

DOTS v 1.0

Design Optimization Tool Set

Grasshopper Plugin for Architecture and Urban design / planning

Nirvik Saha(GIT), Dennis R Shelden(GIT), John R Haymaker(P+W)

01 August 2019



San Francisco



Boston



Rush, Chicago

Problem: Analysis and Synthesis of typical geometric configurations in architecture and planning

- Even simple patterns cannot be easily generalized to all shapes.
- Transformation of patterns do not scale due to variations in intrinsic properties of smooth and discrete segments or drastic variations in angles of segments.
- From literature, we know that there is additional complexity due to accretion. ETC.

Proposal to compute design configurations

- Mathematical abstractions & computational geometry
- Conformity to architecture / planning constraints can be evaluated by measuring properties of output

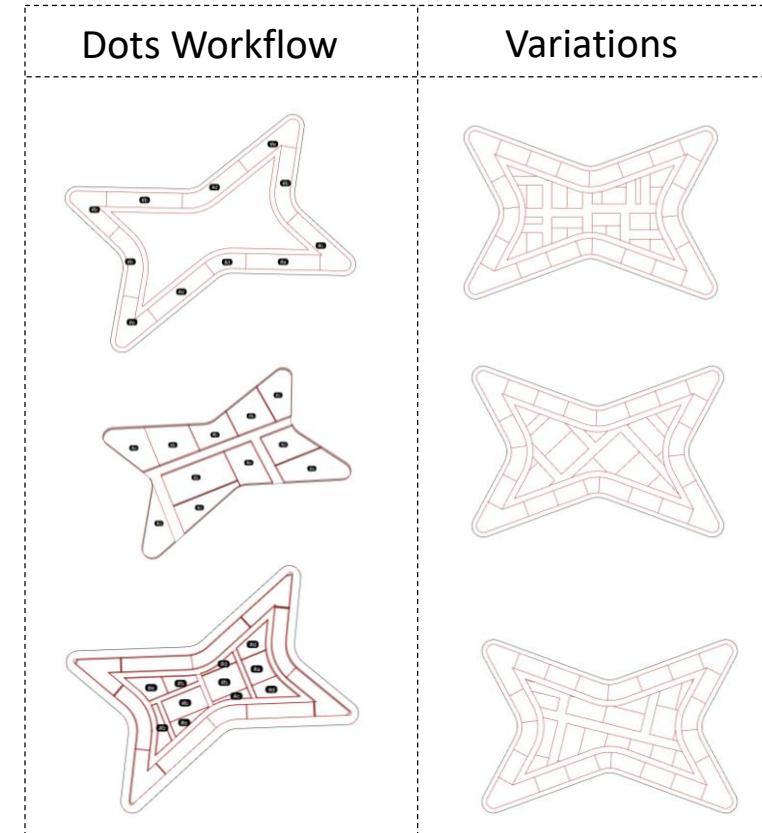
Why now?

- Advancement in processing power – of computers
- Algorithms for graphics and AI
- Cross-domain specialization

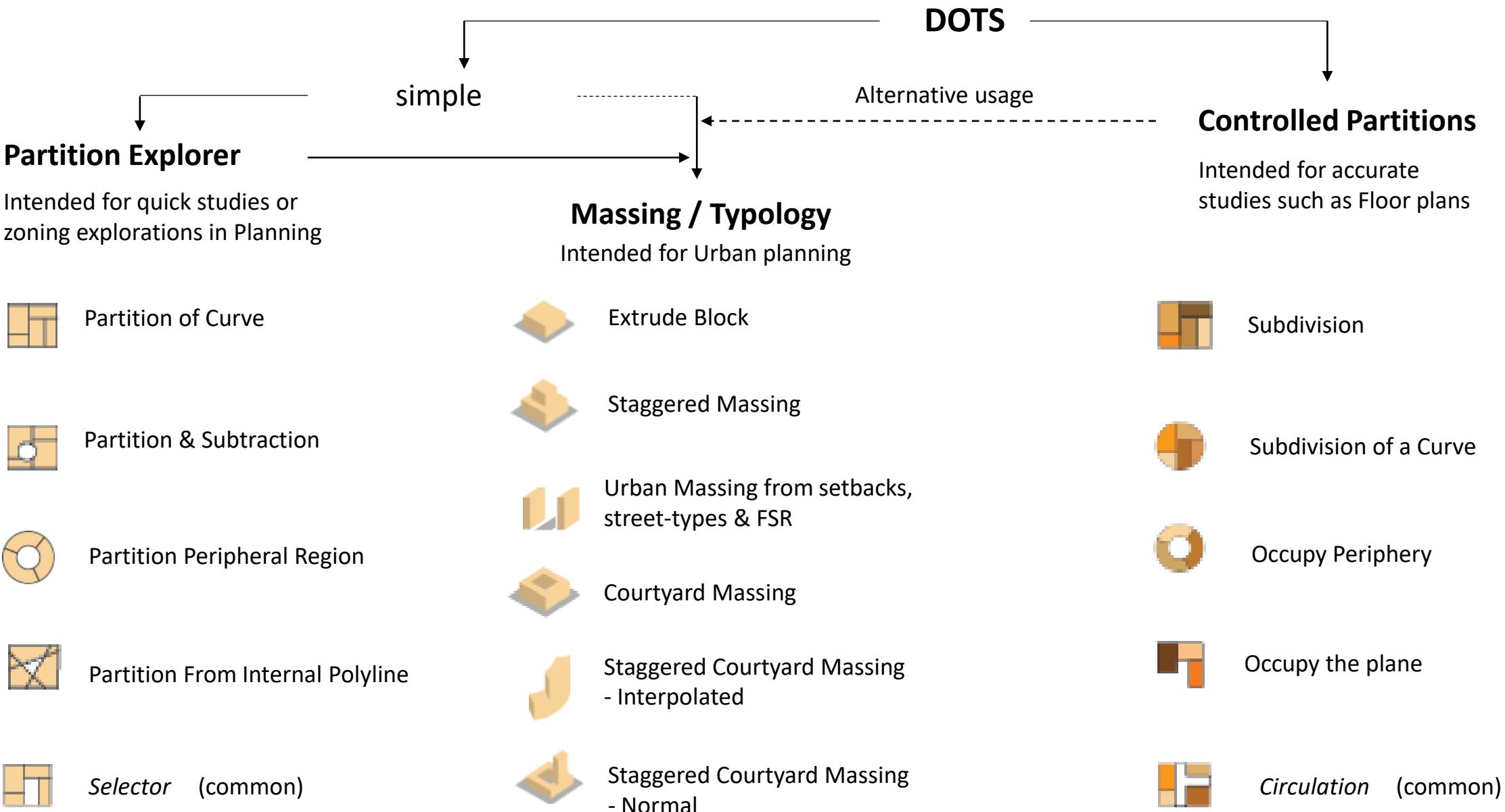
Geometry Processing: Analysis and Synthesis of Planning Configurations

Using DOTS components

- Allows design Architecture & Urban Planning **exploration** through various algorithms.
- It will **try** to maximize the possibility of achieving input-constraints.
- Dots' components are meant to be used in **combination**.
- Appropriate optimization algorithms that respond to domain specific **constraints** are in-built or user-defined.
- Generates SMOOTH OR RECTILINEAR FORMS



Components



Software Design

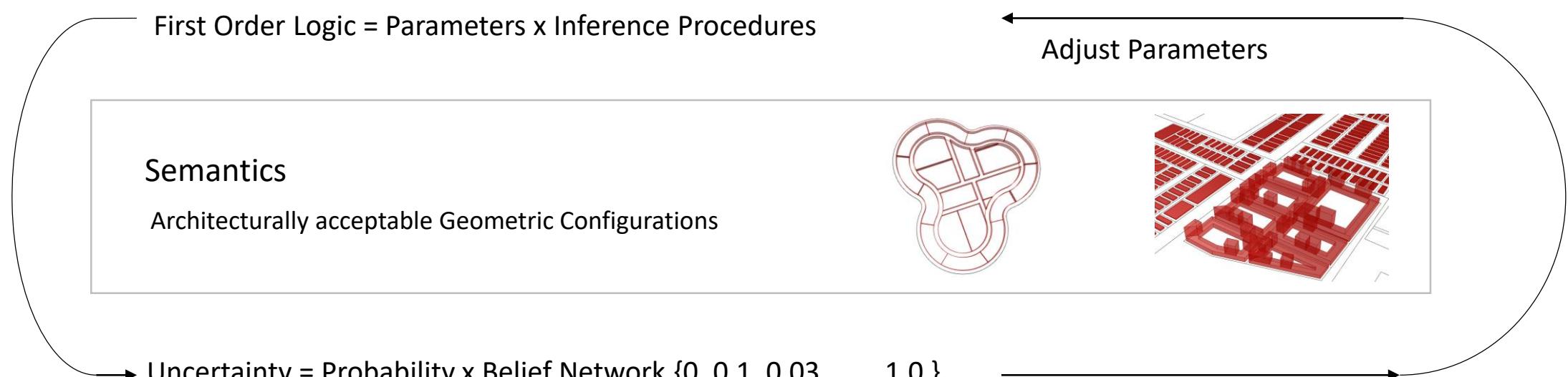
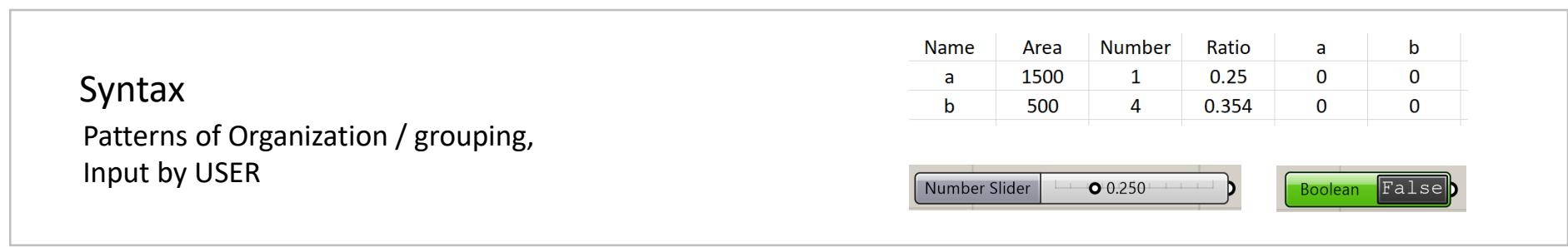
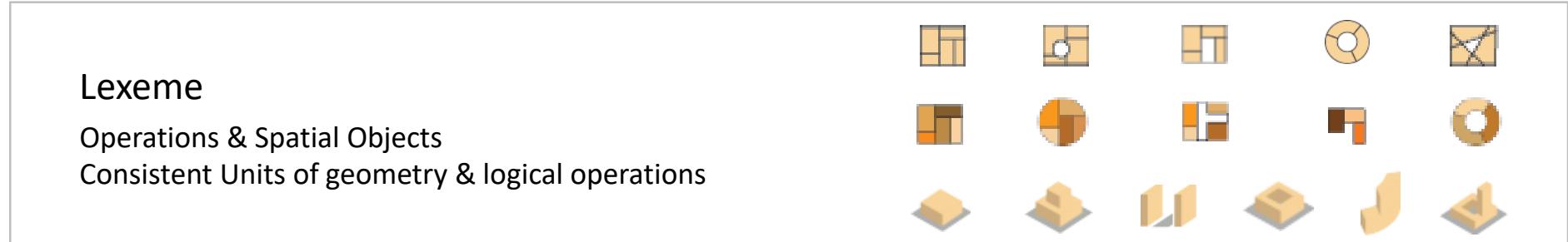
Input



Processing

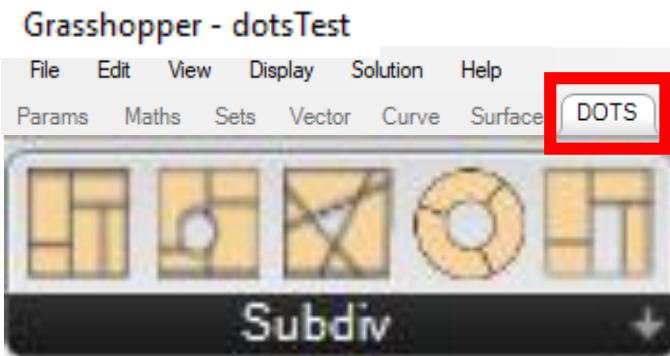


Output



Fundamental Components for *Partitions* of a region (urban layouts)

Intended use : Floor plan automation



Input Types

Number



Boolean



Curve / Geometry



Subdivision



Subdivide a closed curve into parcels and streets



Subdivide a closed curve into parcels and streets and remove internal curves



Subdivide a closed curve from a given polyline

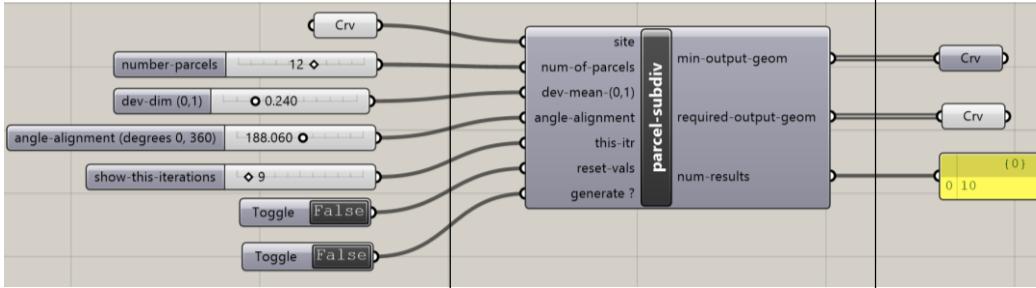
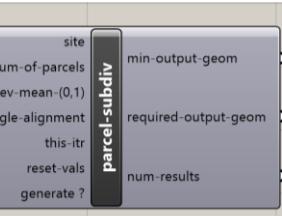
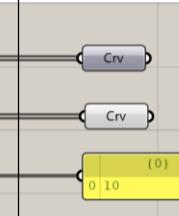
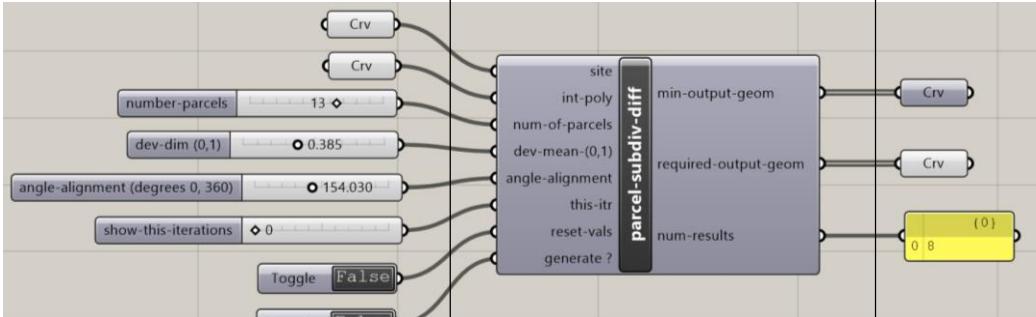
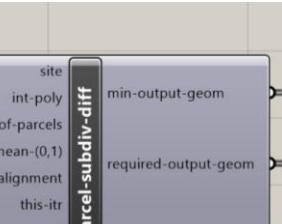
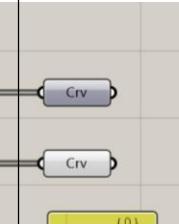
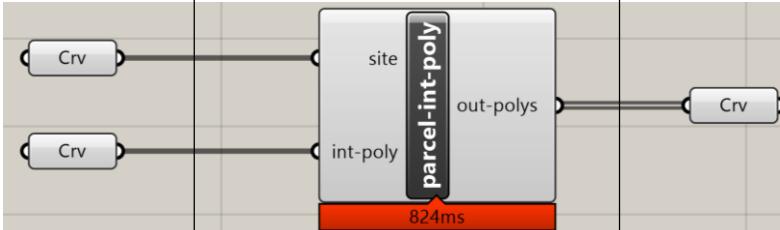


Generates parcels around the periphery

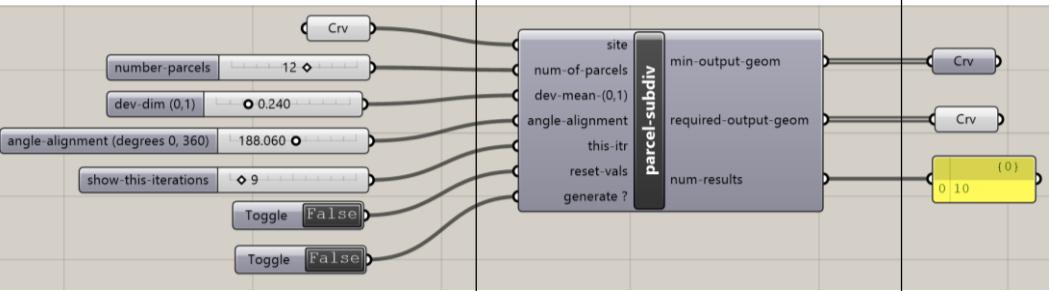
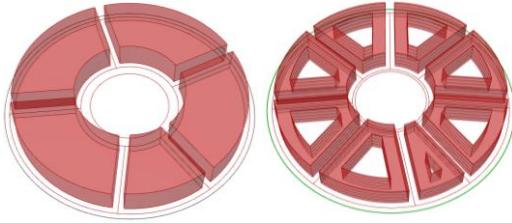
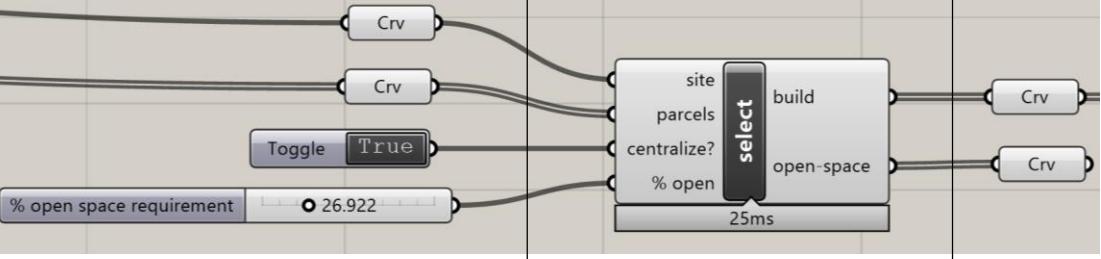


From given set of parcels, separate them for open-space requirements and build-able curves

Fundamental Components for *Partitions* of a region (urban layouts)

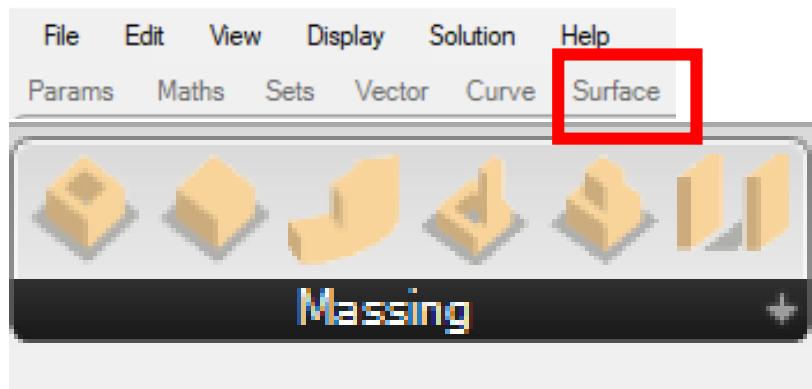
Name	Input	DOTS Component	Output	Illustration
 Parcels by Subdivision				
 Parcels by Subdivision & Subtraction				
 Parcels From Internal Polyline				

Fundamental Components for *Partitions* of a region (urban layouts)

Name	Input	DOTS Component	Output	Illustration
 Generate Parcels on Periphery		Parcel-subdiv site num-of-parcels dev-mean (0,1) angle-alignment this-itr reset-vals generate ? min-output-geom required-output-geom num-results		
 Select open-space requirements		select site parcels centralize? % open build open-space 25ms	 	random central

Fundamental Components for *Massing* or Typologies

Grasshopper - dotsTest



Massing / Typologies

- Extrusion
- Staggered Extrusion
- Courtyard
- Staggered Courtyard (interpolated)
- Staggered Courtyard (normal)
- Large-scale urban mass generator (detect streets & Setbacks)

Intended use : Generate building typologies from parcels

Input Type

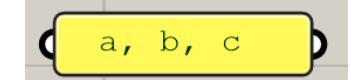
Number



Boolean



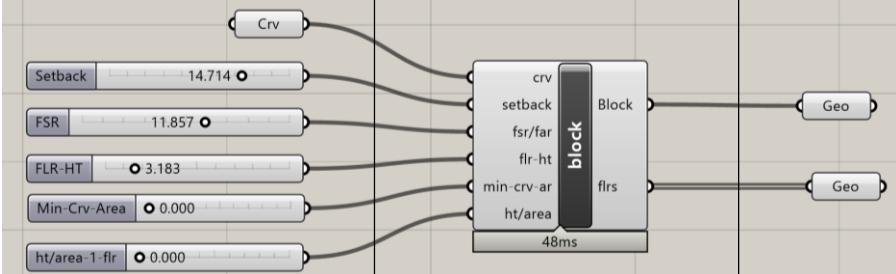
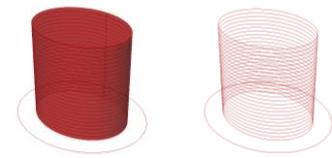
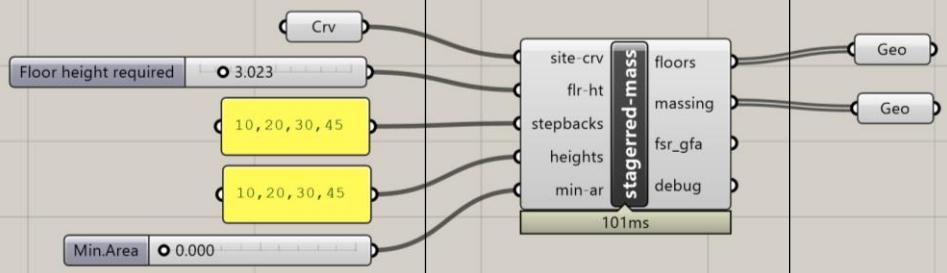
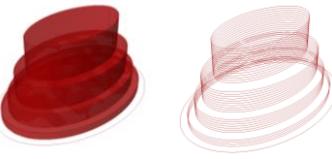
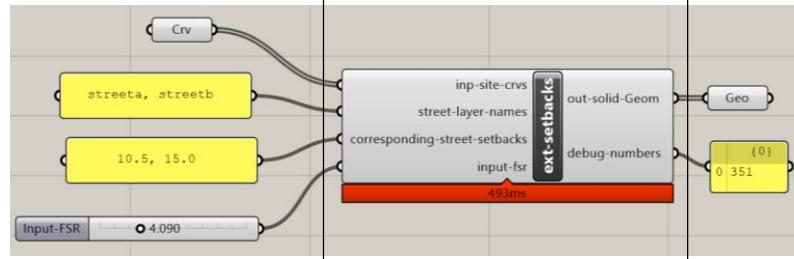
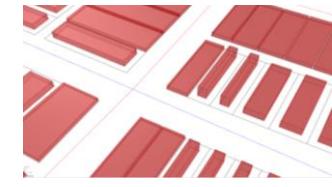
Text Panel



Curve / Geometry



Fundamental Components for *Massing* or Typologies

Name	Input	DOTS Component	Output	Illustration
 Extrude Block (based on FSR)				
 Staggered Massing (user defines ht)				
 Urban Massing from setbacks, street-types & FSR				

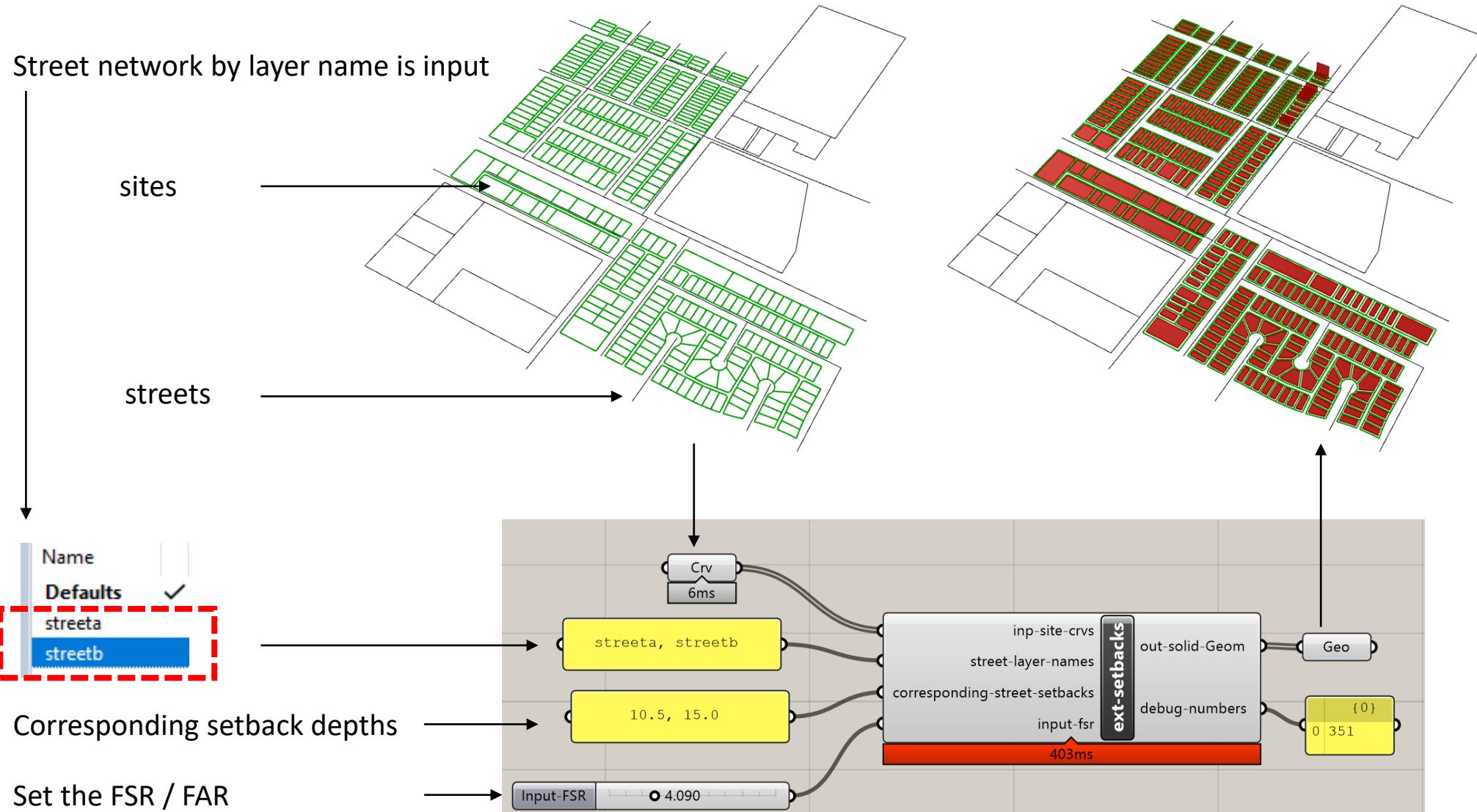
Fundamental Components for *Massing* or Typologies

Name	Input	DOTS Component	Output	Illustration
Courtyard Massing				
Staggered Courtyard Massing - Interpolated				
Staggered Courtyard Massing - Normal				

Sample Workflow



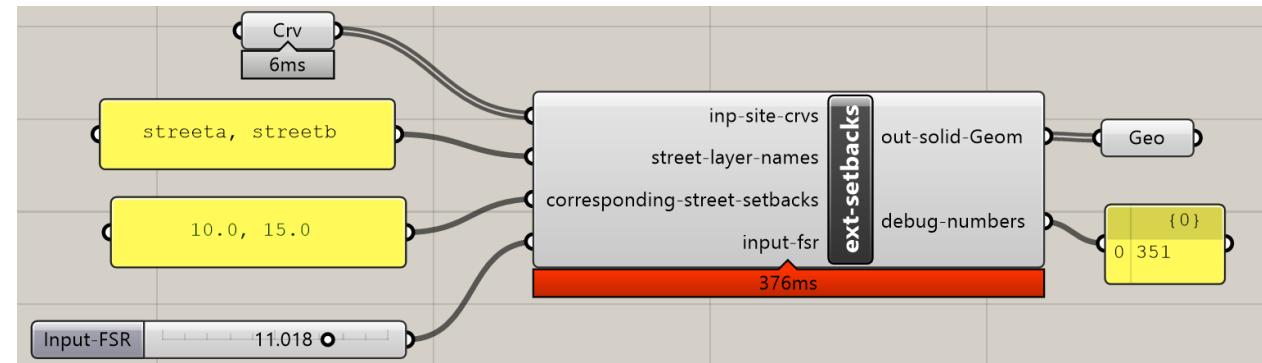
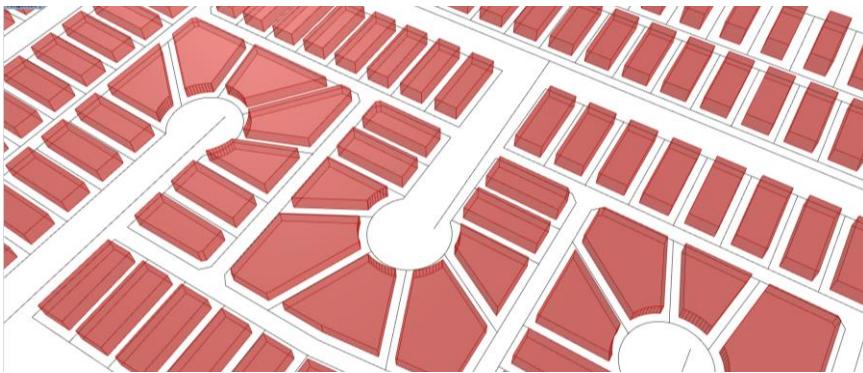
Urban Massing from setbacks, street-types & FSR



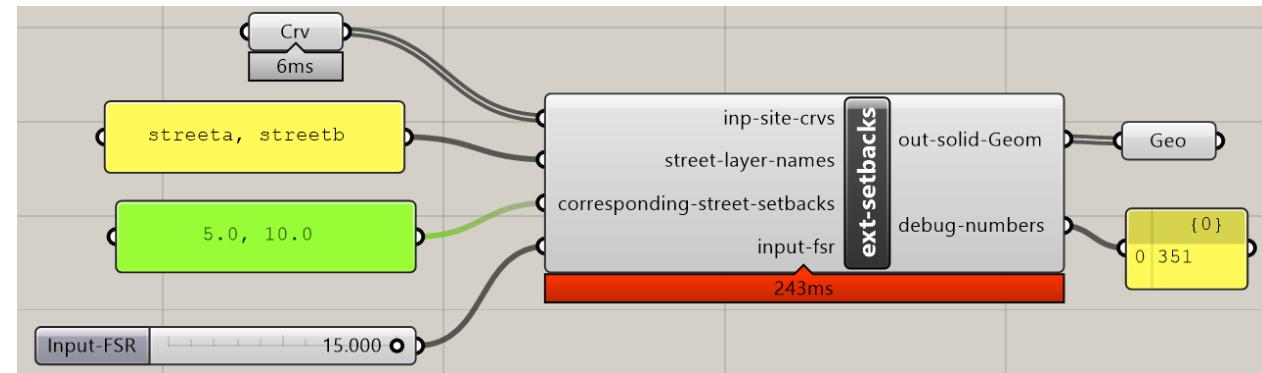
Alternatives



Urban Massing from setbacks, street-types & FSR

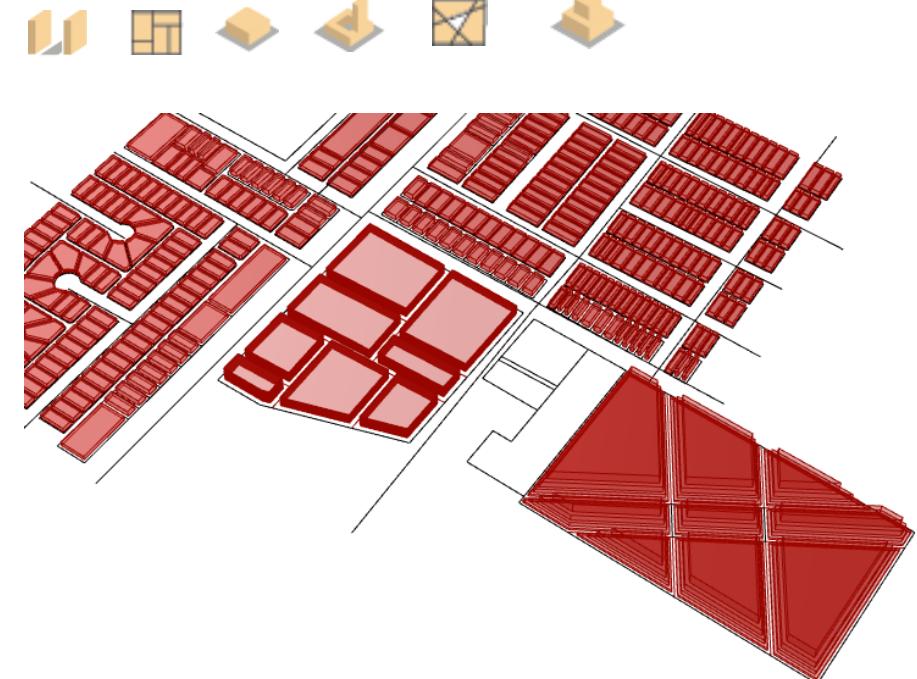
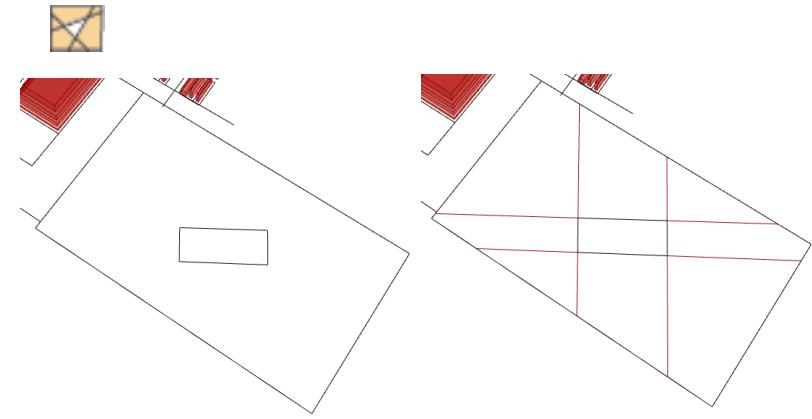
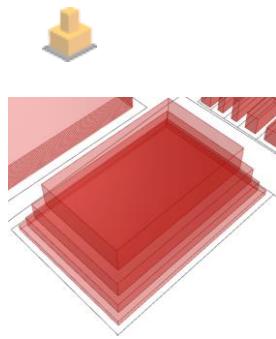
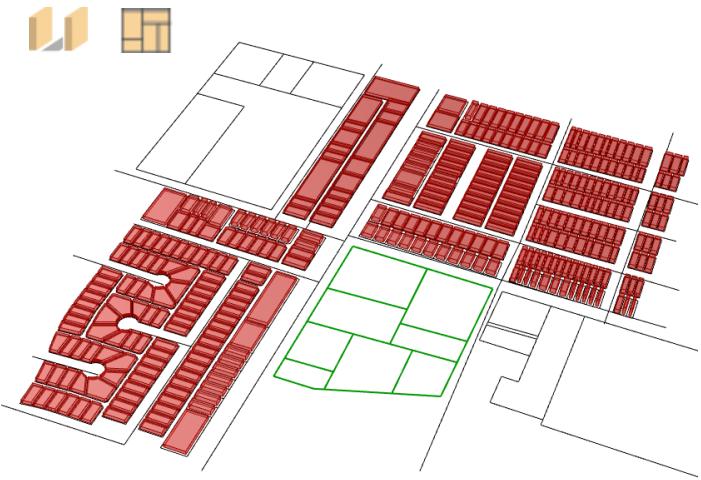


Setback depths = 10.5, 15.0; FSR = 11.018



Setback depths = 5.0, 10.0; FSR = 15.0

Setup ***workflows*** for urban layouts



Fundamental Components of Controlled Subdivision

Grasshopper - dotsTest



Intended use: Generate Floor Plans / Site Plan

- ### Controlled Subdivision
- Subdivide a closed curve
 - Place spaces along the periphery
 - Place orthogonal spaces in a plane
 - Find appropriate circulation

Intended use : Floor plan automation

Inputs

- Number



- Boolean



- Link to .csv file



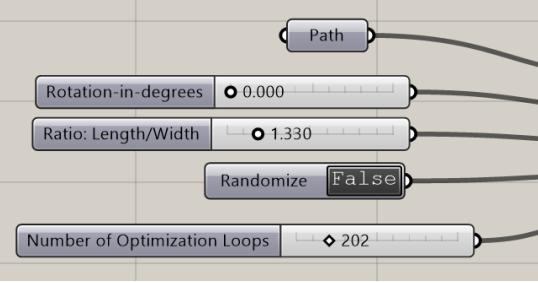
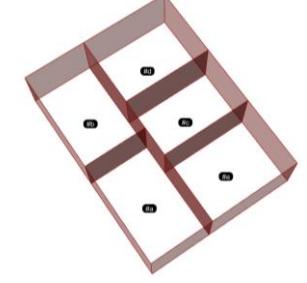
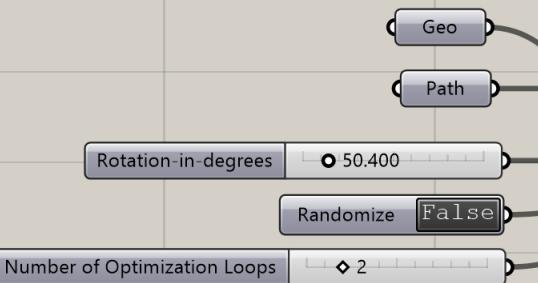
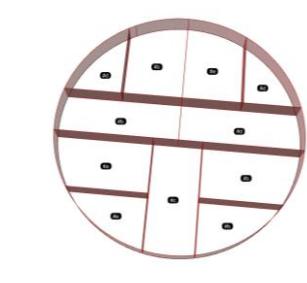
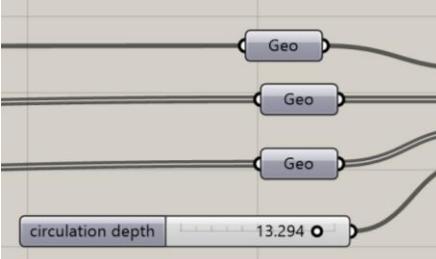
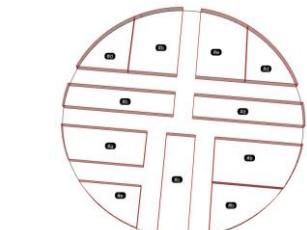
Name	Area	Number	Ratio	a	b	c	d	e
a	1000	1	0.25	0	0	20	0	0
b	1000	4	0.354	0	0	0	0	0
c	1000	1	1	20	0	0	0	0
d	1000	3	1.15	0	0	0	0	0
e	1000	2	1.3	0	0	0	0	-100

Geometric Requirements

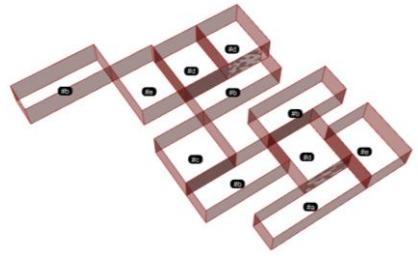
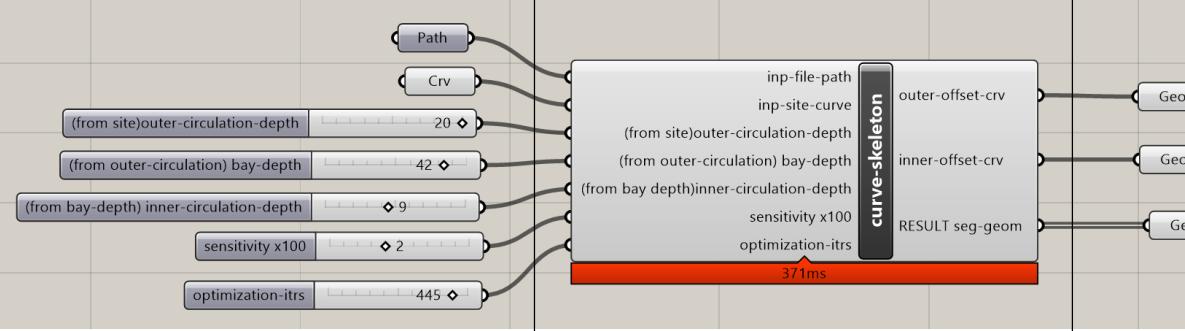
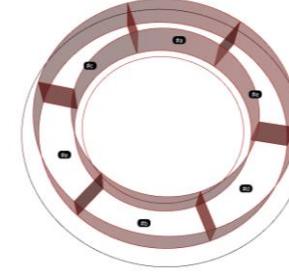
Adjacency Matrix

(neighborhood information)

Fundamental Components for controlled subdivision

Name	Input	DOTS Component	Output	Illustration
 Generate boundary and subdivide		CBSP input-files(csv) Rot-degrees ratio length/width randomize optimization-loops 447ms	debug-Adj-inp debug-BSP-config-inp outer boundary Crv	
 Input boundary and subdivide		cbsp-Site input-files(csv) input-site-crv Rot-degrees randomize optimization-loops 330ms	spatial-crv circulation-lines Geo	
 Generate circulation – corridors / streets		circulation site-crv / outer-boundary cbsp-crvs partition-lines circulation-depth 722ms	0. partition-lines 1. circulation-poly 2. resultant-cbsp-crv Geo	

Fundamental Components for controlled subdivision

Name	Input	DOTS Component	Output	Illustration
 Generate spaces and occupy a plane		exploratory-McMC inp-file-path sensitivity-num-itrs rotation 3.9s	Crv	
 Place spaces along the periphery		curve-skeleton inp-file-path inp-site-curve (from site)outer-circulation-depth (from outer-circulation) bay-depth (from bay-depth) inner-circulation-depth sensitivity x100 optimization-itrs 371ms	outer-offset-crv inner-offset-crv RESULT seg-geom	

Scope & Constraints for optimization

Input Sample : Adjacency

Name	Area	Number	Ratio	a	b	c	d	e
a	1000	1	0.25	0	0	20	0	0
b	1000	4	0.354	0	0	0	0	0
c	1000	1	1	20	0	0	0	0
d	1000	3	1.15	0	0	0	0	0
e	1000	2	1.3	0	0	0	0	-100

Input Sample 2 : Area & Adjacency

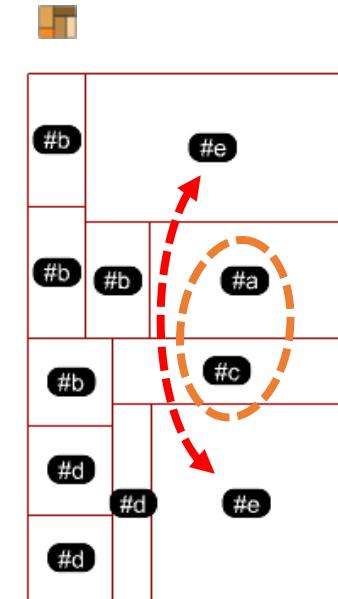
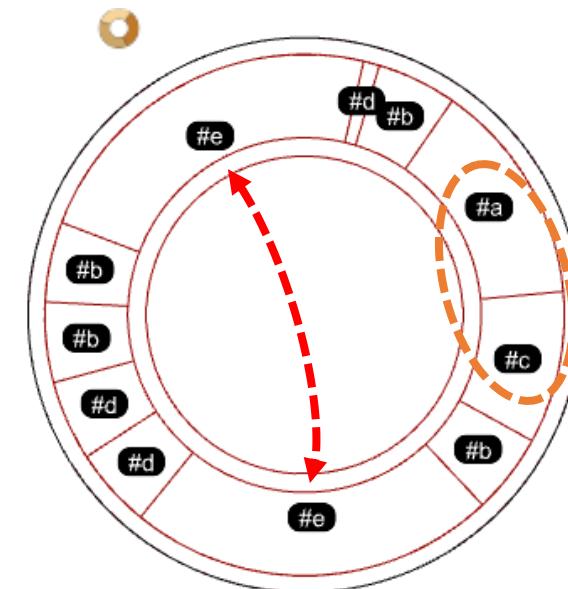
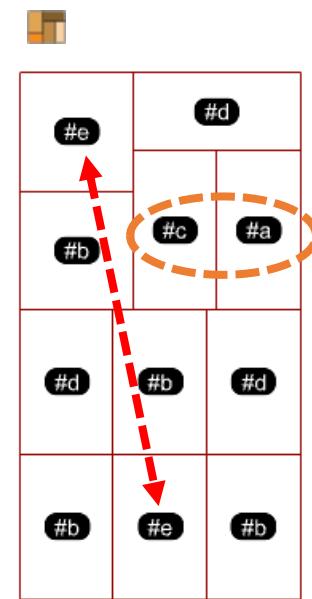
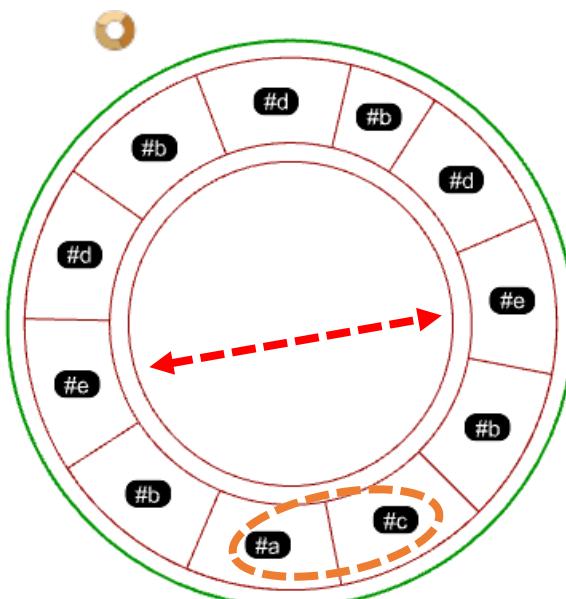
Name	Area	Number	Ratio	a	b	c	d	e
a	1500	1	0.25	0	0	20	0	0
b	500	4	0.354	0	0	0	0	0
c	1000	1	1	20	0	0	0	0
d	500	3	1.15	0	0	0	0	0
e	2500	2	1.3	0	0	0	0	-100

Adjacency Constraints

a & c should be together



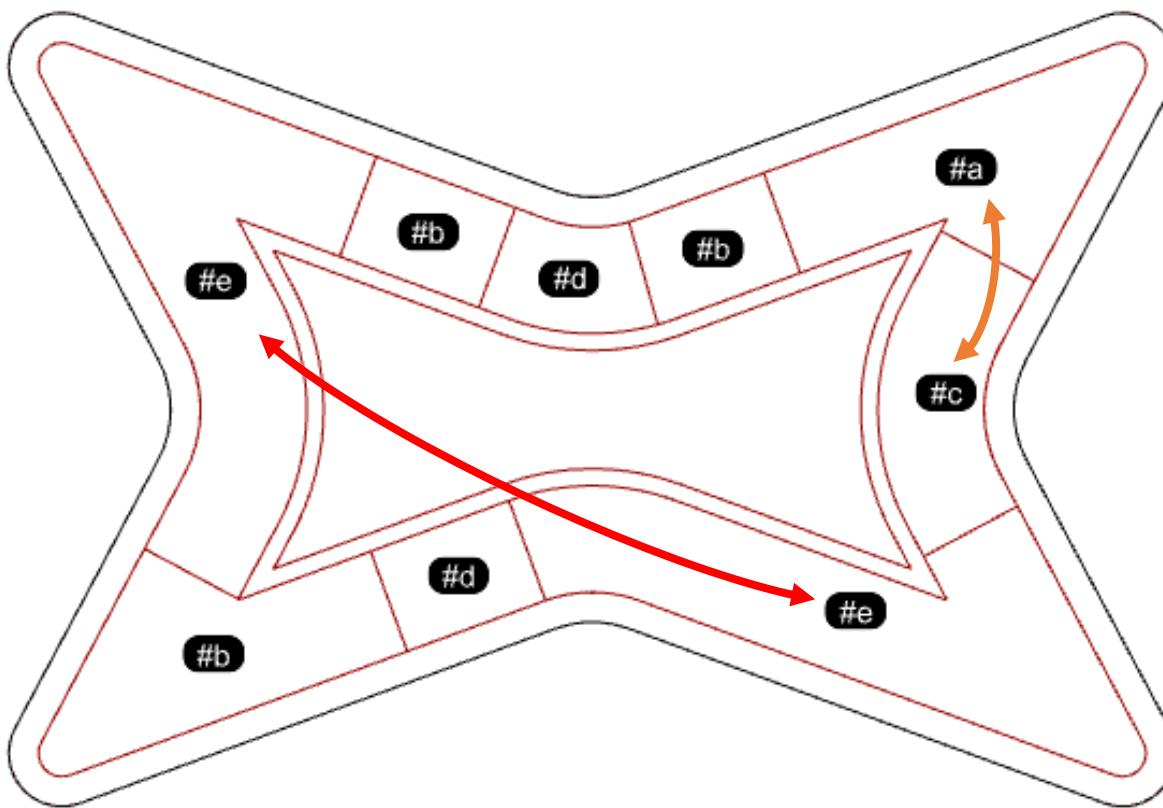
e should be separated



Sample Workflow

Input

geometry				adjacency				
Name	Area	Number	Ratio	a	b	c	d	e
a	1500	1	0.25	0	0	20	0	0
b	500	4	0.354	0	0	0	0	0
c	1000	1	1	20	0	0	0	0
d	500	3	1.15	0	0	0	0	0
e	2500	2	1.3	0	0	0	0	-100



Step 1. use the curve skeleton component

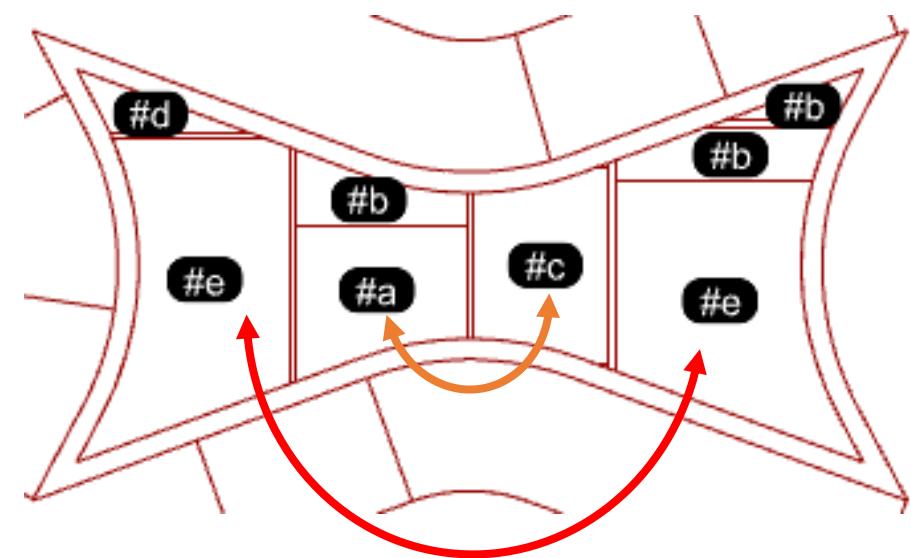
Join the DOTS components



Meet area requirements

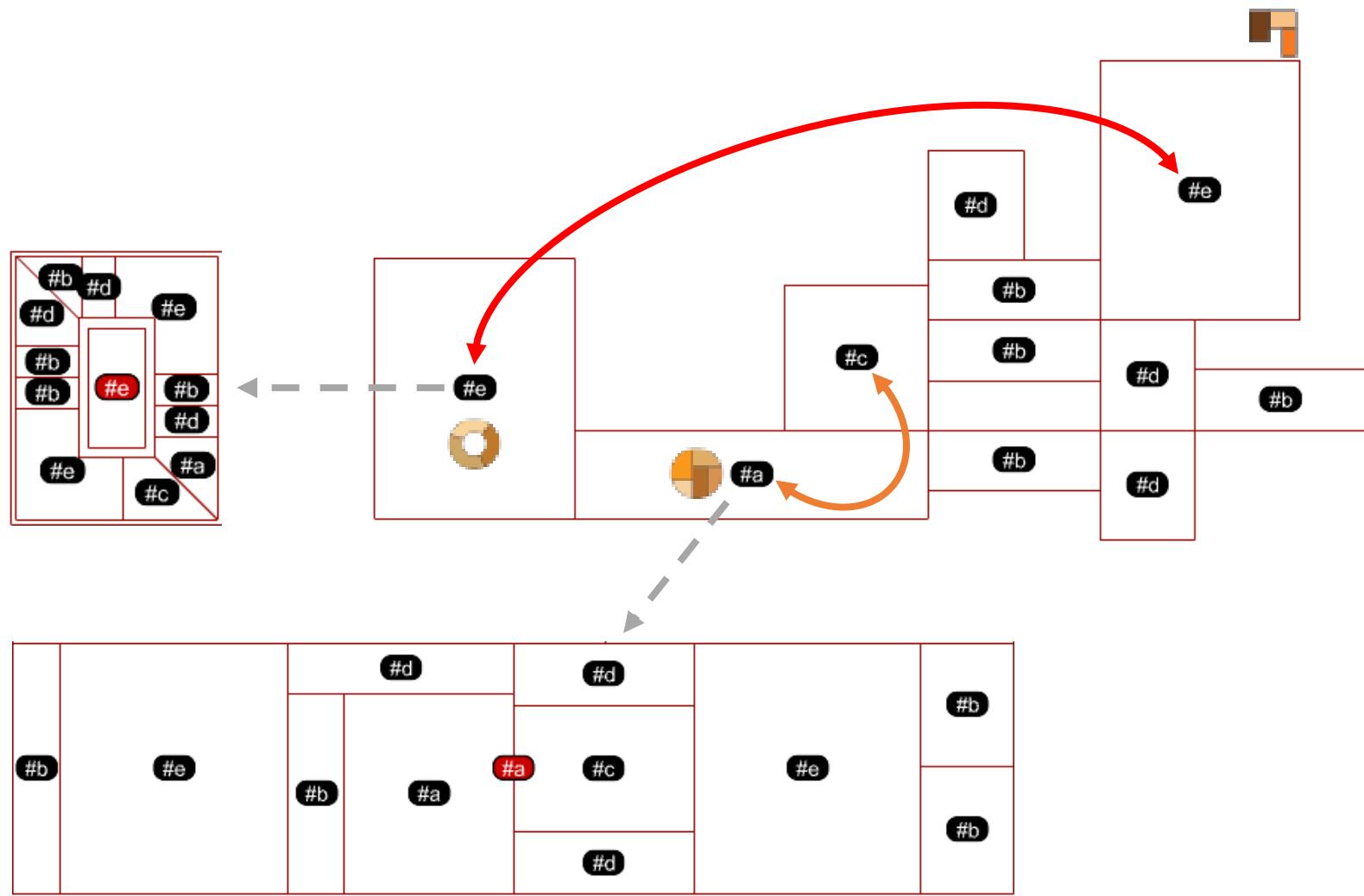
a & c should be together

e should be separated



Step 2. Use the cBSP 2 component

Sample Workflow



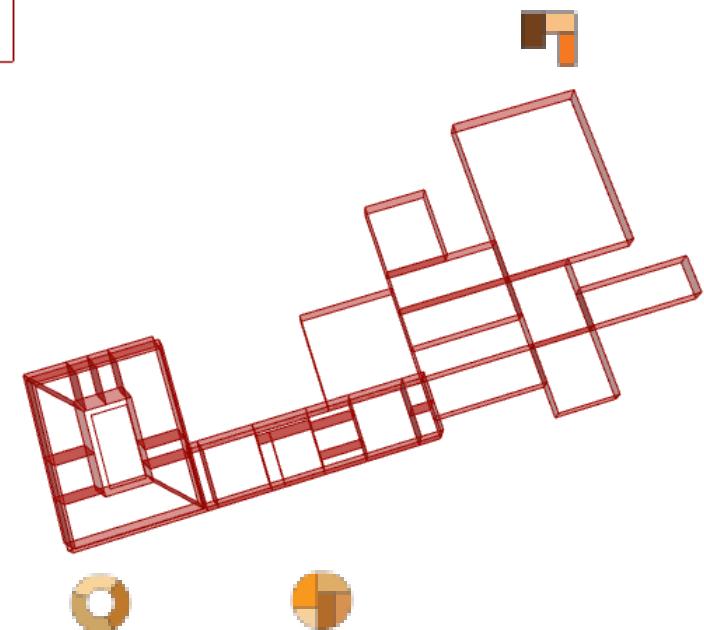
Join the DOTS components



Sample 2 : Area & Adjacency

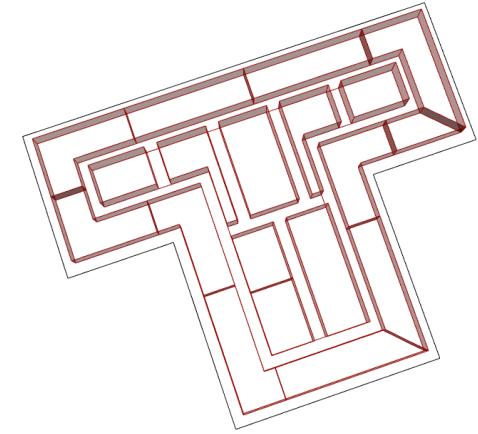
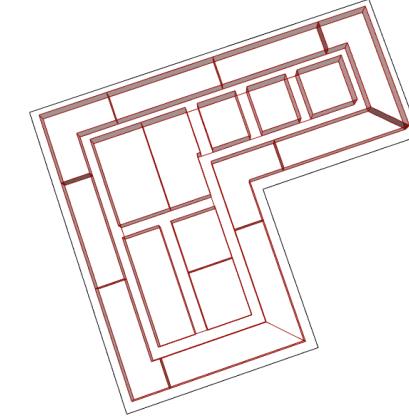
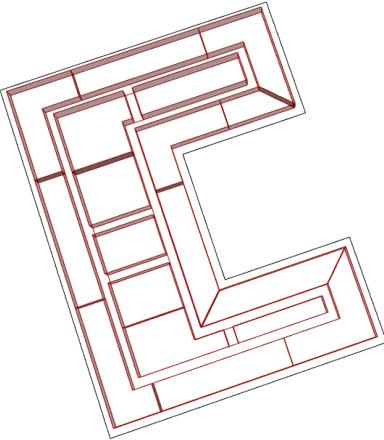
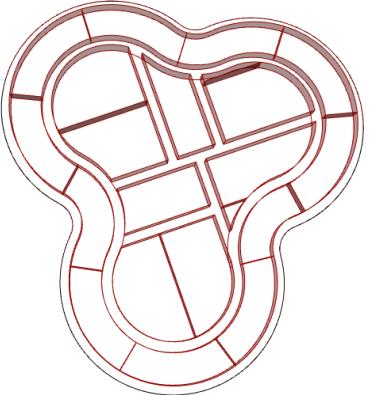
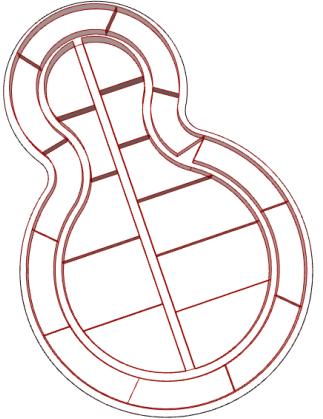
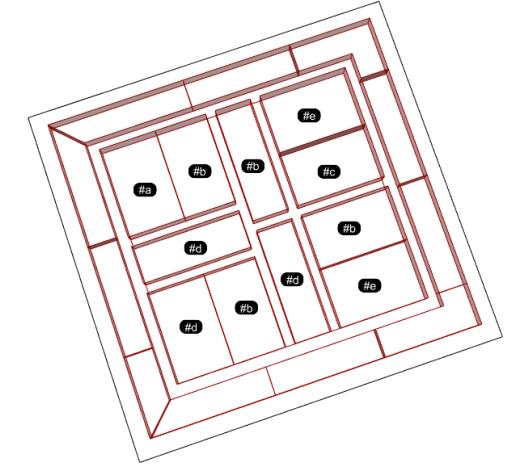
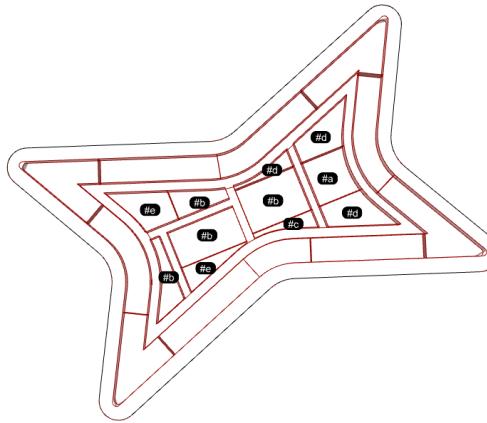
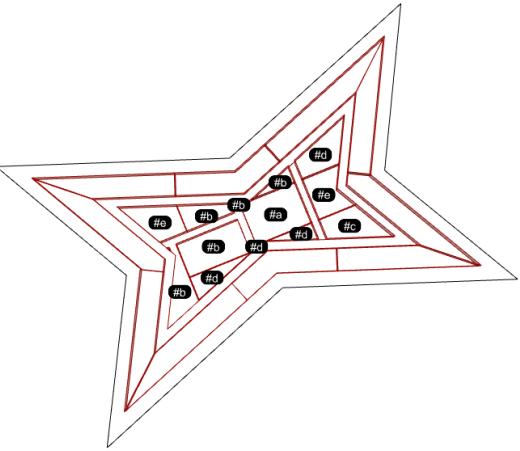
— orange — a & c should be together

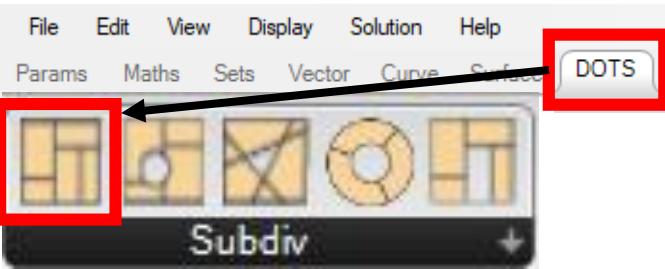
— red — e should be separated



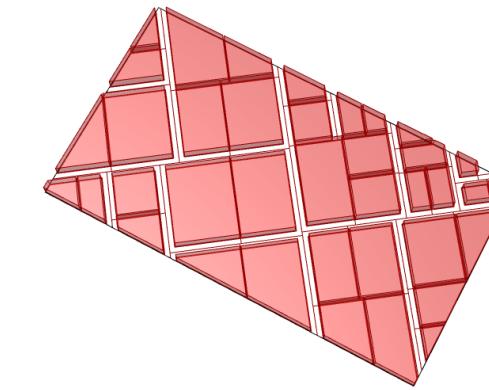
Applicable to a wide variety of geometric forms

Illustrations

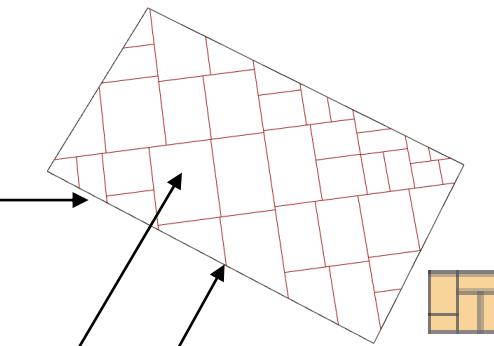




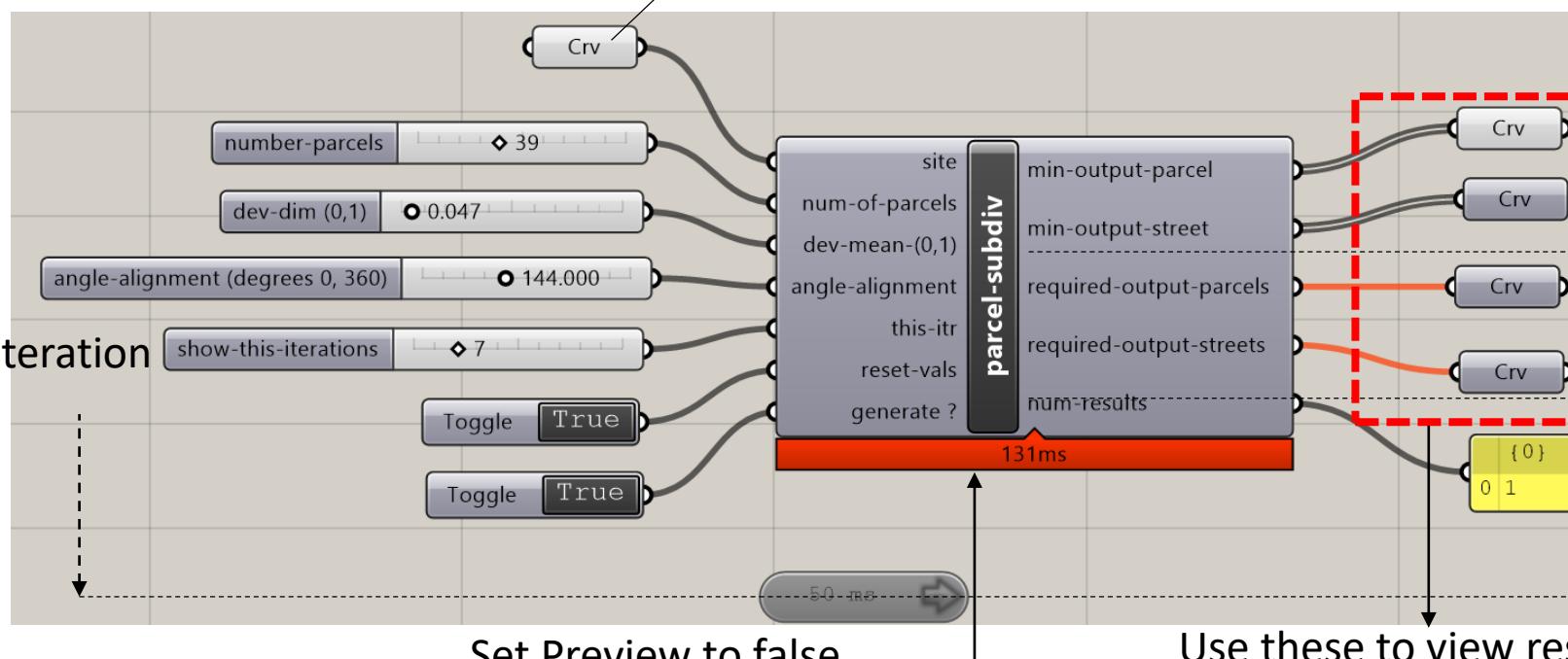
Component Details



Connected to circulation & Massing



Input site curve



Parcel Curves
Streets

Parcel Curves
Streets

Number of configs in stack

Best iteration

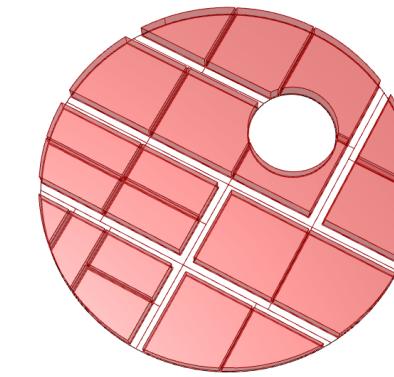
Req. Iteration

Set Preview to false

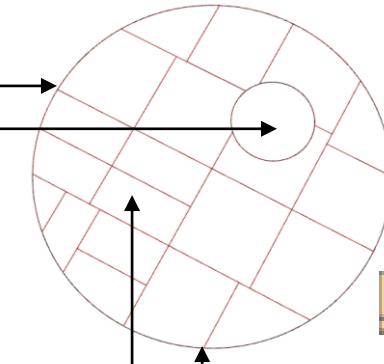
Use these to view results



Component Details



Connected to circulation & Massing



Input site curve
Input subtraction curve

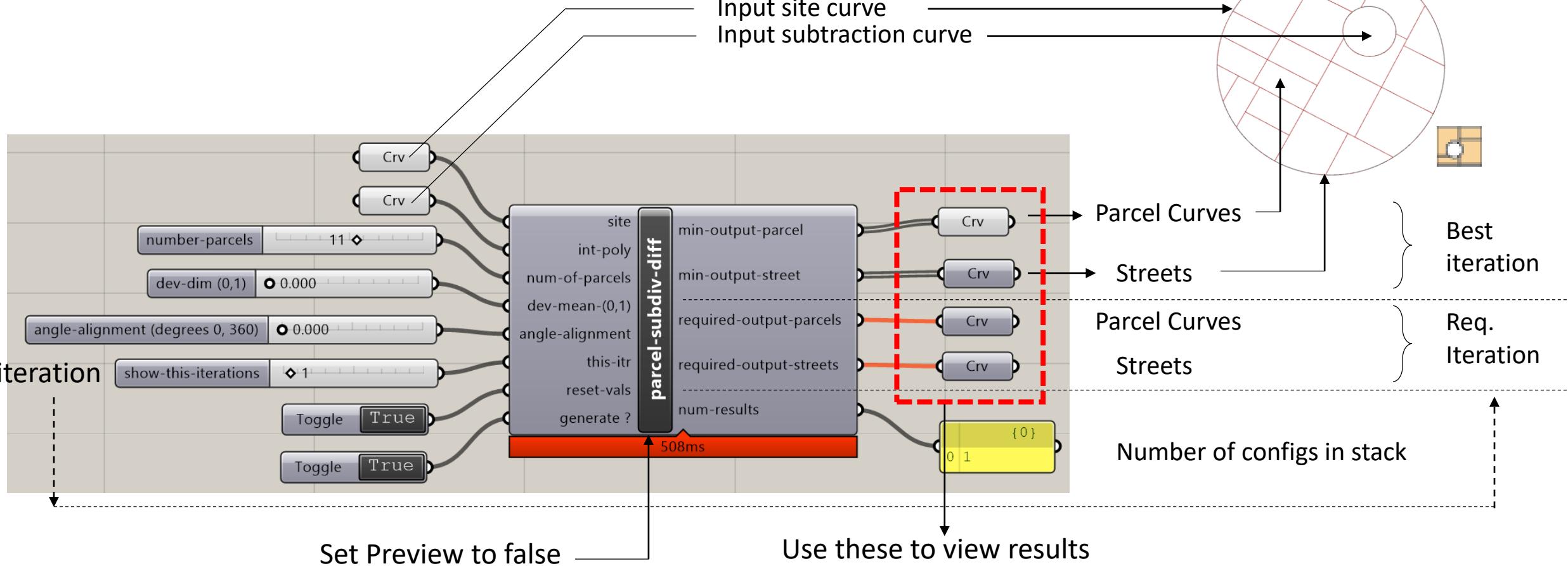
Parcel Curves
Streets

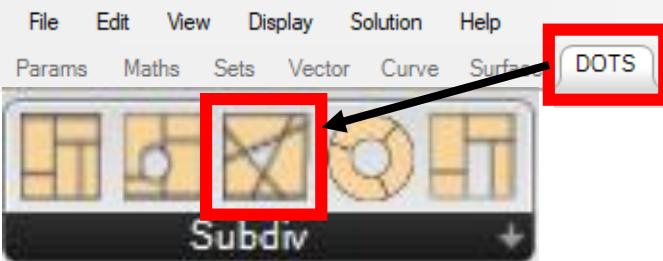
Parcel Curves
Streets

Best iteration

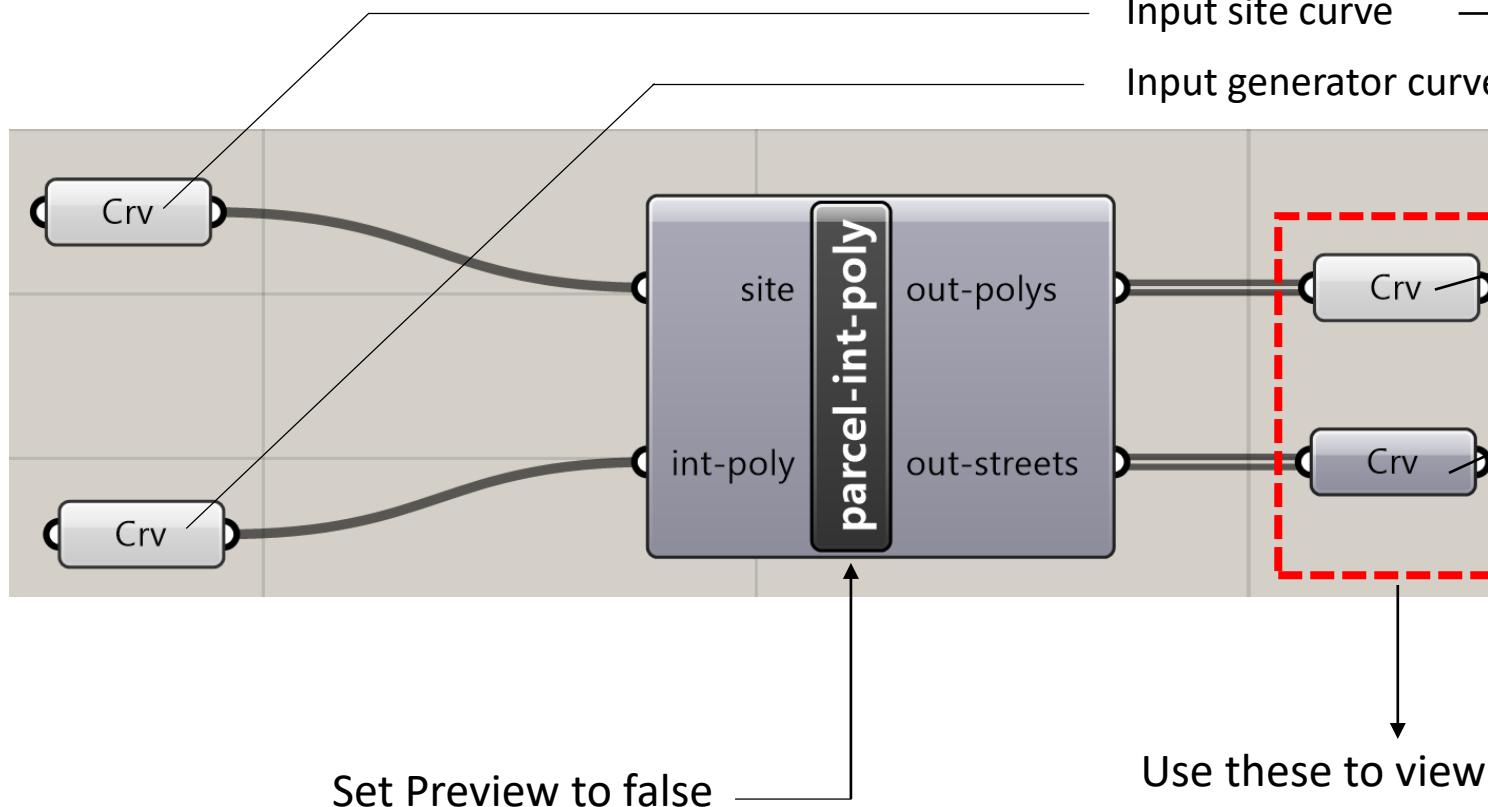
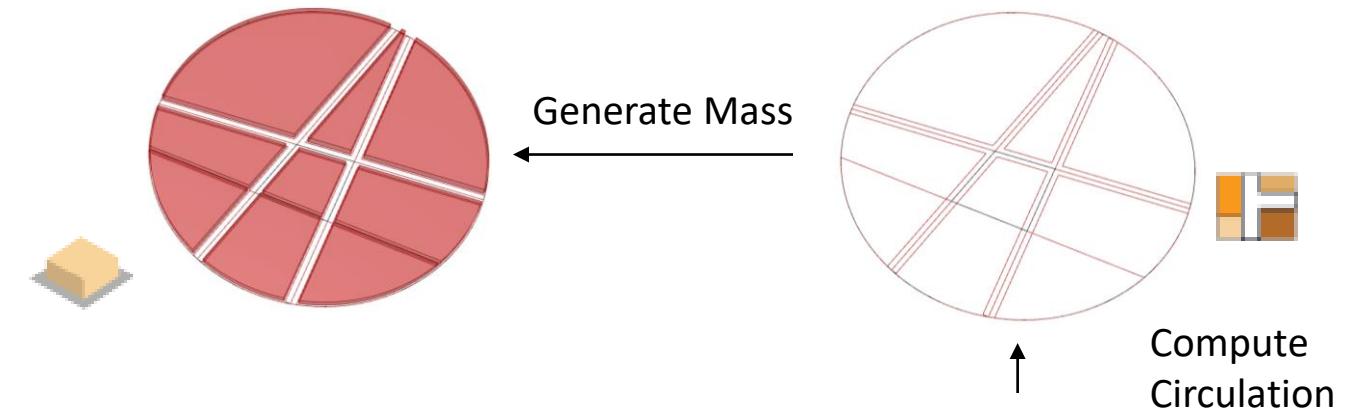
Req. Iteration

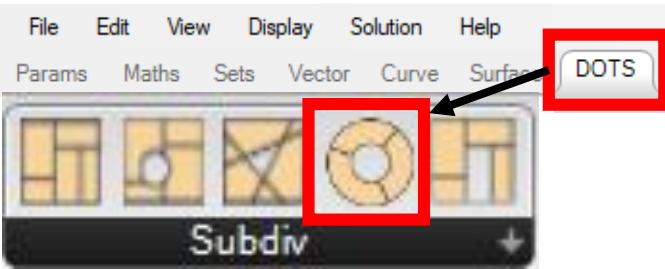
Number of configs in stack



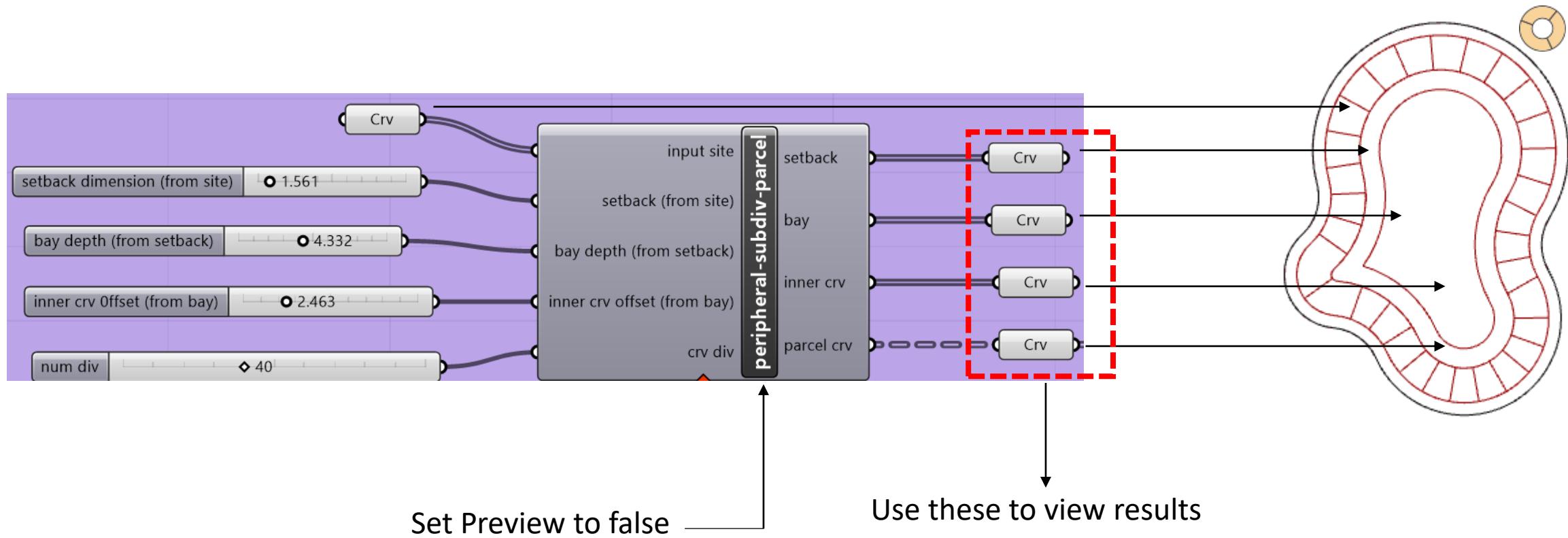
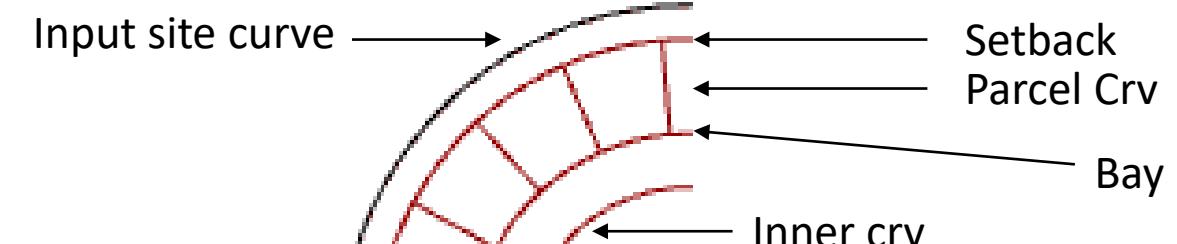


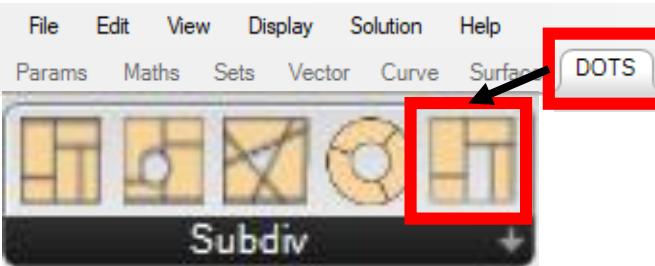
Component Details



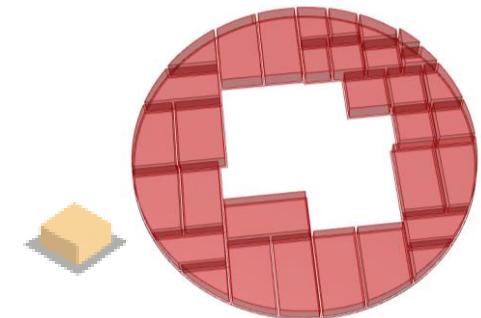


Component Details

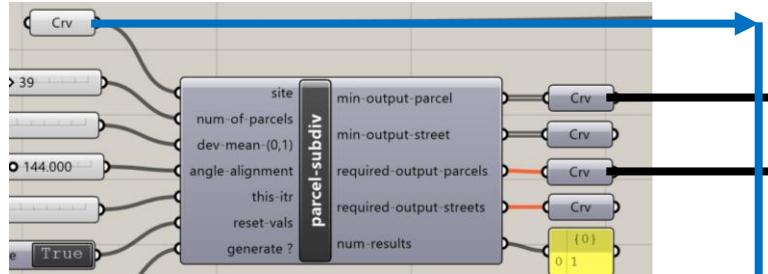




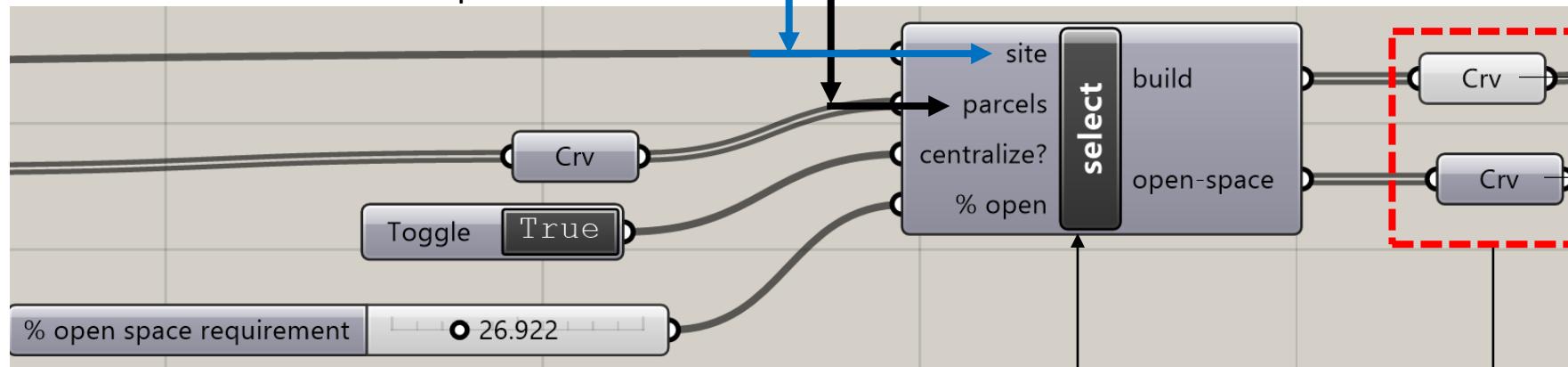
Component Details



Sample of Previous Subdivision Component

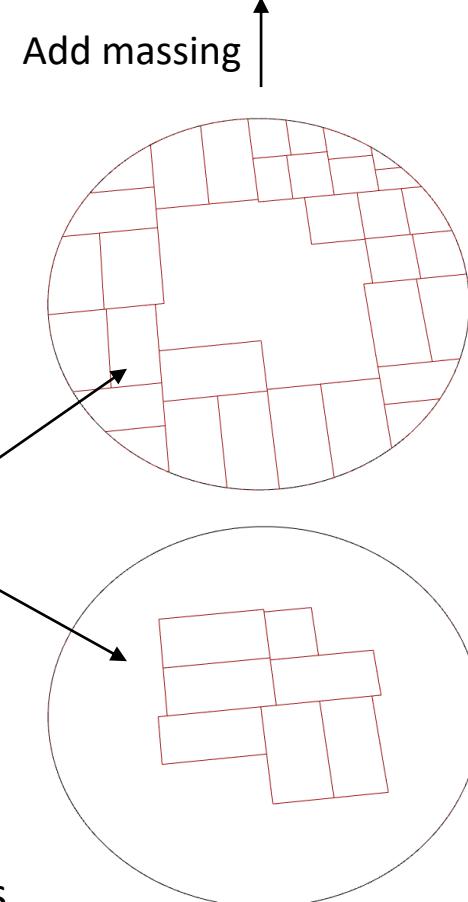


From Subdivision component



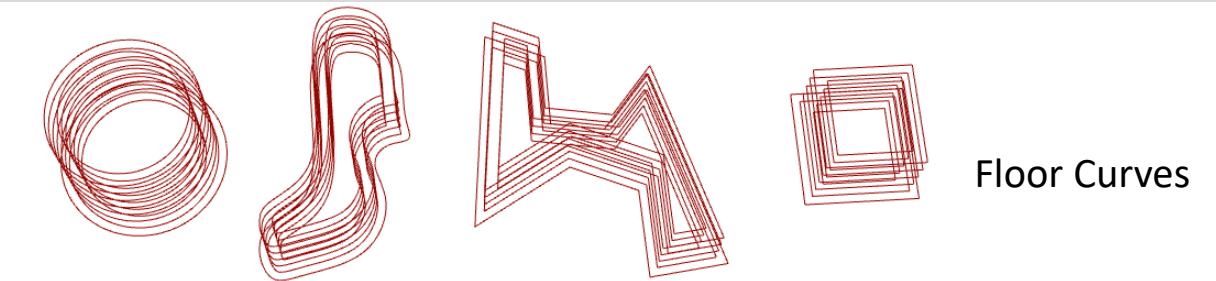
Set Preview to false

Use these to view results

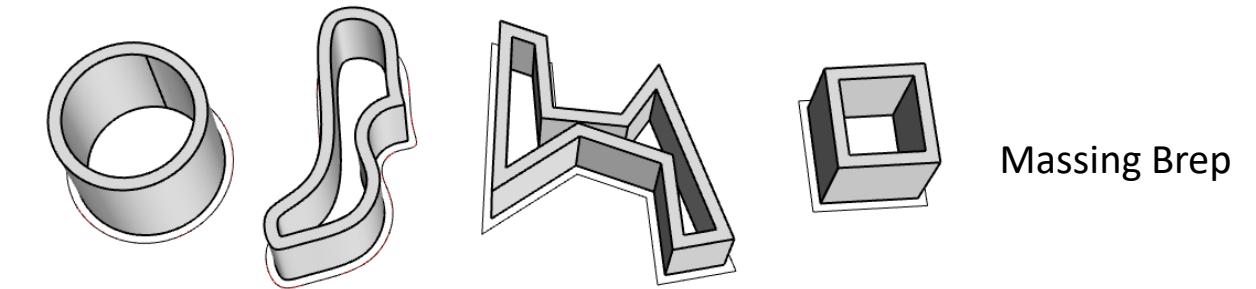




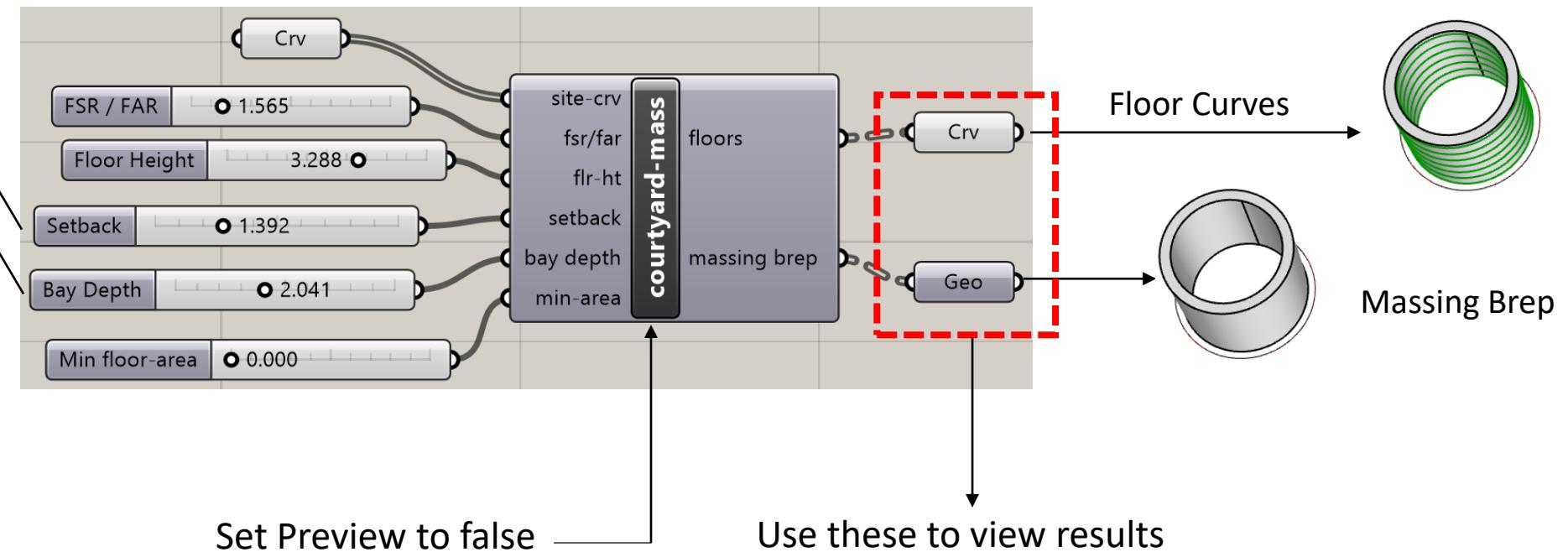
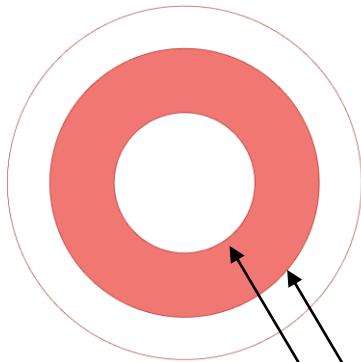
Component Details

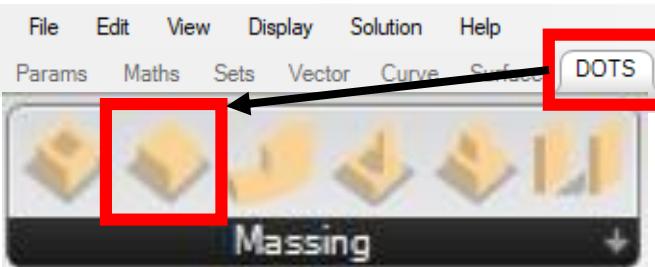


Floor Curves

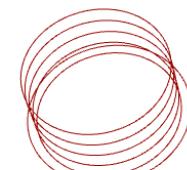
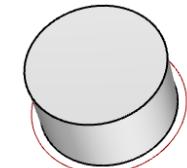
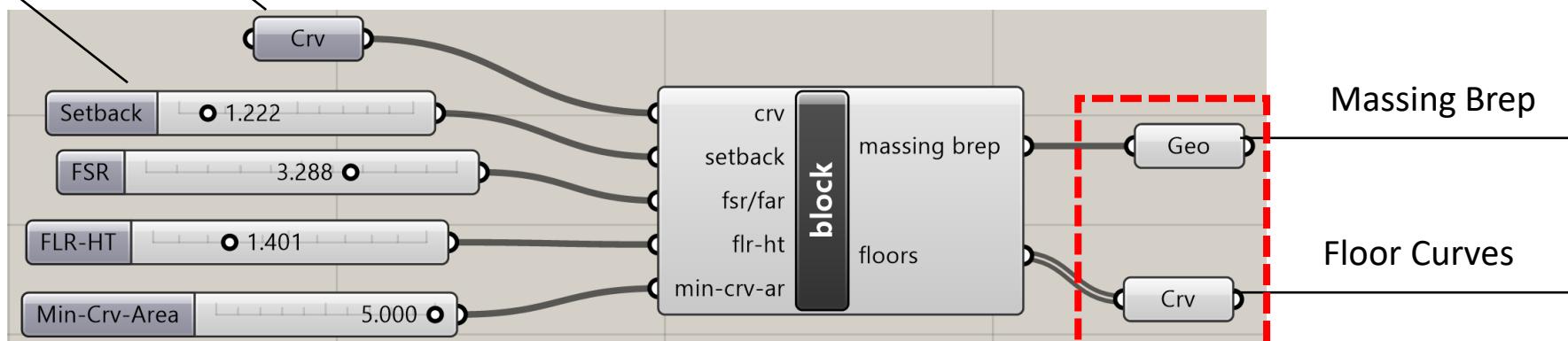
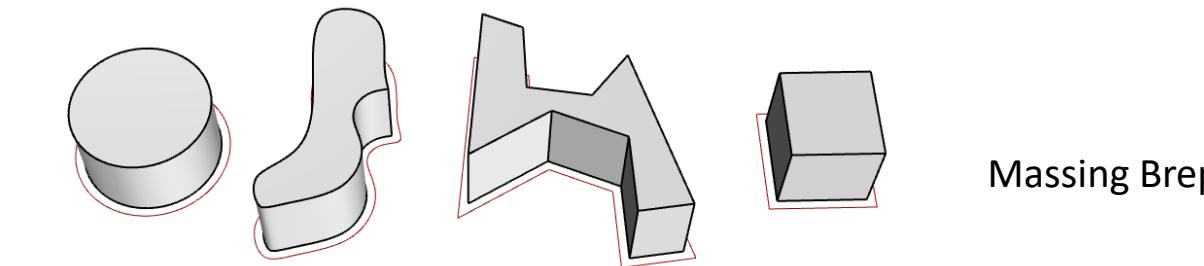
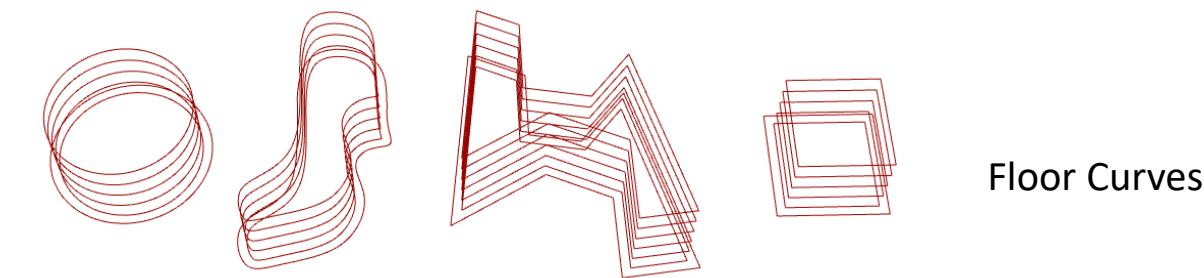


Massing Brep



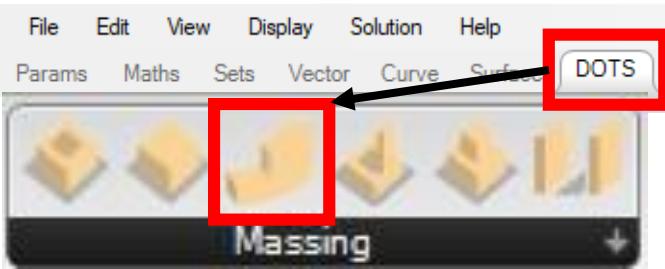


Component Details

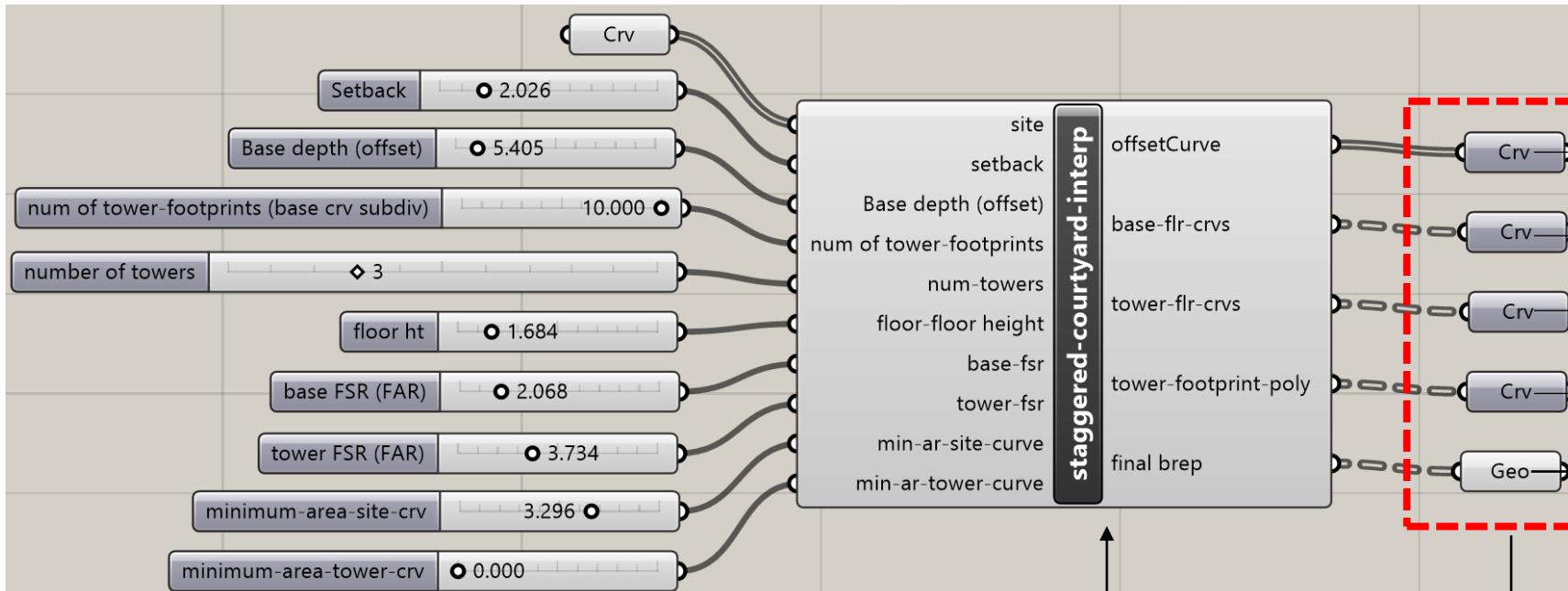
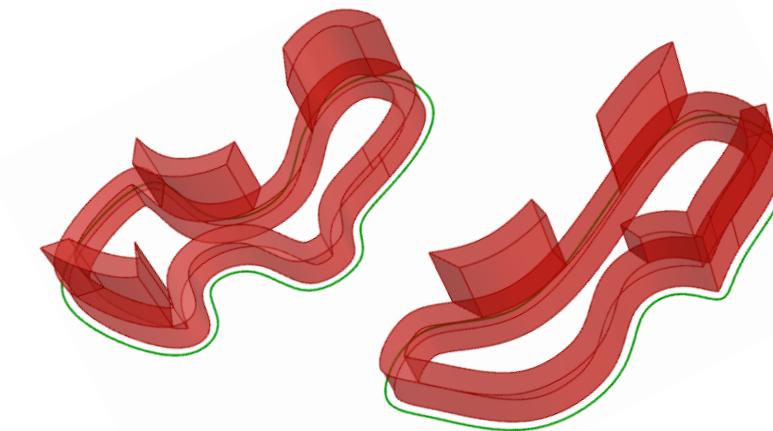


Set Preview to false

Use these to view results

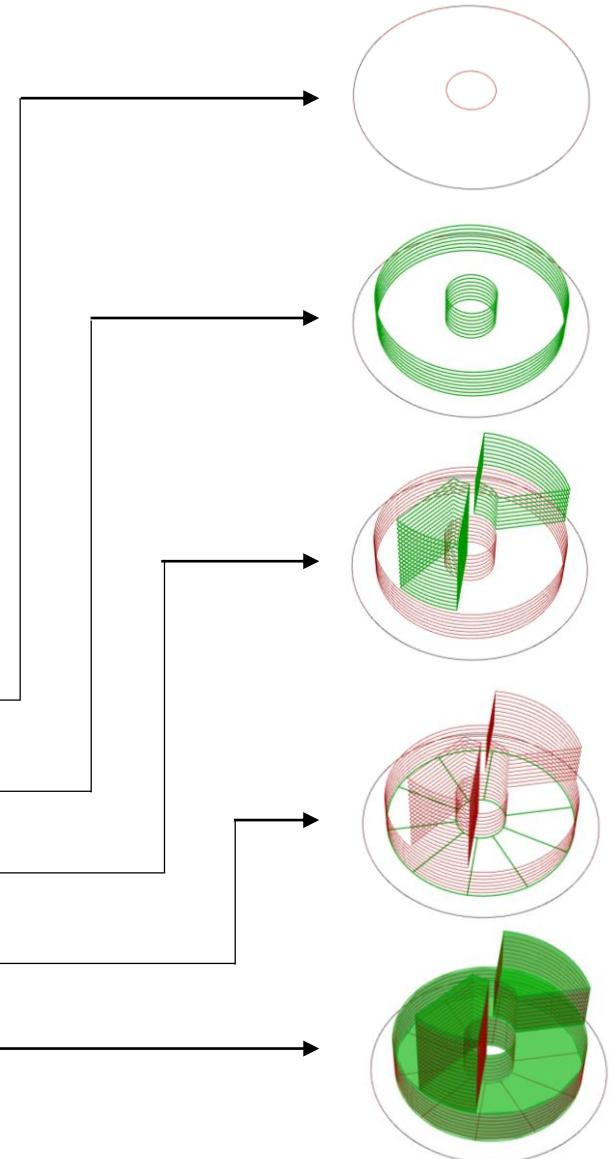


Component Details

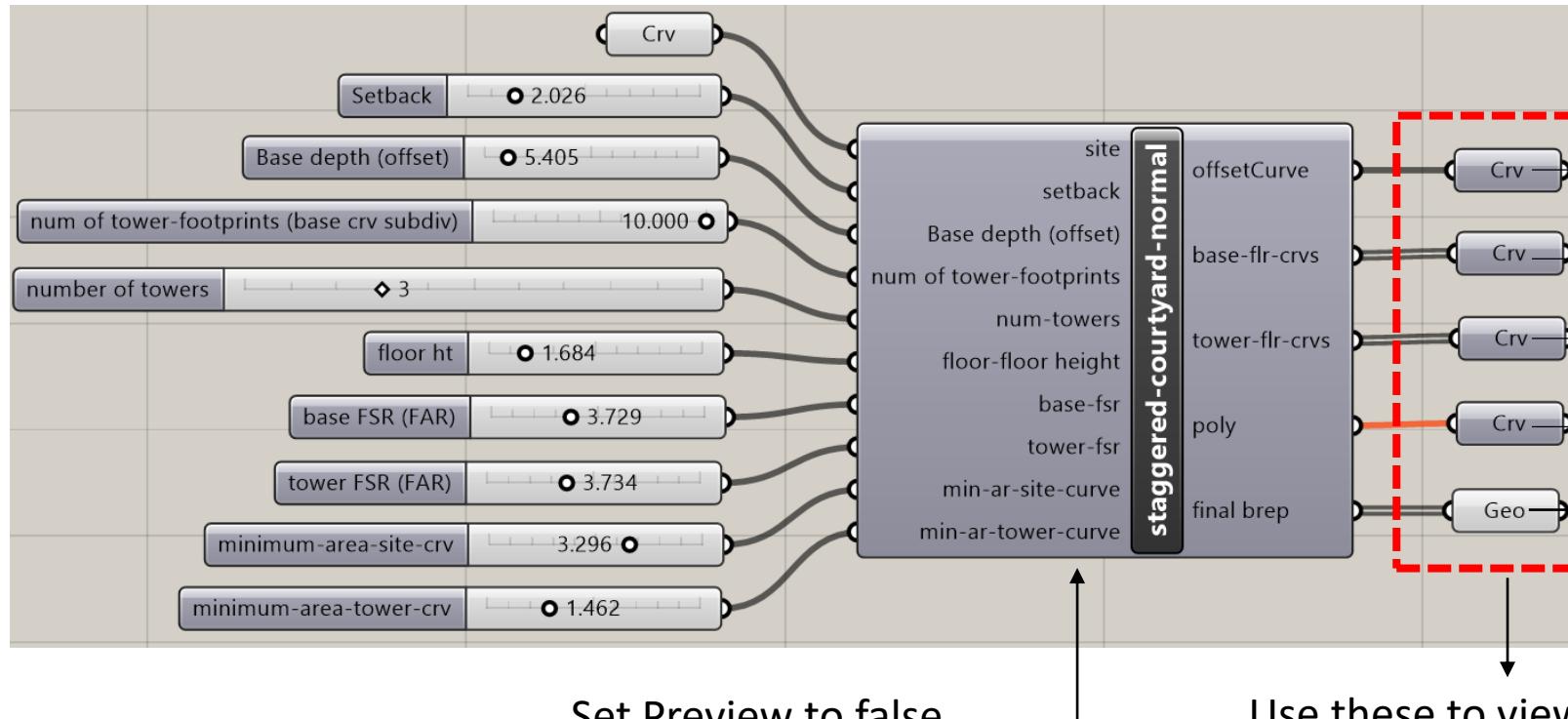
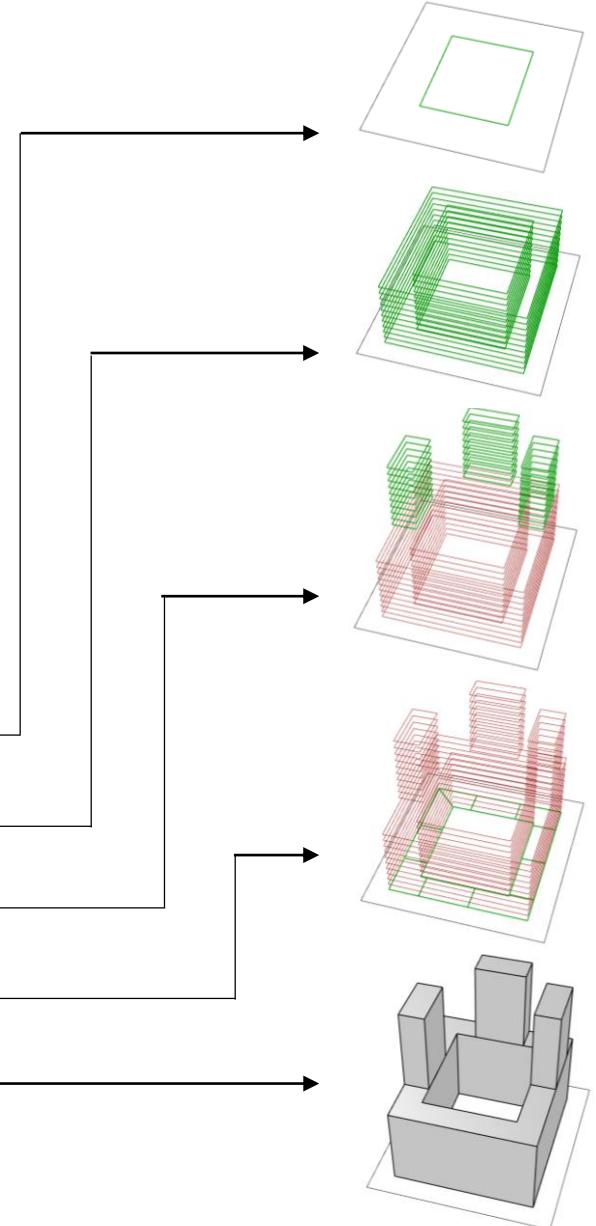
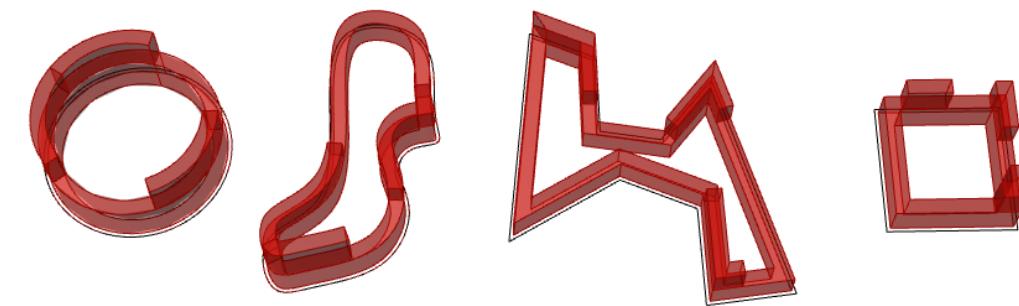
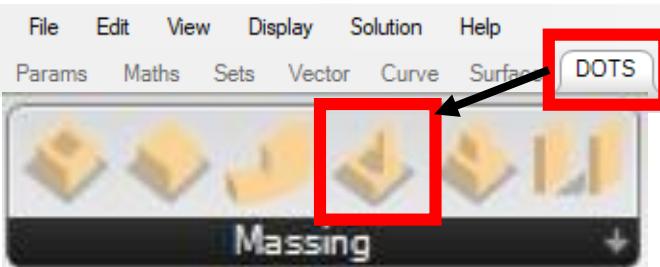


Set Preview to false

Use these to view results



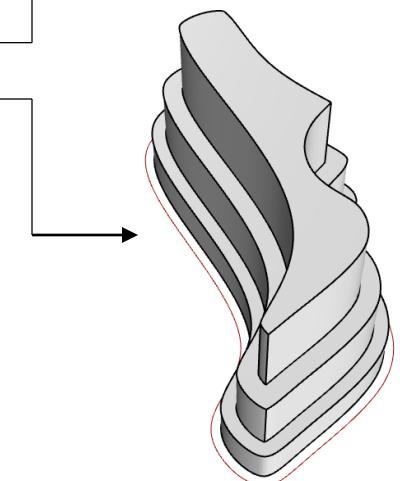
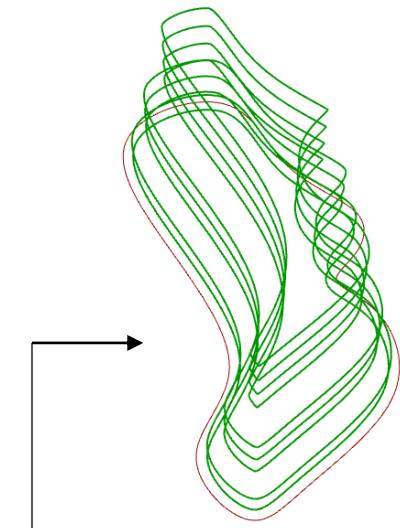
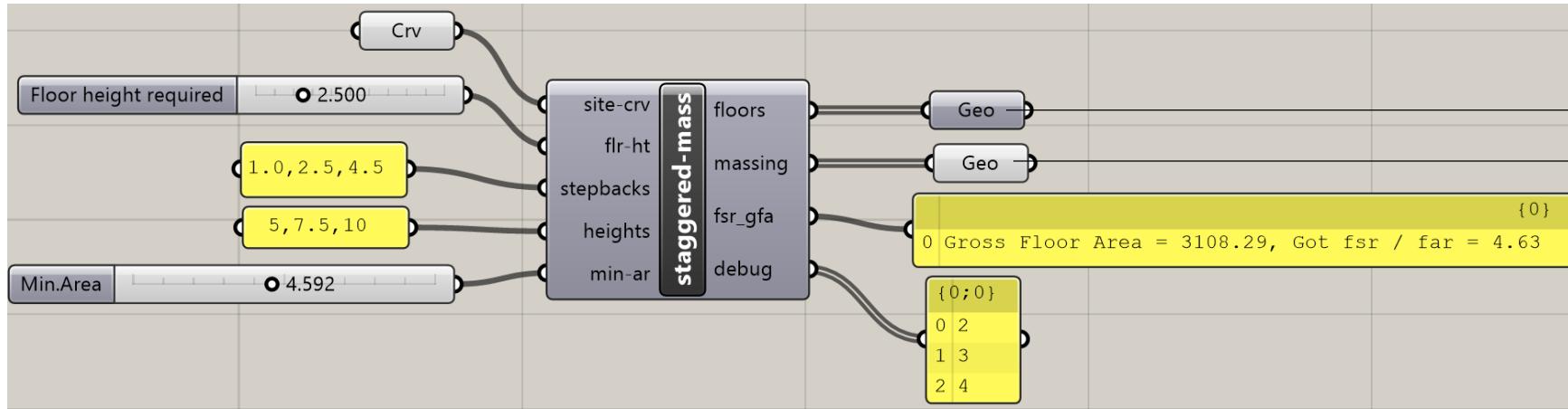
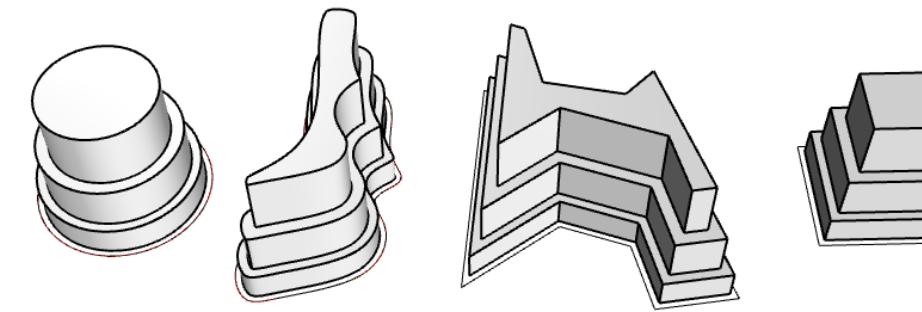
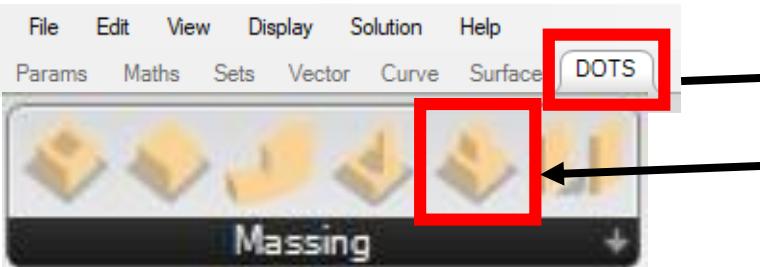
Component Details



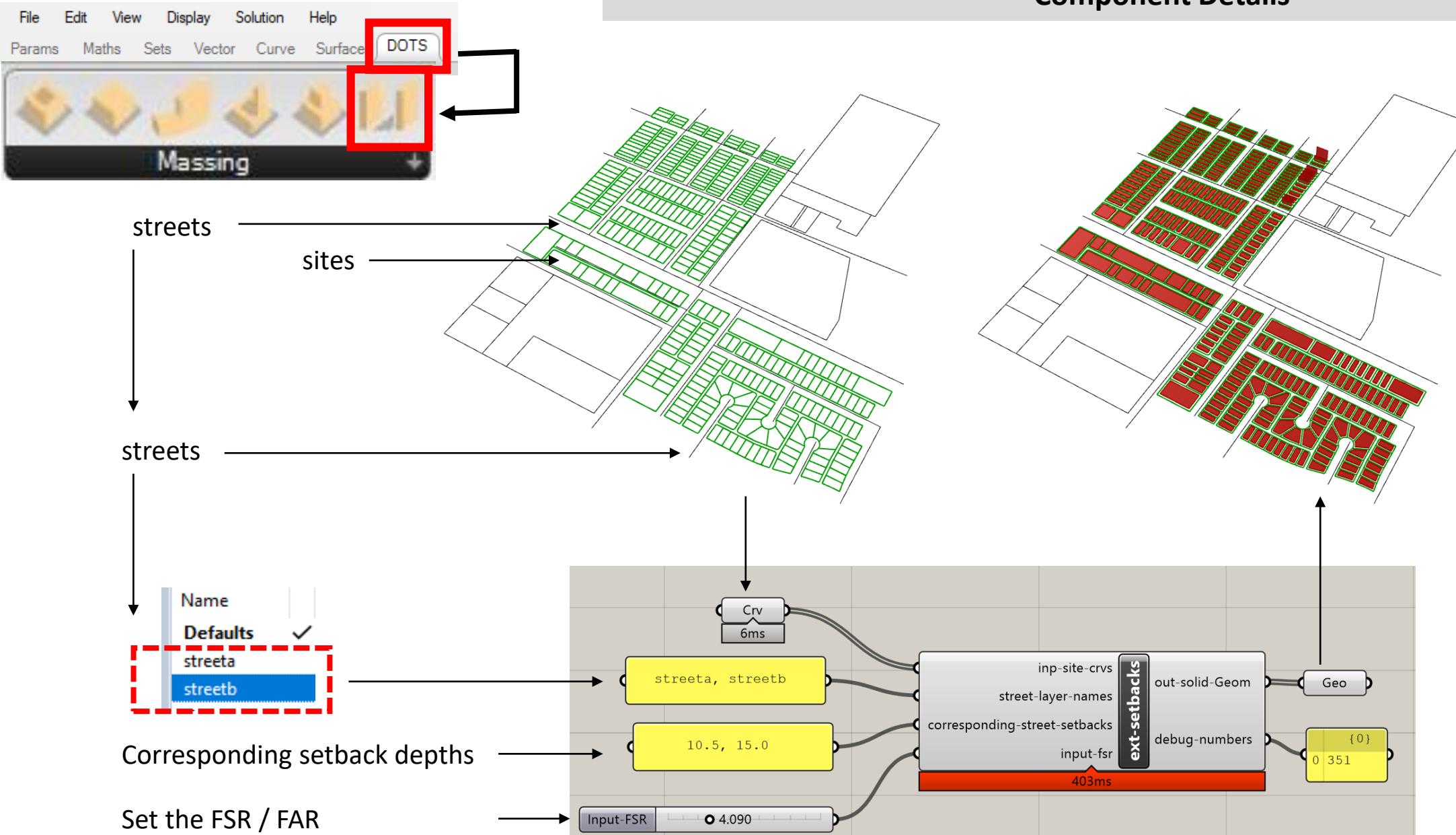
Set Preview to false

Use these to view results

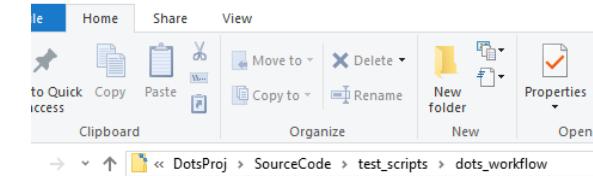
Component Details



Component Details



Component Details



Right-Click:
“Set File Path”:
navigate to file

Name	Area	Number	Ratio	a	b
a	1000	5	0.25	0	
b	1000	5	0.354	0	

Outer
rectangle

Rotation-in-degrees

Ratio: Length/Width

Randomize geometric ops

Toggle

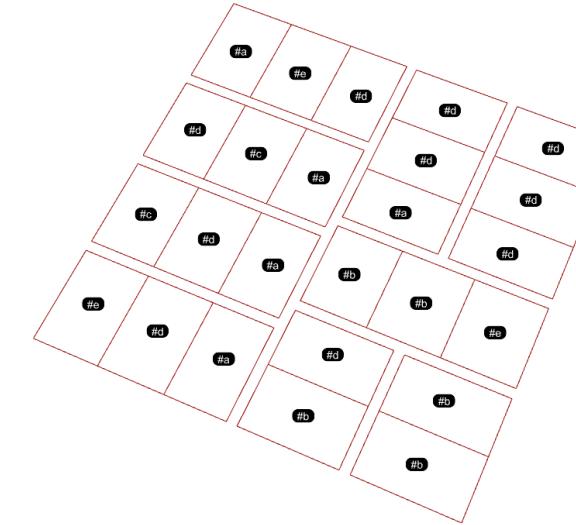
False

Number of Optimization Loops

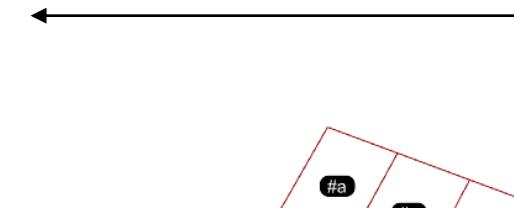
110

Optimization iterations = max 500

Set Preview to false



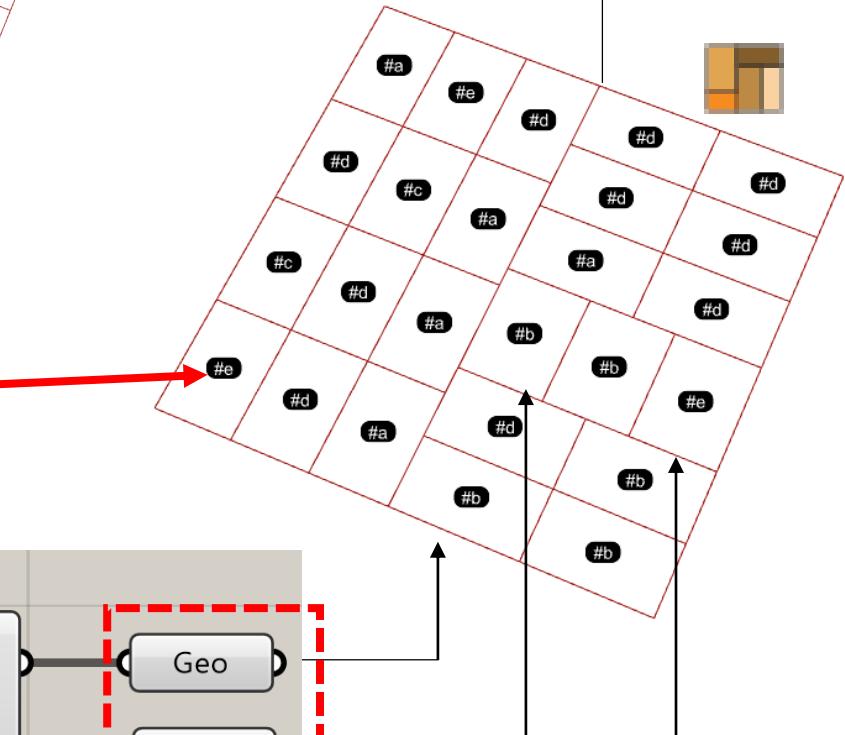
Connected to Circulation



Name of space

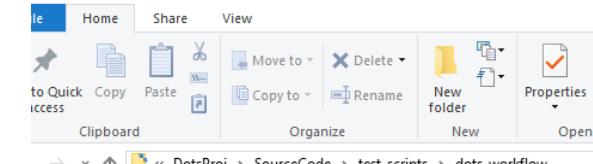
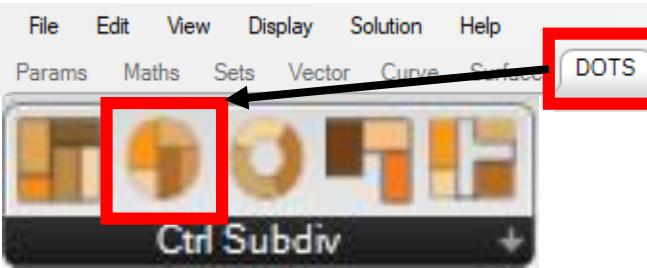
input-files(csv)
outer boundary
Rot-degrees
ratio length/width
bsp-crvs
randomize
optimization-loops
partition-lines

CBSP



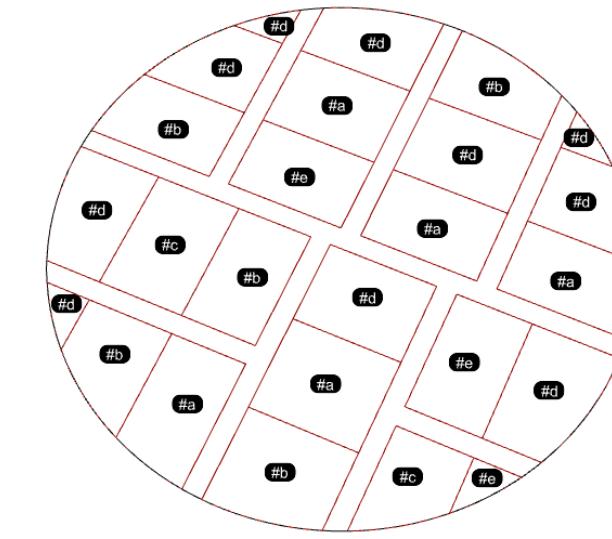
Use these to view results

Component Details

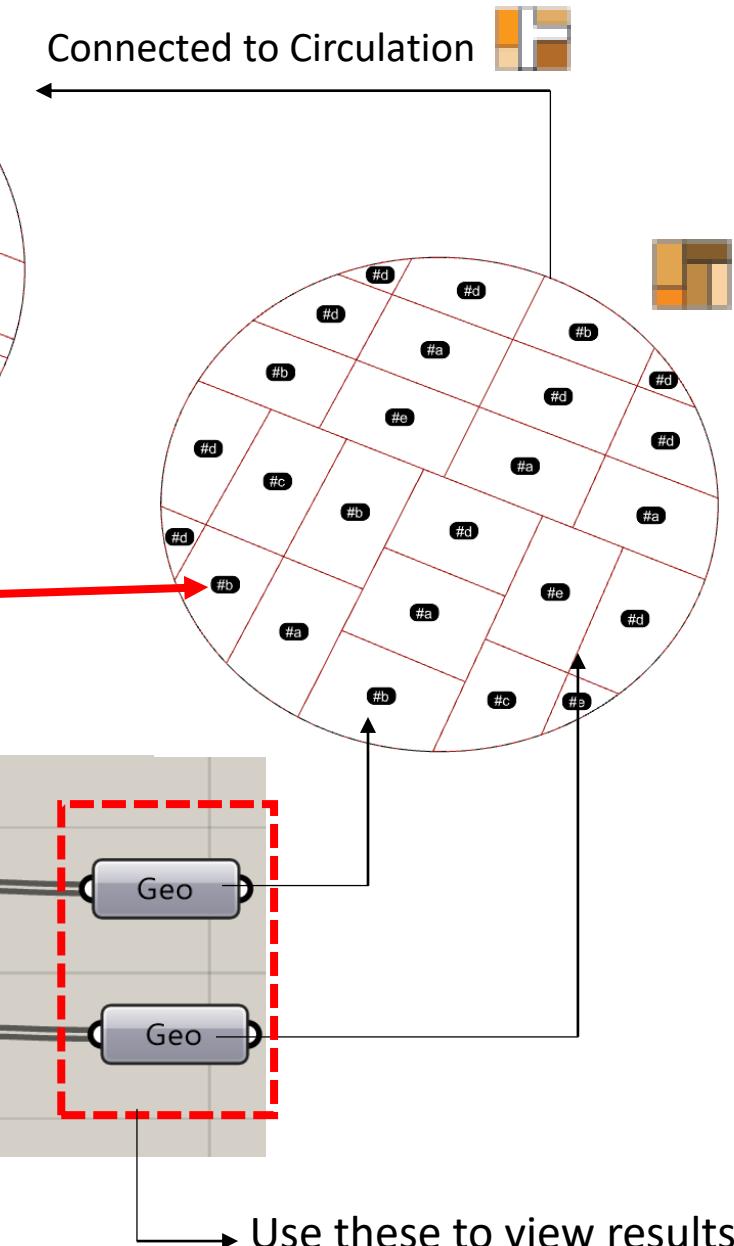


Right-Click:
“Set File Path”:
 navigate to file

Name	Area	Number	Ratio	a	b
a	1000	5	0.25	0	
b	1000	5	0.354	0	

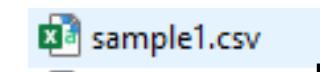
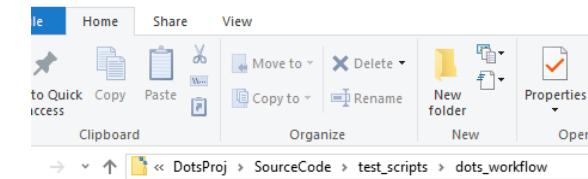


Name of space



Optimization iterations = max 500

Set Preview to false



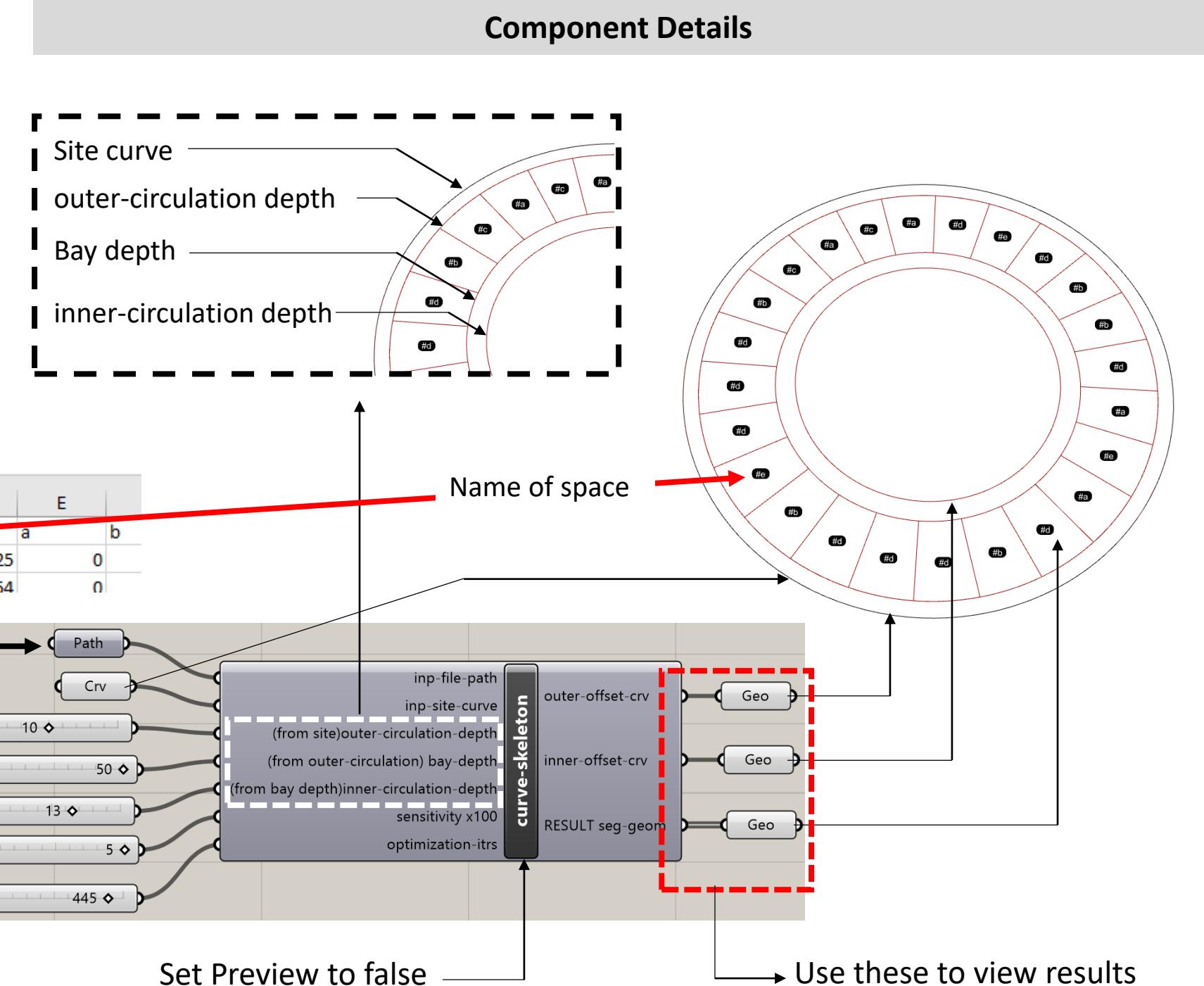
Right-Click:
"Set File Path":
navigate to file

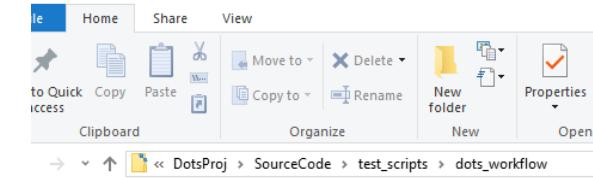
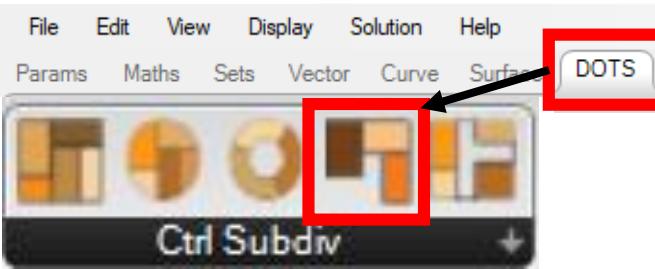
Right-Click "Set File Path": navigate to file

A	B	C	D	E	
Name	Area	Number	Ratio	a	b
a	1000	5	0.25	0	
b	1000	5	0.354	0	

Sensitivity = x, where $0.1 < x < 5.0$

Optimization iterations = max 500



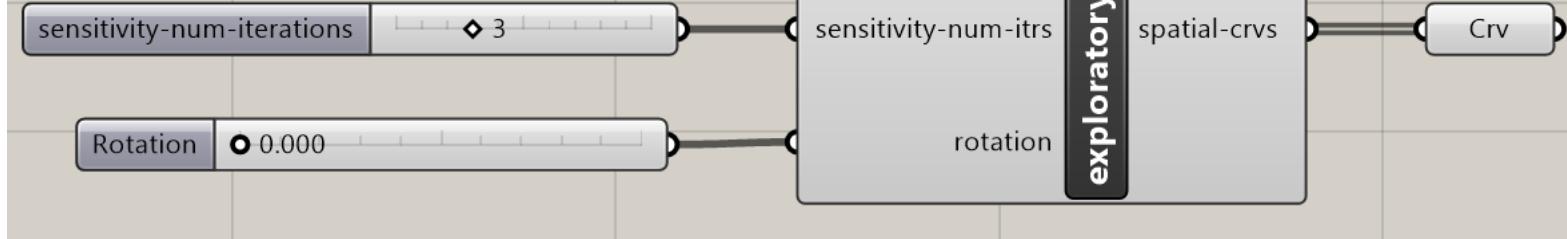


Right-Click:
"Set File Path":
navigate to file

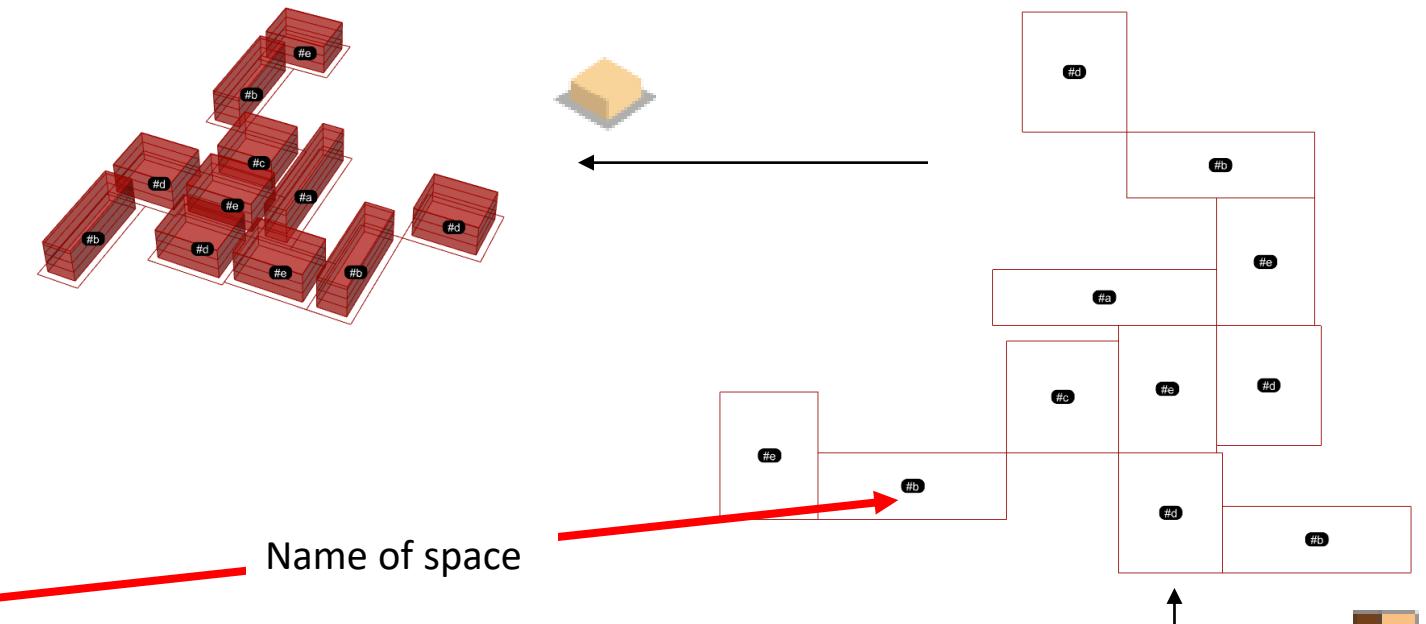
Name of space

Name	Area	Number	Ratio	a	b
a	1000	5	0.25	0	
b	1000	5	0.354	0	

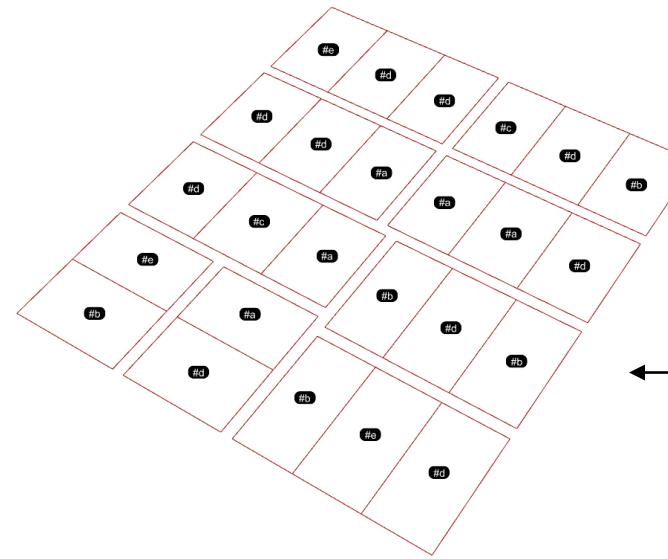
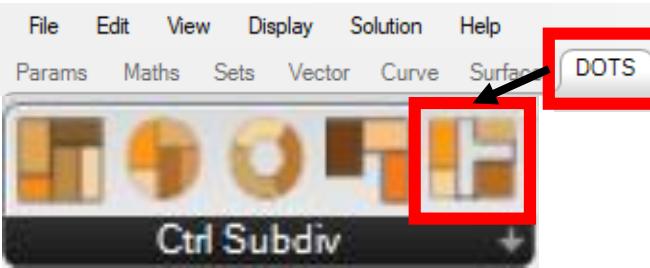
Sensitivity = x, where $1 < x < 10$



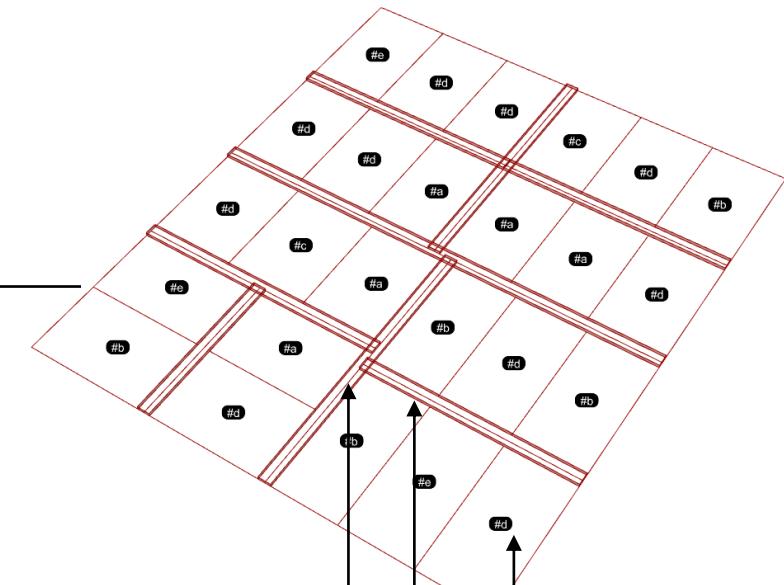
Component Details



Component Details

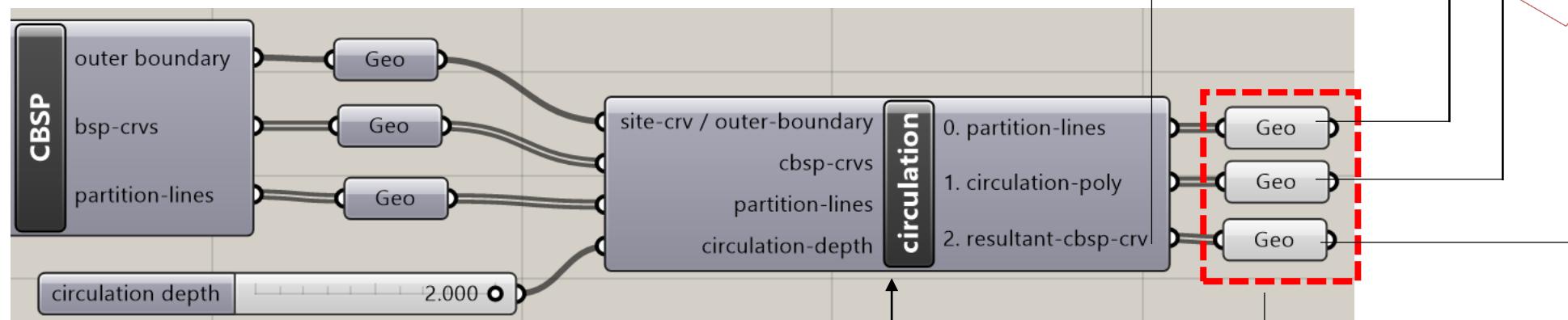


Preview off: output 0, 1



Preview on: output 2

Ex. Previous Generative Component

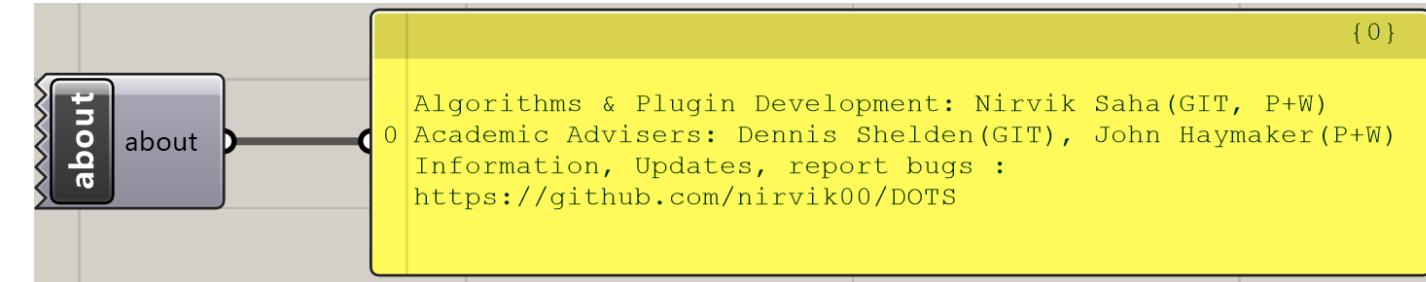


Set Preview to false

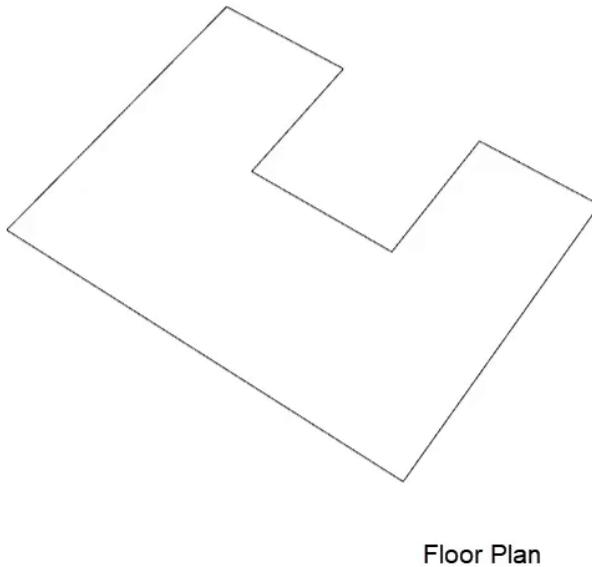
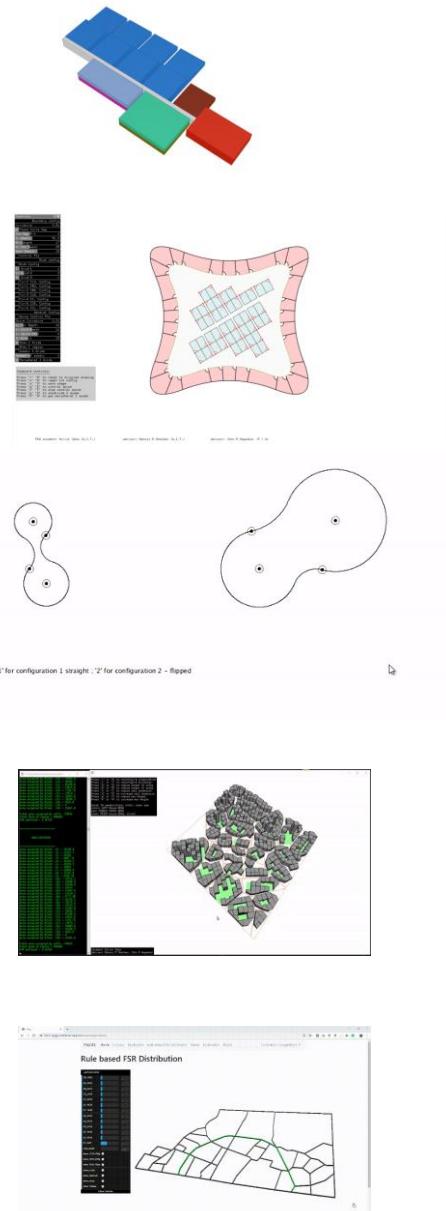


Use these to view results





Prior Efforts



Floor Plan

Thank you