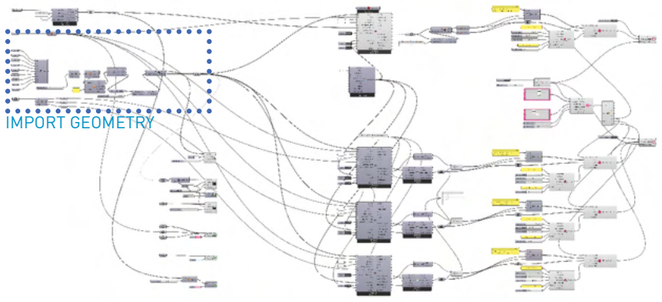


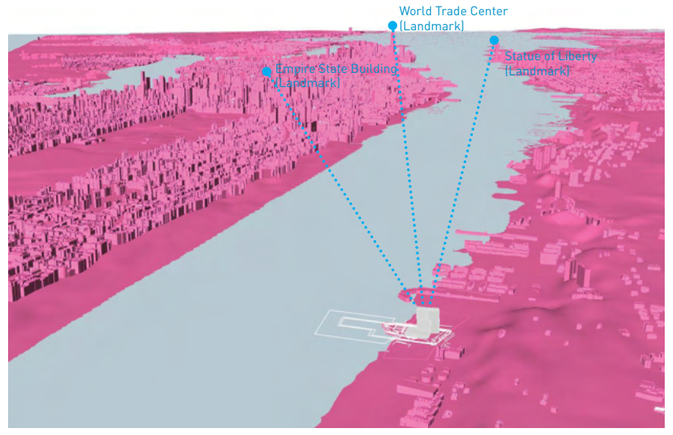


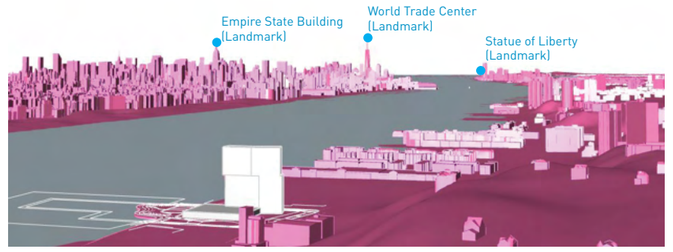


COMPARISON OF WATERFRONT / CITY VIEW ANALYSIS









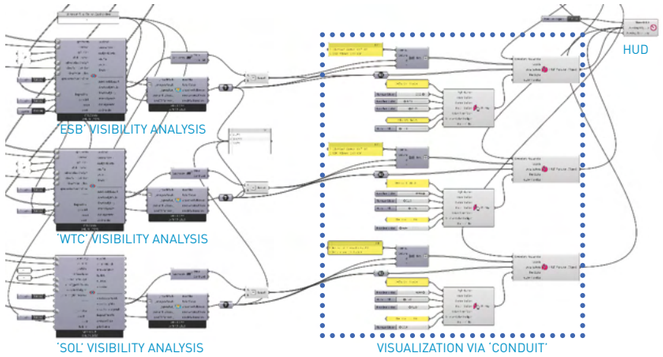
LANDMARK SETUP

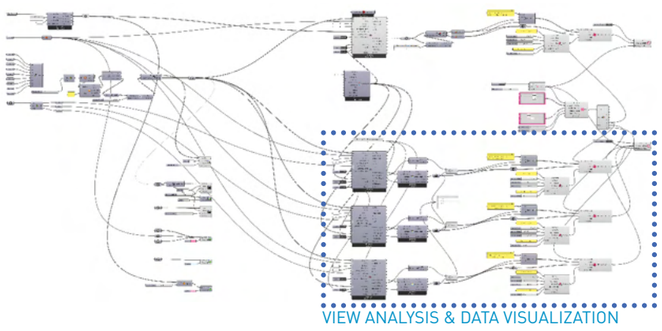
Set main landmarks for the Visibility simulation

1) Set focal points of landmarks

2) Cull out unnecessary flat surface such as roof

3) Connect buildings and geographic data as an context blocking the view

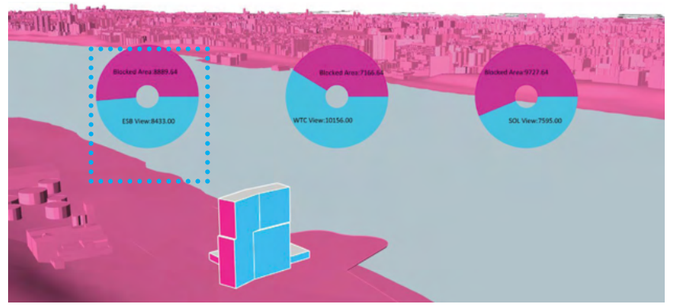




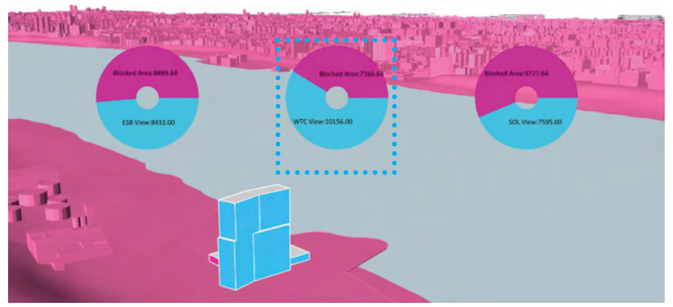
View Analysis

1) Create View analysis for each landmarks

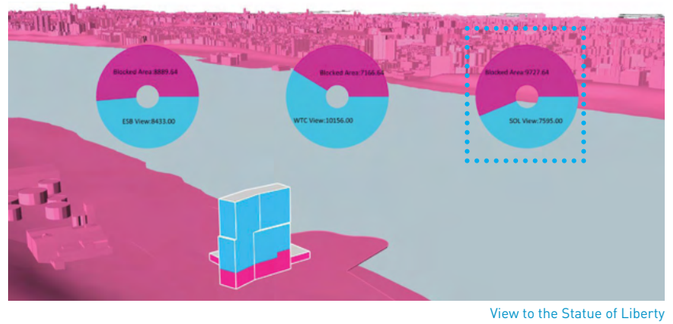
2) Run each analysis separately and sort scoring numbers as former simulation



View to the Empire State Building



View to the World Trade Center



View to the Statue of Liberty

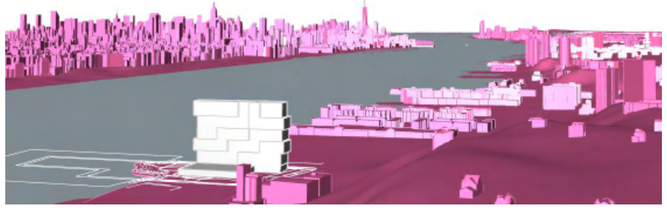
View analysis scoring & representation

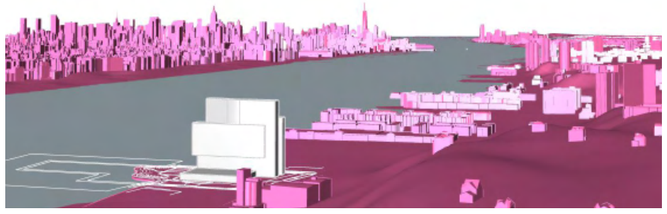
1) Set percentage of focal points visivle from each area of the building volume

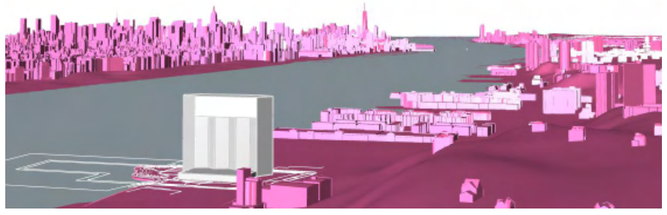
2) In this project, standard percentage is 30% of focal points

3) Sorting the score of each area and connect it to conduit

4) Create Pie chart for each portion of view quality

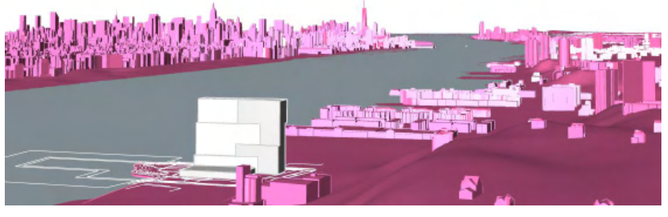


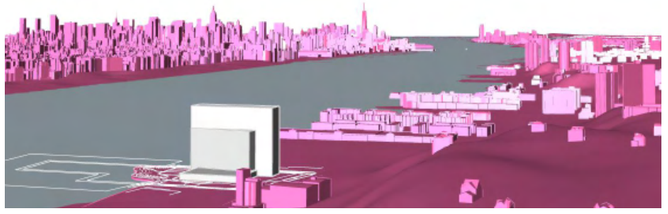


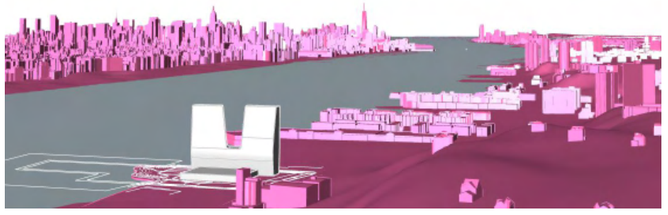


A: Quality View to the Empire State Building
B: Quality View to the World Trade Center
C: Quality View to the Statue of Liberty

COMPARISON OF LANDMARK VISIBILITY ANALYSIS







A: Quality View to the Empire State Building
B: Quality View to the World Trade Center
C: Quality View to the Statue of Liberty

COMPARISON OF LANDMARK VISIBILITY ANALYSIS

METHODOLOGY.04

Visualization

Visualization

Data visualization is one of the major part in architectural data fact sheet process and preliminary design representation. This repetitive, time-consuming work requires clear and same standards for each design option with abundant and accurate background numbers.

While the general and manual process of creating data visualization is usually based on intuitive delivery or the message with somewhat subjective representations, The examples shown in the previous chapters are relatively more focused on delivering objective, factual, numerical, and precise information to the designer or decision maker.

Conduit is a representation tool developed in Proving Ground. The tool is having several different types of graphs and layout options such as Pie graphs, Bar charts, or Line graphs. Since this tool is designed to treat repetitive numerical data into a certain typology of data representation, several different design options and its value can be juxtaposed in a timely manner with easy to compare layout.

INPUT FACTORS - NUMERICAL VALUES FOR GRAPH FORMAT

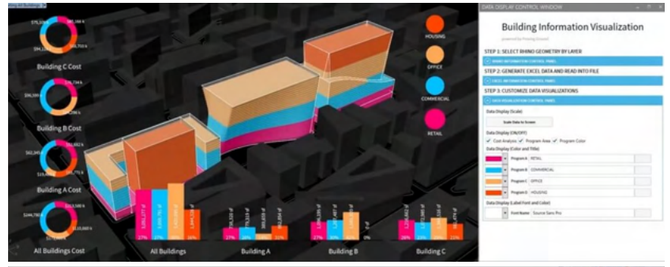
e.g. Floor area, Level, Programs, Heights, Population, Location (XYZ), Direction, Score

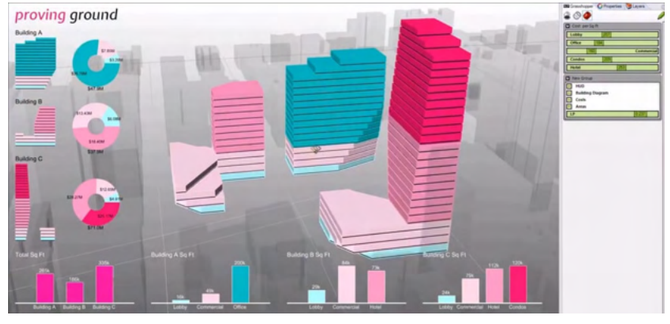
	A	B	C	D
1	Floor	Height	Level	Type
2	1	20	0	Lobby
3	2	10	20	Lobby
4	3	20	30	Common
5	4	12	50	Mech
6	5	20	62	Common
7	6	20	82	Common
8	7	15	102	Residential
9	8	12	117	Residential
10	9	12	129	Residential
11	10	12	141	Residential
12	11	12	153	Residential
13	12	12	165	Residential
14	13	12	177	Residential
15	14	12	189	Residential
16	15	12	201	Residential
17	16	12	213	Residential
18	17	20	225	Mech
19	18	15	245	Residential
20	19	15	260	Residential
21	20	15	275	Residential
22	21	15	290	Residential
23	22	15	305	Residential

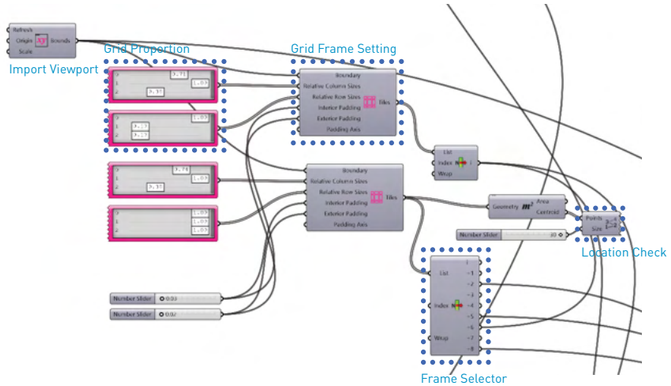
	A	B	C	D	E	F
1	Floor	Height (ft)	Level (ft)	Program	G.F.A. (sqft)	Core Area (sqft)
2	B2F	10 ft	-20 ft	Parking	226269 sqft	-
3	B1F	10 ft	-10 ft	Service	226269 sqft	-
4	1F	20 ft	0 ft	Lobby	87550 sqft	1019 sqft
5	2F	10 ft	20 ft	Lobby	110534 sqft	1019 sqft
6	3F	20 ft	30 ft	Common	45959 sqft	1019 sqft
7	4F	12 ft	50 ft	Mech	45959 sqft	1019 sqft
8	5F	20 ft	62 ft	Common	45959 sqft	1019 sqft
9	6F	20 ft	82 ft	Common	45959 sqft	1019 sqft
10	7F	15 ft	102 ft	Residential	45959 sqft	1019 sqft
11	8F	12 ft	117 ft	Residential	45959 sqft	1019 sqft
12	9F	12 ft	129 ft	Residential	45959 sqft	1019 sqft
13	10F	12 ft	141 ft	Residential	45959 sqft	1019 sqft
14	11F	12 ft	153 ft	Residential	45959 sqft	911 sqft
15	12F	12 ft	165 ft	Residential	45959 sqft	911 sqft
16	13F	12 ft	177 ft	Residential	45959 sqft	911 sqft
17	14F	12 ft	189 ft	Residential	45959 sqft	911 sqft
18	15F	12 ft	201 ft	Residential	45959 sqft	911 sqft
19	16F	12 ft	213 ft	Residential	45959 sqft	911 sqft
20	17F	20 ft	225 ft	Mech	44330 sqft	911 sqft
21	18F	15 ft	245 ft	Residential	44330 sqft	911 sqft
22	19F	15 ft	260 ft	Residential	44330 sqft	911 sqft
23	20F	15 ft	275 ft	Residential	44330 sqft	911 sqft
24	21F	15 ft	290 ft	Residential	44330 sqft	911 sqft
25	22F	15 ft	305 ft	Residential	44330 sqft	911 sqft
26					1560037 sqft	21132 sqft
27						

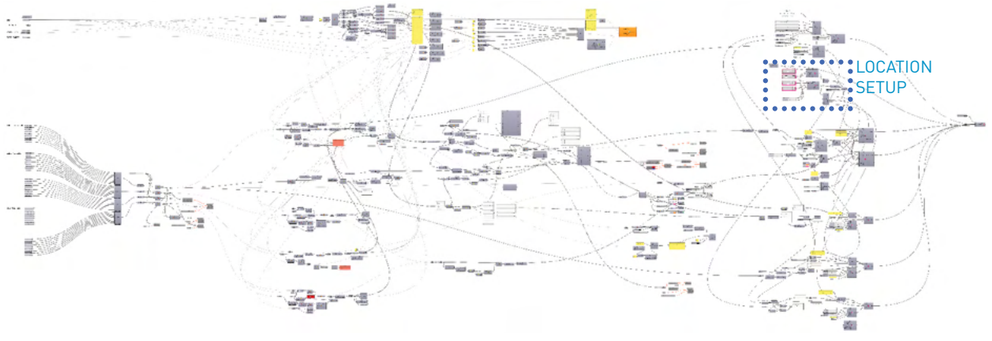
RESULT - CUSTOMIZED VISUAL REPRESENTATION

e.g. Pie chart, Bar Graph, Line Graph, etc





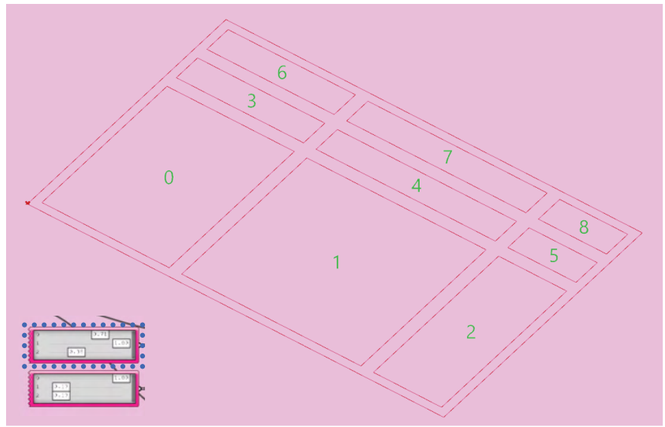




Importing Rhino viewport

1) Import Rhino viewport to GH environment

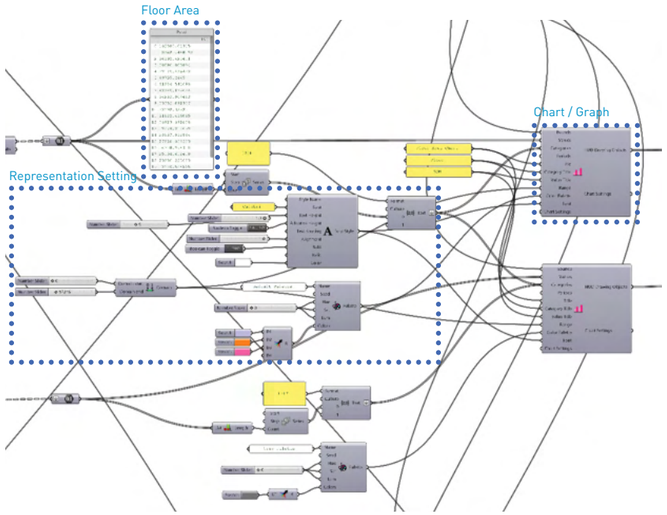
2) set scale of the viewport to display the replicated representation to the 3d modeling

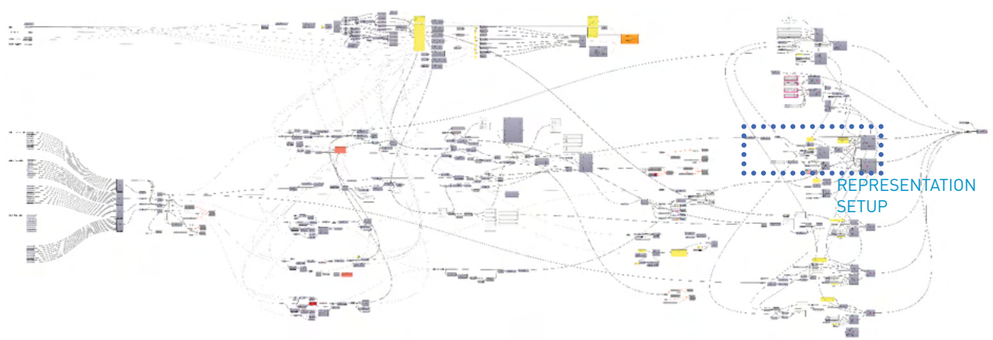


Define layout of the representation in viewport

1) Create grid frame based on the viewport

2) Regulate the numerical value to adjust the grid size and composition





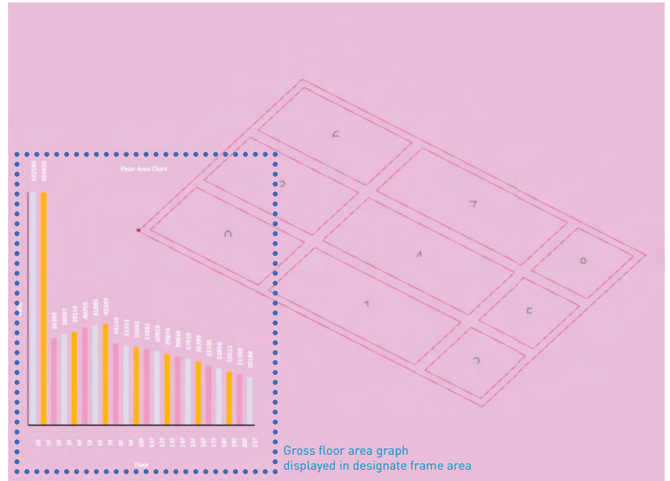
Define numerical data for representation

1) Bring floor area with designated standard's (sqm or sqft) numerical value

2) Setiup representation settings with pre-defined text & font settings

	A	B	C	D	E	F	G	H
1	Floor	Height (ft)	Level (ft)	Program	G.F.A. (sqft)	Core Area (sqft)	Deduction Area (sqft)	Z.F.A. (sqft)
2	B2F	10 ft	-20 ft	Parking	226269 sqft	-	-	-
3	B1F	10 ft	-10 ft	Service	226269 sqft	-	-	-
4	1F	20 ft	0 ft	Lobby	87550 sqft	1019 sqft	75860 sqft	11689 sqft
5	2F	10 ft	20 ft	Lobby	110534 sqft	1019 sqft	75860 sqft	34673 sqft
6	3F	20 ft	30 ft	Common	45959 sqft	1019 sqft	288 sqft	45670 sqft
7	4F	12 ft	50 ft	Mech	45959 sqft	1019 sqft	288 sqft	45670 sqft
8	5F	20 ft	62 ft	Common	45959 sqft	1019 sqft	288 sqft	45670 sqft
9	6F	20 ft	82 ft	Common	45959 sqft	1019 sqft	288 sqft	45670 sqft
10	7F	15 ft	102 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
11	8F	12 ft	117 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
12	9F	12 ft	129 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
13	10F	12 ft	141 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
14	11F	12 ft	153 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
15	12F	12 ft	165 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
16	13F	12 ft	177 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft

IDENTICAL AREA VALUE IMPORTED TO EXCEL

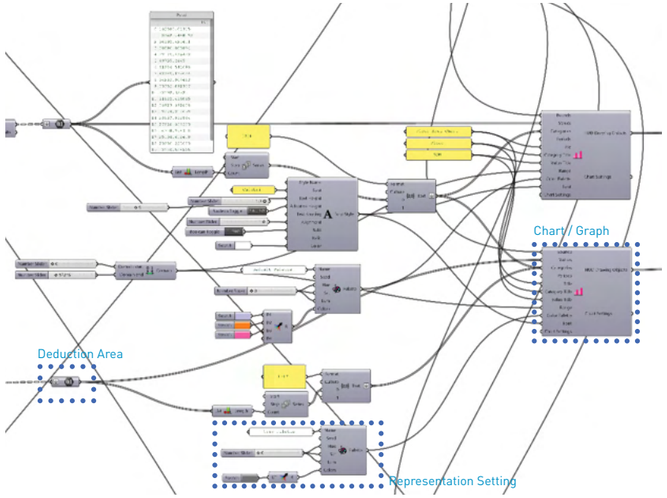


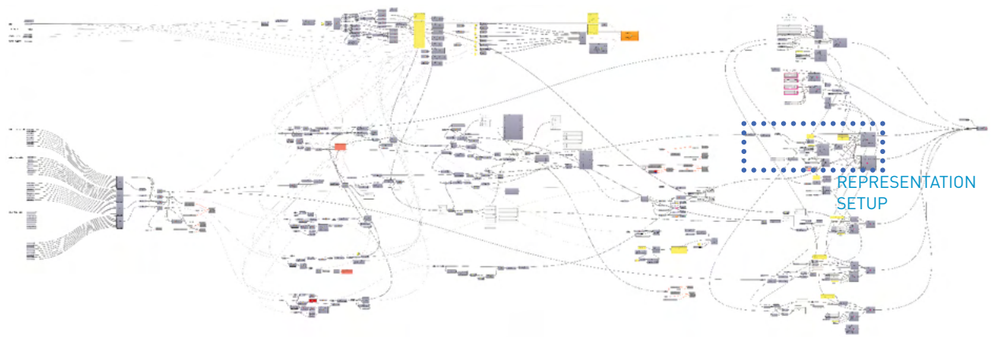
Define numerical data for representation

1) Bring floor area with designated standard's (sqm or sqft) numerical value

2) Create grafted floor areas in accordance to the program types

3) merge each grafted area data for each program area





Connect data to the graph

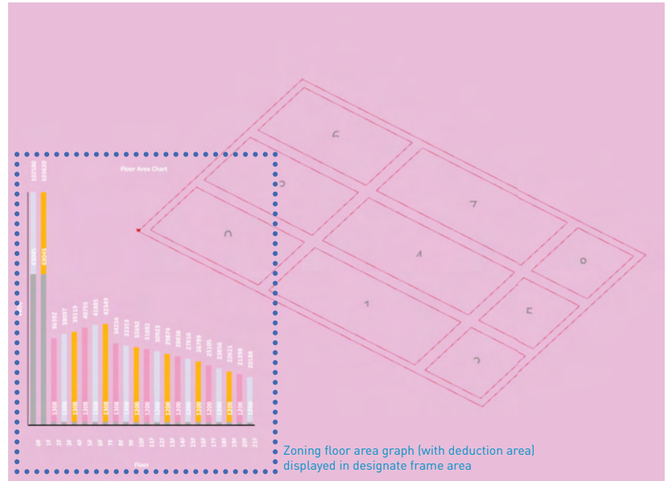
1) Connect data to the graph

2) Assign designated tile number to the graph by connecting 'tile' to the 'bound'

2) Connect graph to the HUD component

	A	B	C	D	E	F	G	H
1	Floor	Height (ft)	Level (ft)	Program	G.F.A. (sqft)	Core Area (sqft)	Deduction Area (sqft)	Z.F.A. (sqft)
2	B2F	10 ft	-20 ft	Parking	226269 sqft	-	-	-
3	B1F	10 ft	-10 ft	Service	226269 sqft	-	-	-
4	1F	20 ft	0 ft	Lobby	87550 sqft	1019 sqft	75860 sqft	11689 sqft
5	2F	10 ft	20 ft	Lobby	110534 sqft	1019 sqft	75860 sqft	34673 sqft
6	3F	20 ft	30 ft	Common	45959 sqft	1019 sqft	288 sqft	45670 sqft
7	4F	12 ft	50 ft	Mech	45959 sqft	1019 sqft	288 sqft	45670 sqft
8	5F	20 ft	62 ft	Common	45959 sqft	1019 sqft	288 sqft	45670 sqft
9	6F	20 ft	82 ft	Common	45959 sqft	1019 sqft	288 sqft	45670 sqft
10	7F	15 ft	102 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
11	8F	12 ft	117 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
12	9F	12 ft	129 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
13	10F	12 ft	141 ft	Residential	45959 sqft	1019 sqft	288 sqft	45670 sqft
14	11F	12 ft	153 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
15	12F	12 ft	165 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft
16	13F	12 ft	177 ft	Residential	45959 sqft	911 sqft	288 sqft	45670 sqft

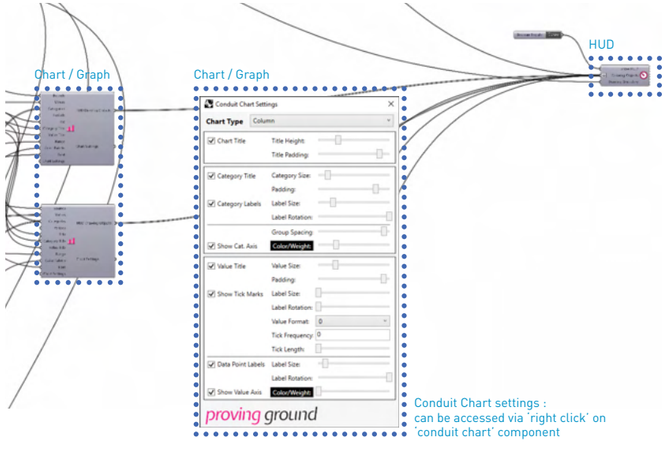
IDENTICAL AREA VALUE IMPORTED TO EXCEL



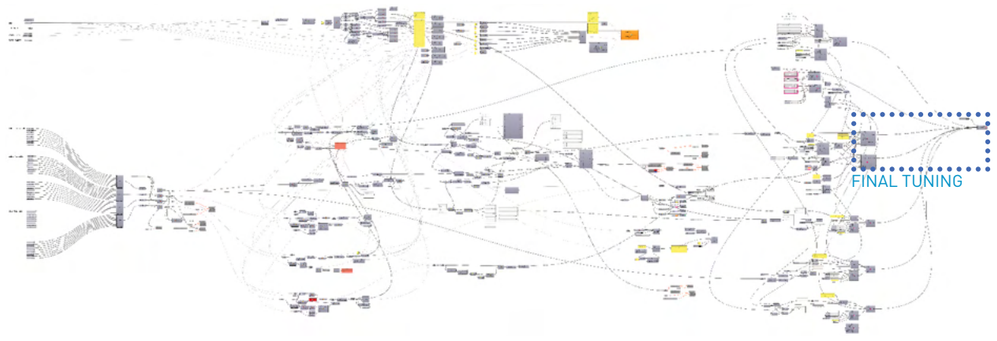
Graph Overlapping

1) Connect another graph to the same tile

2) Remove redundant graphics (font, title, etc) by adjusting the graph setting



Conduit Chart settings :
can be accessed via 'right click' on
'conduit chart' component



Graph type fine tuning

1) Adjust graph type's parameters for better representation through 'conduit chart'

2) Title text heights, Value scaling, formatting can be adjusted through setup

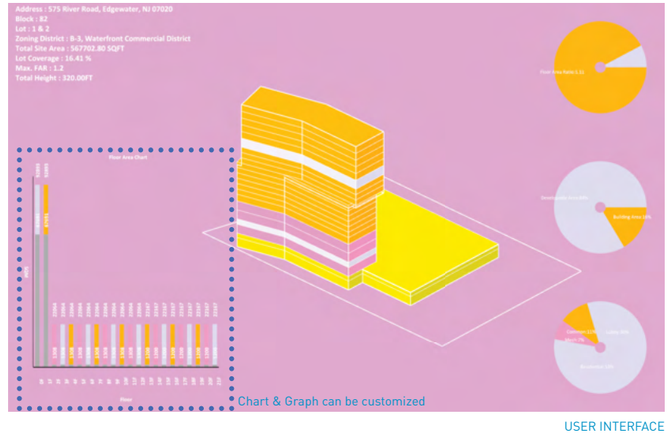
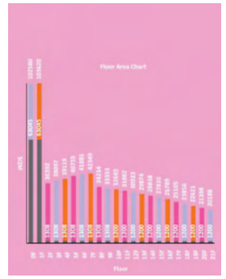
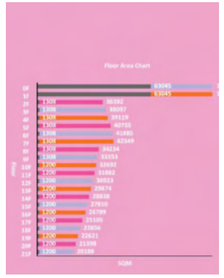


Chart & Graph can be customized

USER INTERFACE



BAR TYPE



COLUMN TYPE

LINE TYPE

Changing Graph type

1) Adjust Graph types for better representation

2) Bar, Column, Line type graphs are available

RESULT

Semi-automated Preliminary Project Assessment

Result

The methods introduced in this research generate a set of quintessential data for the decision-making process for preliminary project assessment. While a manual process could achieve the same results, the manual process requires more resources and limits the designer's creative capability. Through a semi-automated process, immediate graphical and numerical feedback is provided to the designers and enhances their creativity to adjust design solutions for the project, achieving higher quality design.

CONCLUSION & FUTURE STUDY

Conclusion & Future Study

This research introduced methods to generate critical data for preliminary project assessment with minimal input data in an intuitive format. Unlike self-autonomous engines, the semi-automated process has the benefit of human intuition in complex design decision process during the course of the project development. While liberating designers from repetitive computing processes, this research provides graphical and numerical feedback, allowing architect and designer to focus on making decisions based on their knowledge, experience, and intuition.

This research introduced three analysis methods and one visualization method. Area tabulation used 'TT Toolbox' to bridge data between Grasshopper and MS Excel, parking solution used 'Parking Solver' and 'Galapagos' to generate a parking strategy with the maximum number of stalls, Context analysis utilized 'Ladybug' and 'Honeybee' to analyze the influence on and from the context to the project, and 'Conduit' visualizes simulated data in intuitive formats.

The methods in this research provide an immediate overview of data to architects, planners and designers. The process, however, could be further enhanced by developing different data set parameters incorperating govermental regulation and design criteria by outside of context.

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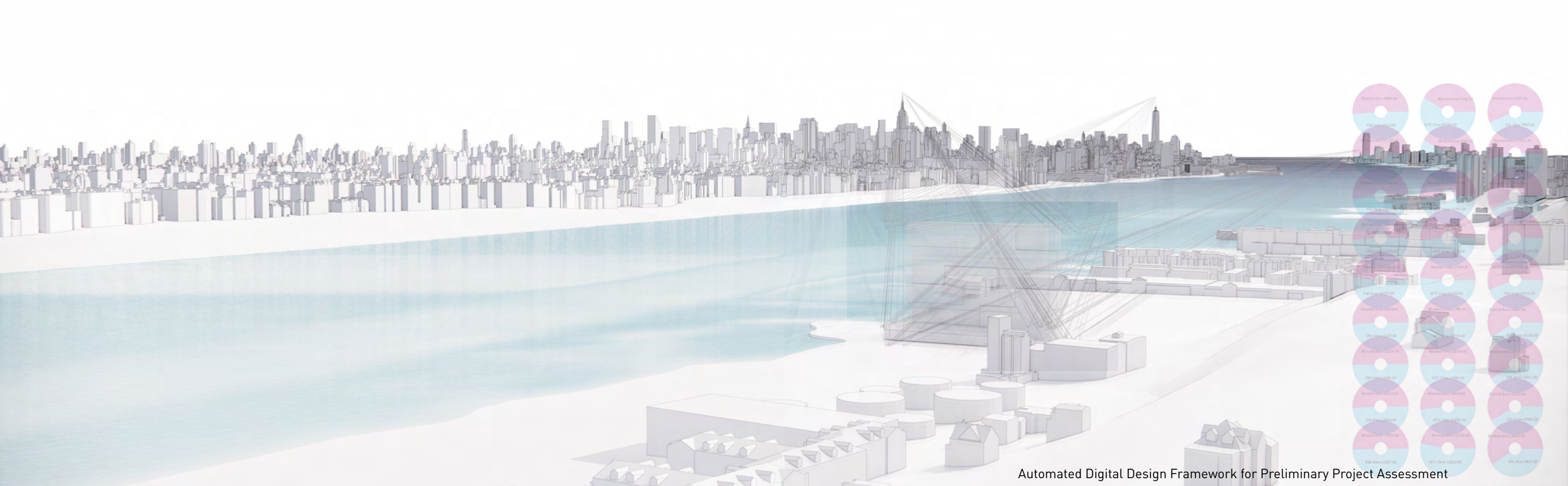

Automated Digital Design Framework for Preliminary Project Assessment

DIGITAL WORKFLOW IN ARCHITECTURAL PRACTICE VOL.01

SEMI-AUTOMATION IN ARCHITECTURE

3D Framework to Support Data Driven Decision Making in Preliminary Project Assessment

H Architecture

This research paper was written and edited by Dongil Kim, Jake Jaekyung Han, John Hanghyun Cho at H Architecture, 2022.

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