ENR FutureTech
CONSTRUCTION'S LEADING TECHNOLOGY FORUM

Automating Design With Modular Thinking

Phil Langley
Board Director, Creative Tech
Bryden Wood Technology Ltd.

Jami Cresser-Brown
Director, Creative Tech
Bryden Wood Technology Ltd.

#ENRTech

We are an integrated design and engineering consultancy of

architects

engineers

designers

creative technologists

analysts

Working together for a better built environment.

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Automating the physical
from the digital
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Design(ing) **Automation**

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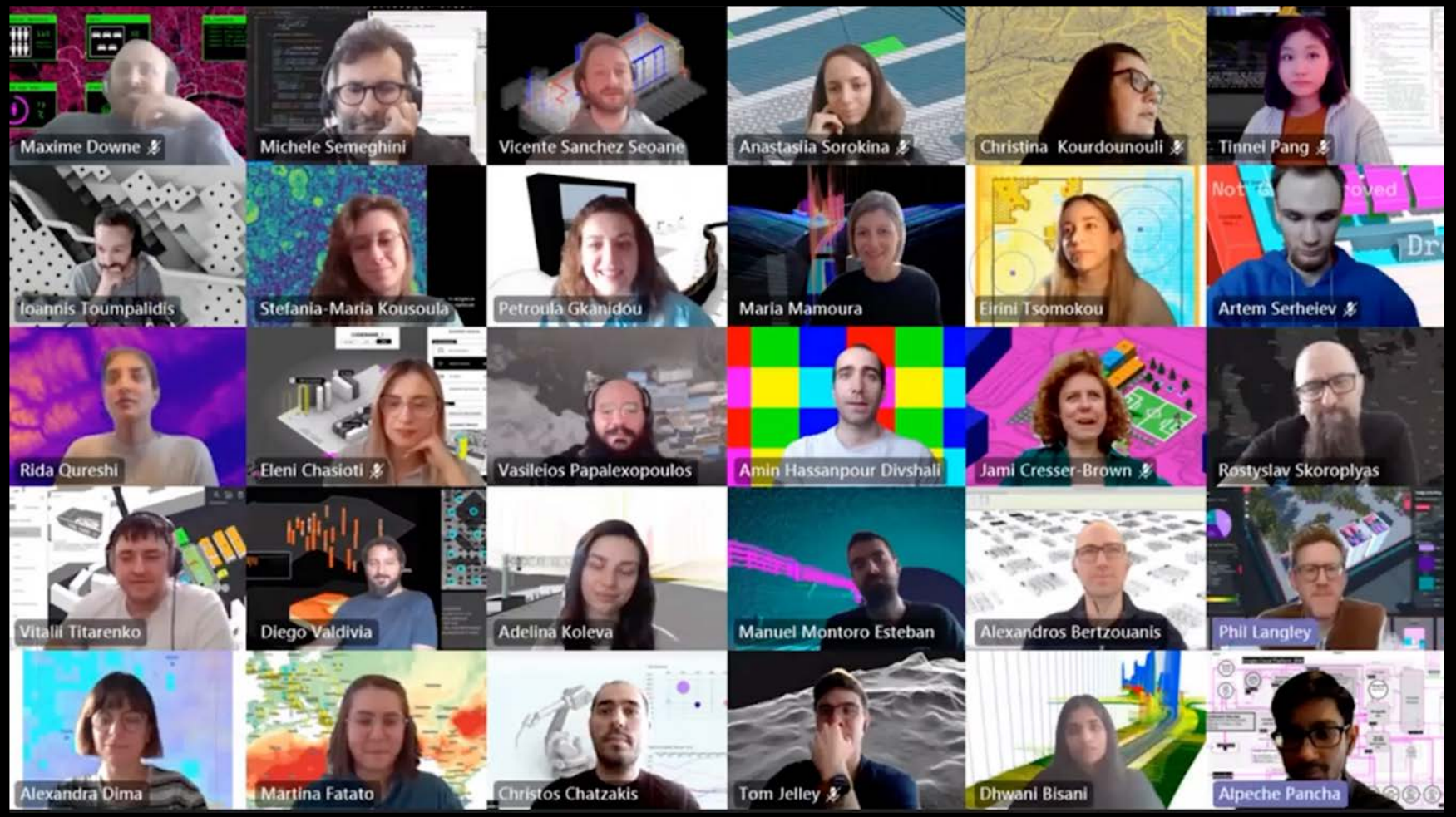
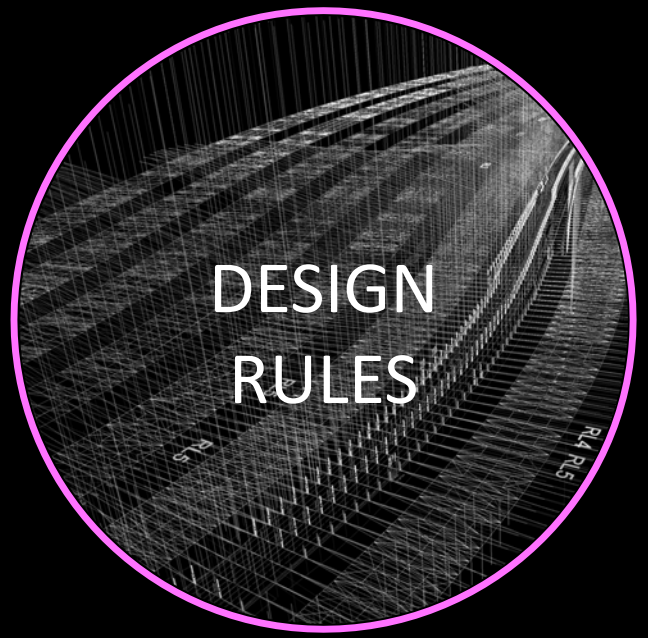
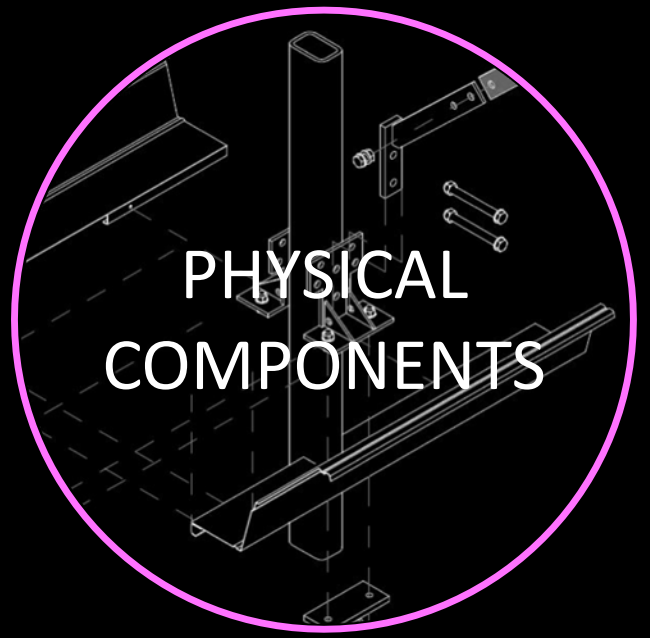

Maxime Downe
Michele Semeghini
Vicente Sanchez Seoane
Anastasiia Sorokina
Christina Kourdounouli
Tinnei Pang
Ioannis Toumpalidis
Stefania-Maria Kousoula
Petroula Gkanidou
Maria Mamoura
Eirini Tsomokou
Artem Serheiev
Rida Qureshi
Eleni Chasioti
Vasileios Papalexopoulos
Amin Hassanpour Divshali
Jami Cresser-Brown
Rostyslav Skoroplyas
Vitalii Titarenko
Diego Valdivia
Adelina Koleva
Manuel Montoro Esteban
Alexandros Bertzouanis
Phil Langley
Alexandra Dima
Martina Fatato
Christos Chatzakis
Tom Jelley
Dhwani Bisani
Alpeche Pancha

PATTERNS *human readable*





machine readable CONFIGURATIONS

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Don’t Design, **Configure**

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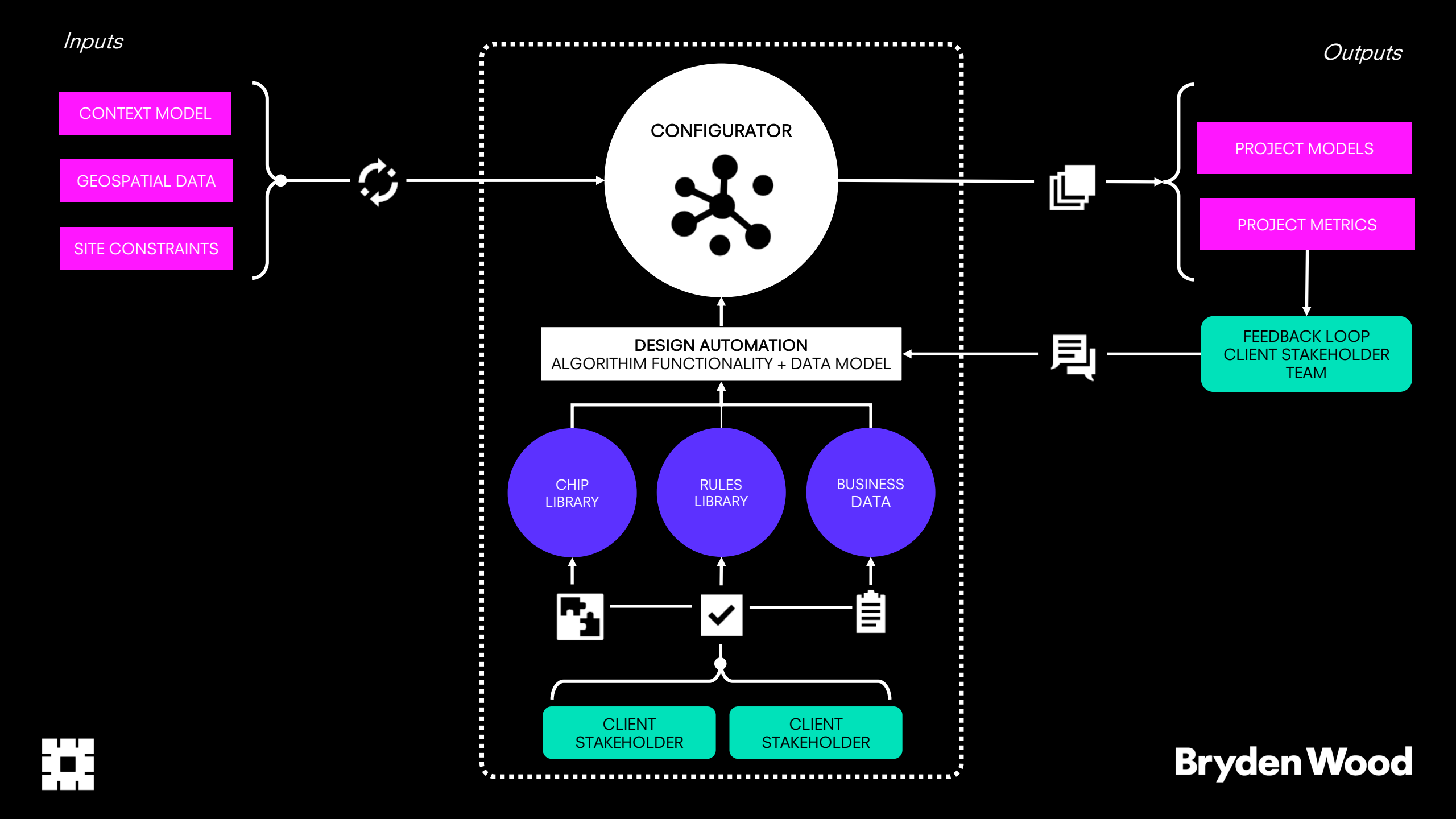
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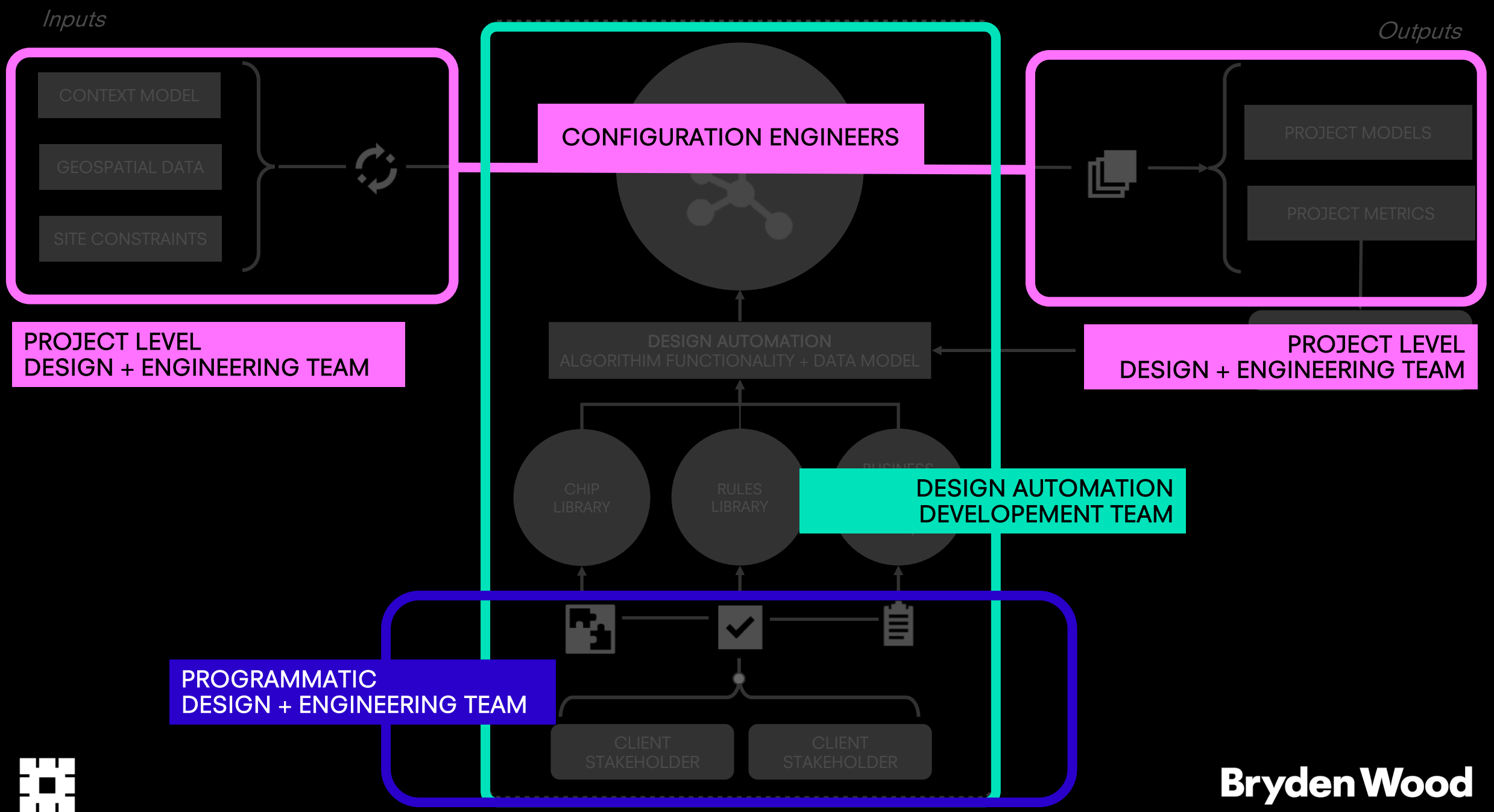
CONTEXT MODEL
GEOSPATIAL DATA
SITE CONSTRAINTS
CONFIGURATOR
DESIGN AUTOMATION
ALGORITHIM FUNCTIONALITY + DATA MODEL
CHIP LIBRARY
RULES LIBRARY
BUSINESS DATA
CLIENT STAKEHOLDER
CLIENT STAKEHOLDER
Outputs
PROJECT MODELS
PROJECT METRICS
FEEDBACK LOOP
CLIENT STAKEHOLDER
TEAM
Bryden Wood


Inputs
CONTEXT MODEL
GEOSPATIAL DATA
SITE CONSTRAINTS
PROJECT LEVEL
DESIGN + ENGINEERING TEAM
CONFIGURATION ENGINEERS
DESIGN AUTOMATION
ALGORITHIM FUNCTIONALITY + DATA MODEL
CHIP
LIBRARY
RULES
LIBRARY
DESIGN AUTOMATION
DEVELOPEMENT TEAM
PROGRAMMATIC
DESIGN + ENGINEERING TEAM
CLIENT
STAKEHOLDER
CLIENT
STAKEHOLDER
Outputs
PROJECT MODELS
PROJECT METRICS
PROJECT LEVEL
DESIGN + ENGINEERING TEAM
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Roads
National Highways

The Tube
TfL

Housing
Mayor of London

Housing
Prism to Platforms

Data Centres
///

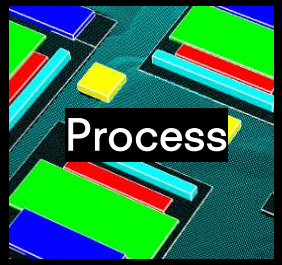
Robotics
Open source

Rail
Network Rail

Cycling
DfT

Schools
DfE

Pharmaceutical
GSK



Process
///

Industrial
Tata

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Infrastructure

Roads
National Highways

The Tube
TfL

Rail
Network Rail

Cycling
DfT

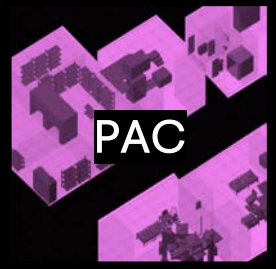
Buildings

Housing
Mayor of London

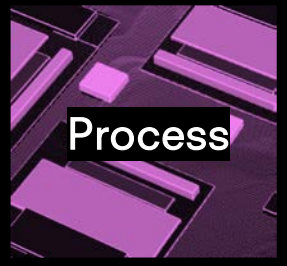
Housing
Prism to Platforms

Data Centres
///

Schools
DfE



Pharmaceutical
GSK



Process
///

Manufacturing

Robotics
Open source

Industrial
Tata

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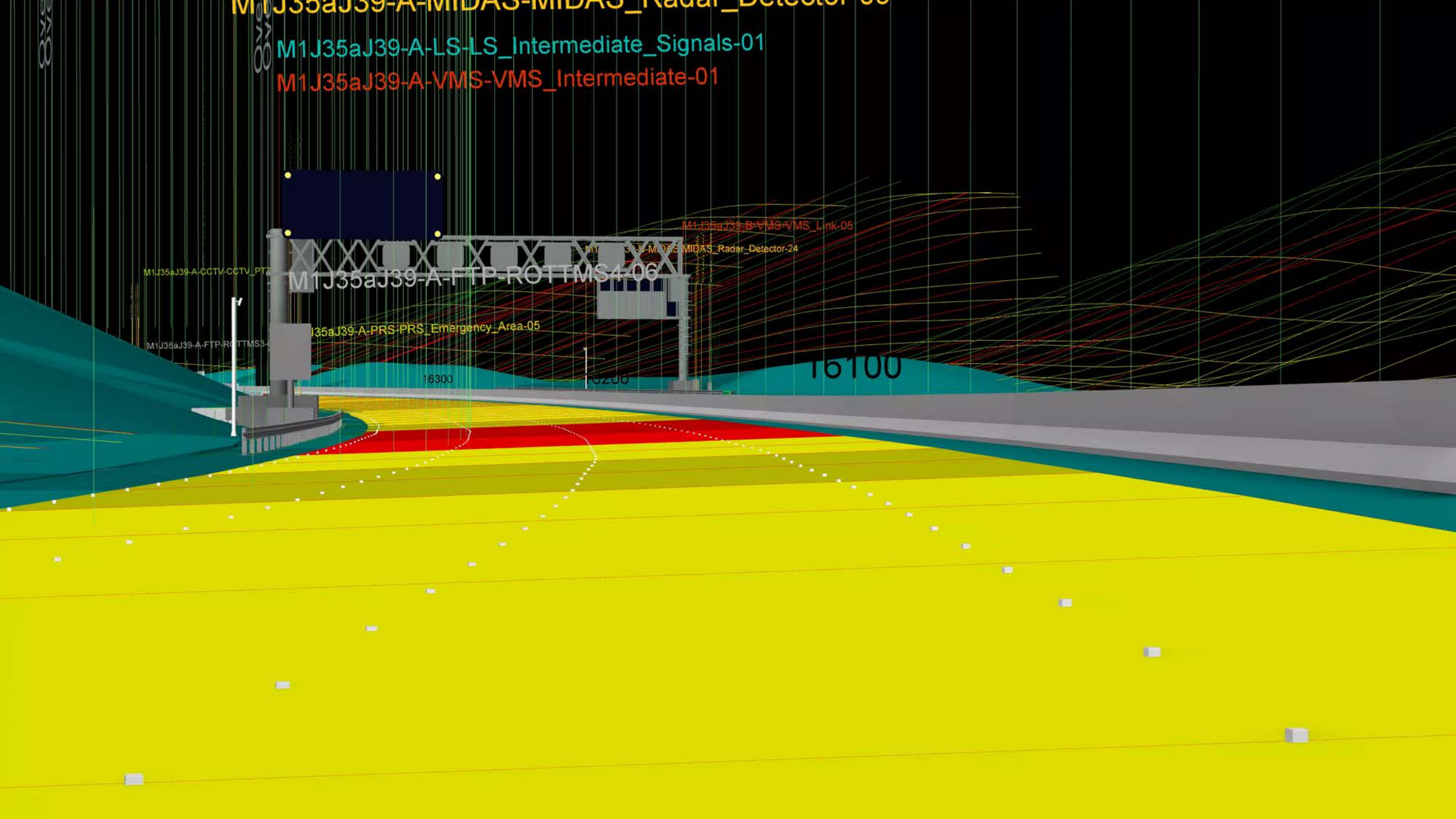
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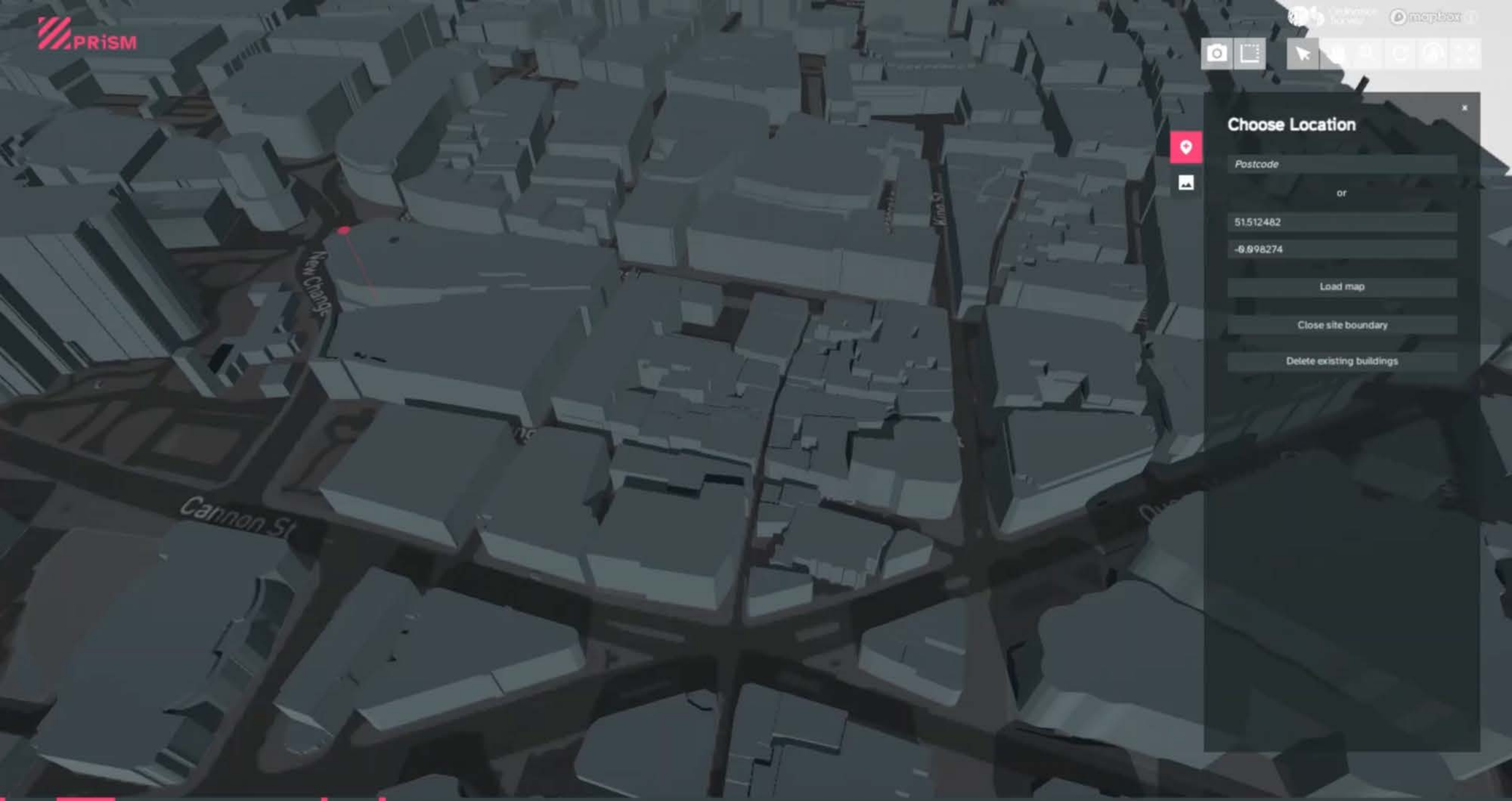
16100


PRiSM
New Change
Cannon St
Choose Location
Postcode
or
51.512482
-0.898274
Load map
Close site boundary
Delete existing buildings

Rule-based, ‘choice-point’ optionality, from **actual business drivers**

An extensive solution space representing **genuine mass customization possibilities**

Evidence-based down selection to the **most applicable solution**

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Housing in 15 mins
Hospitals in 30 mins
Railways in 1 hour
Data Centers in 2 hours
Highways in 24 hours

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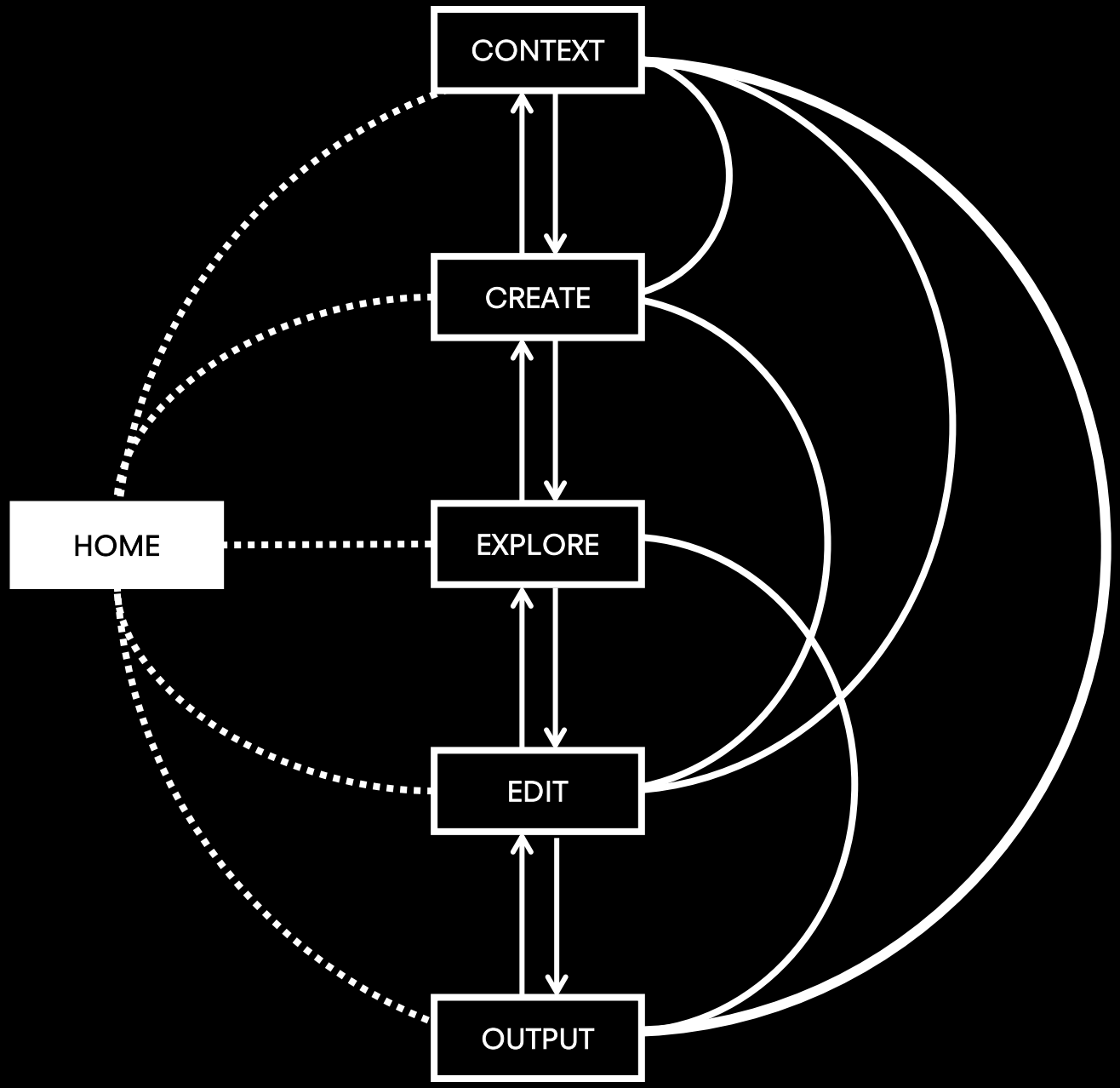

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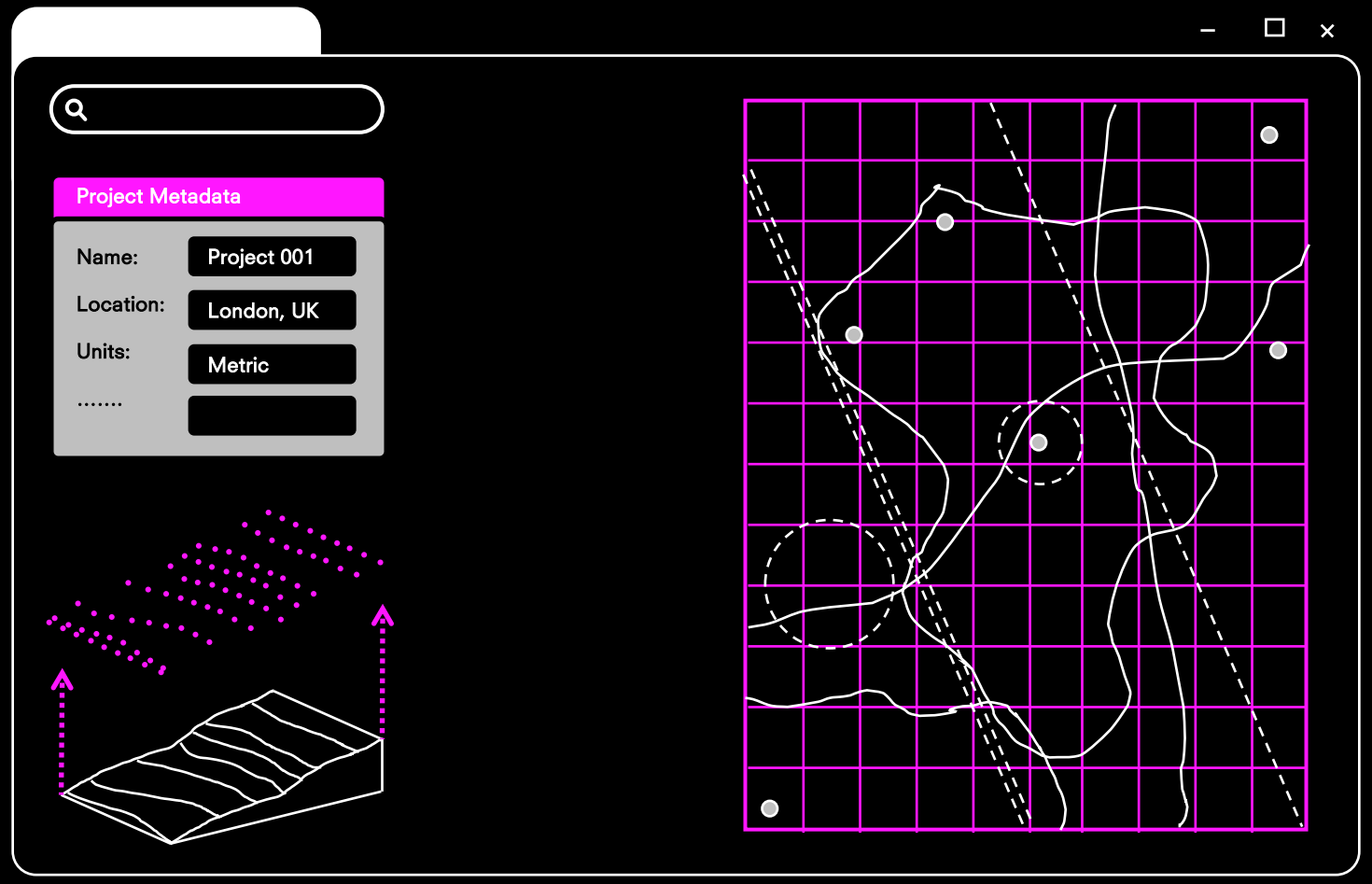
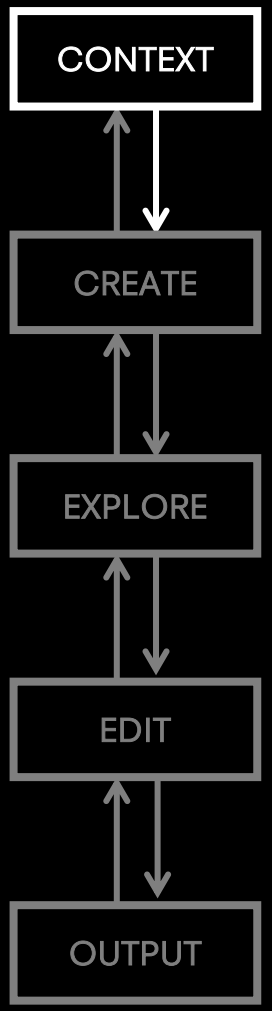
Define project constraints





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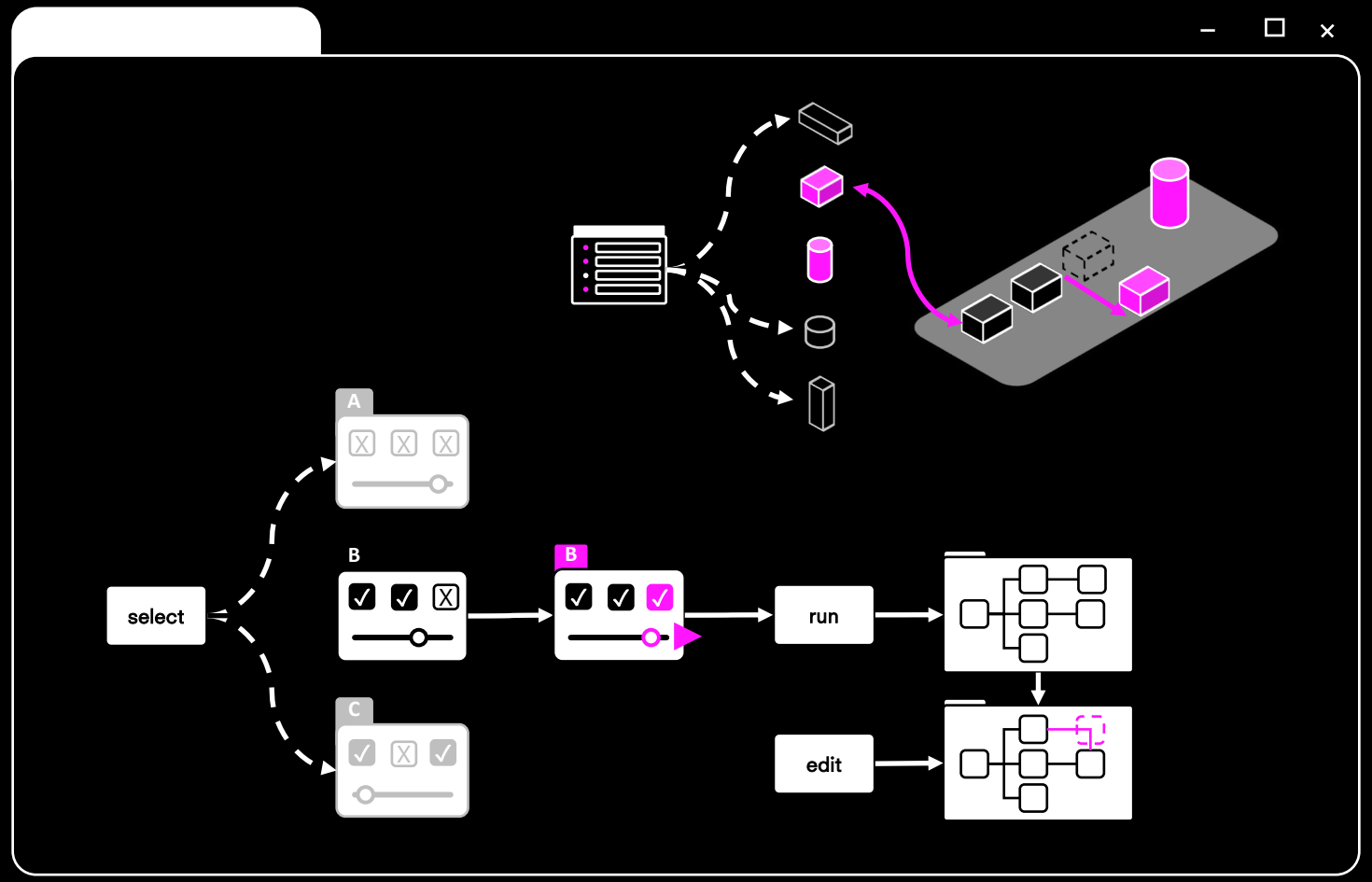
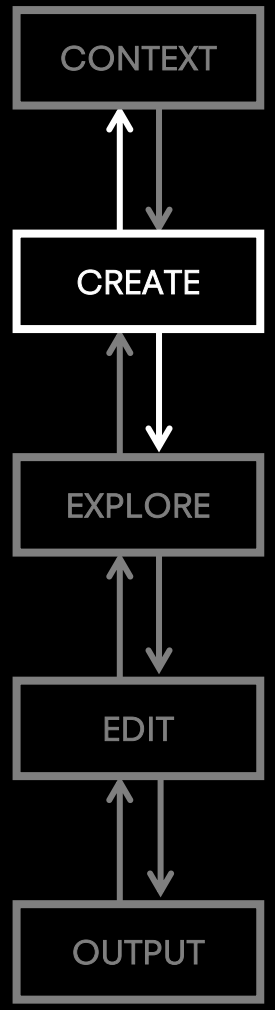
Run configuration algorithms





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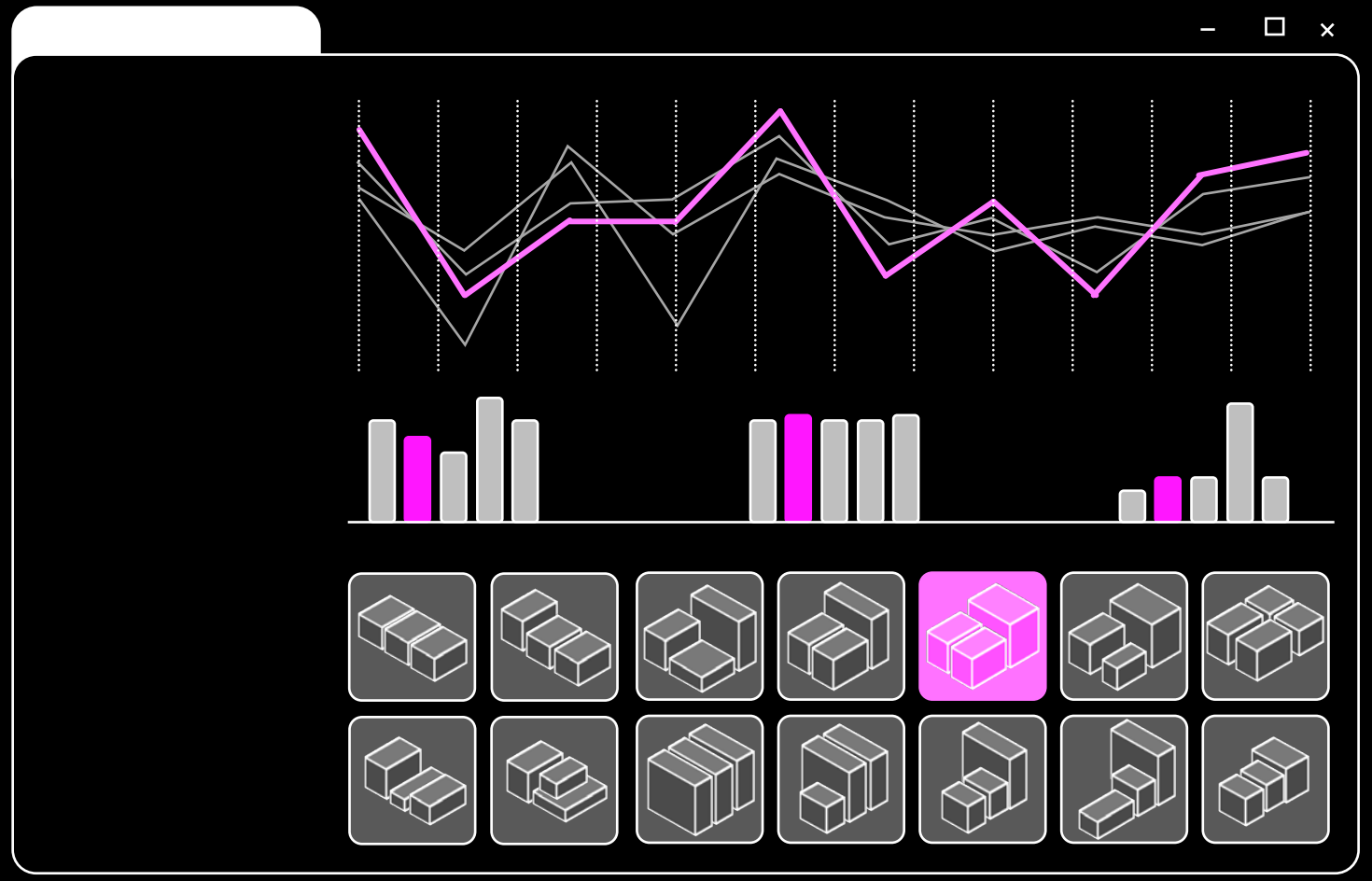
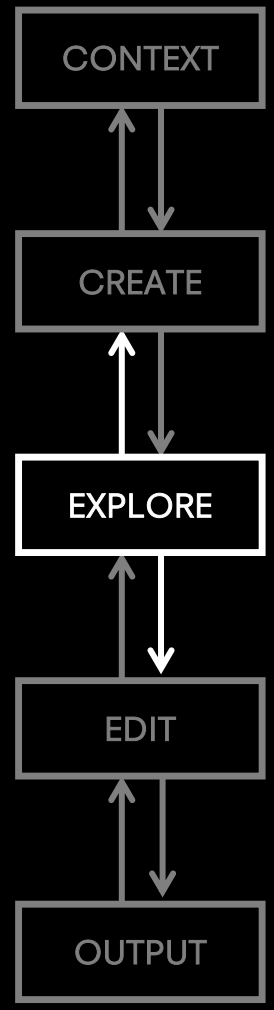
Enable evidence based decision making





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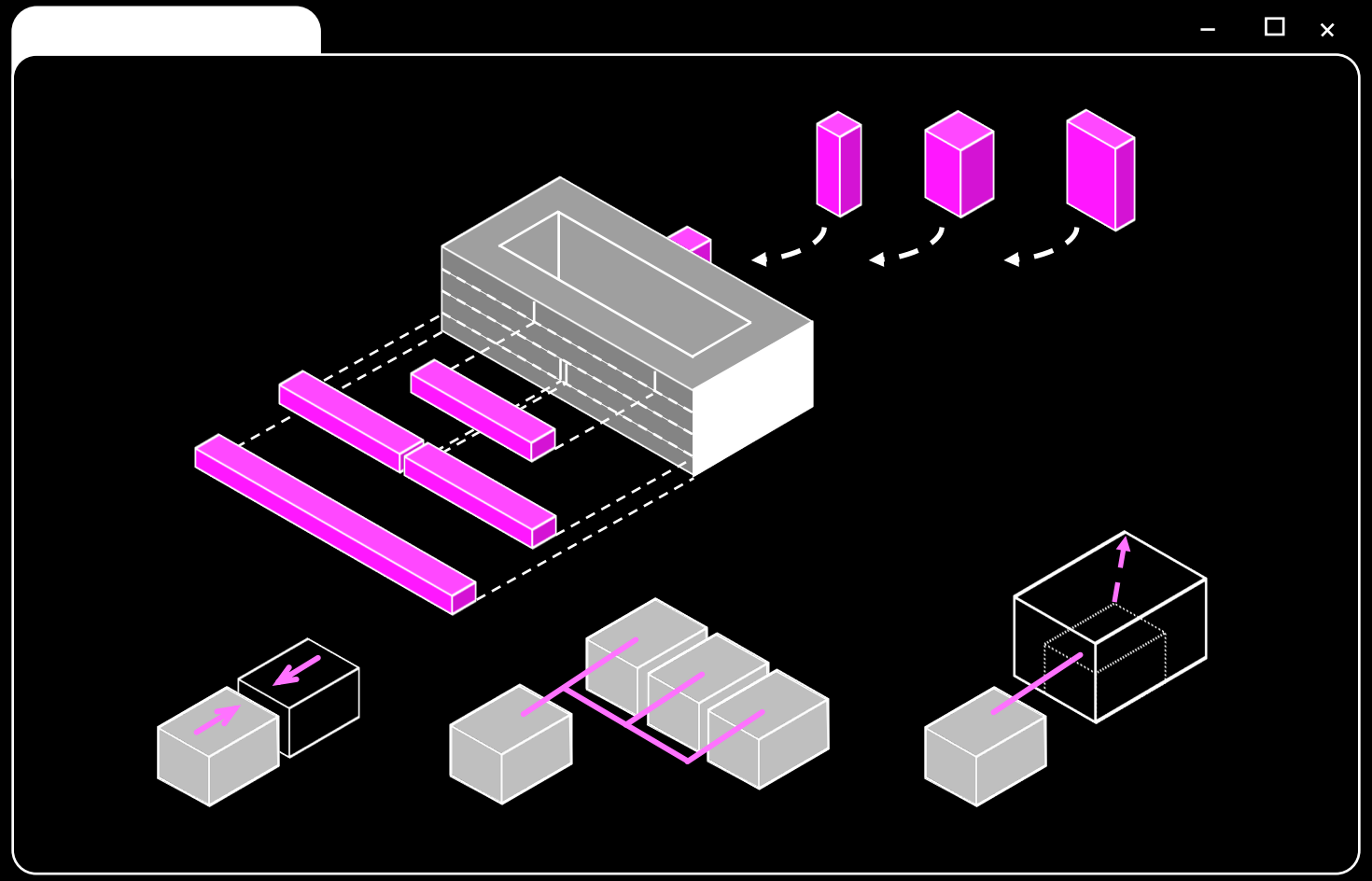
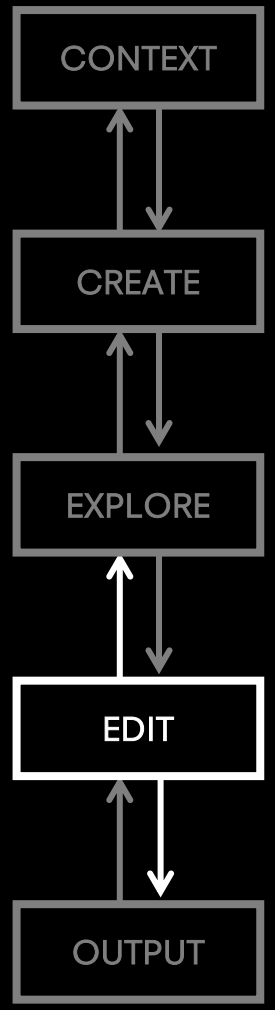
Allow for human intervention





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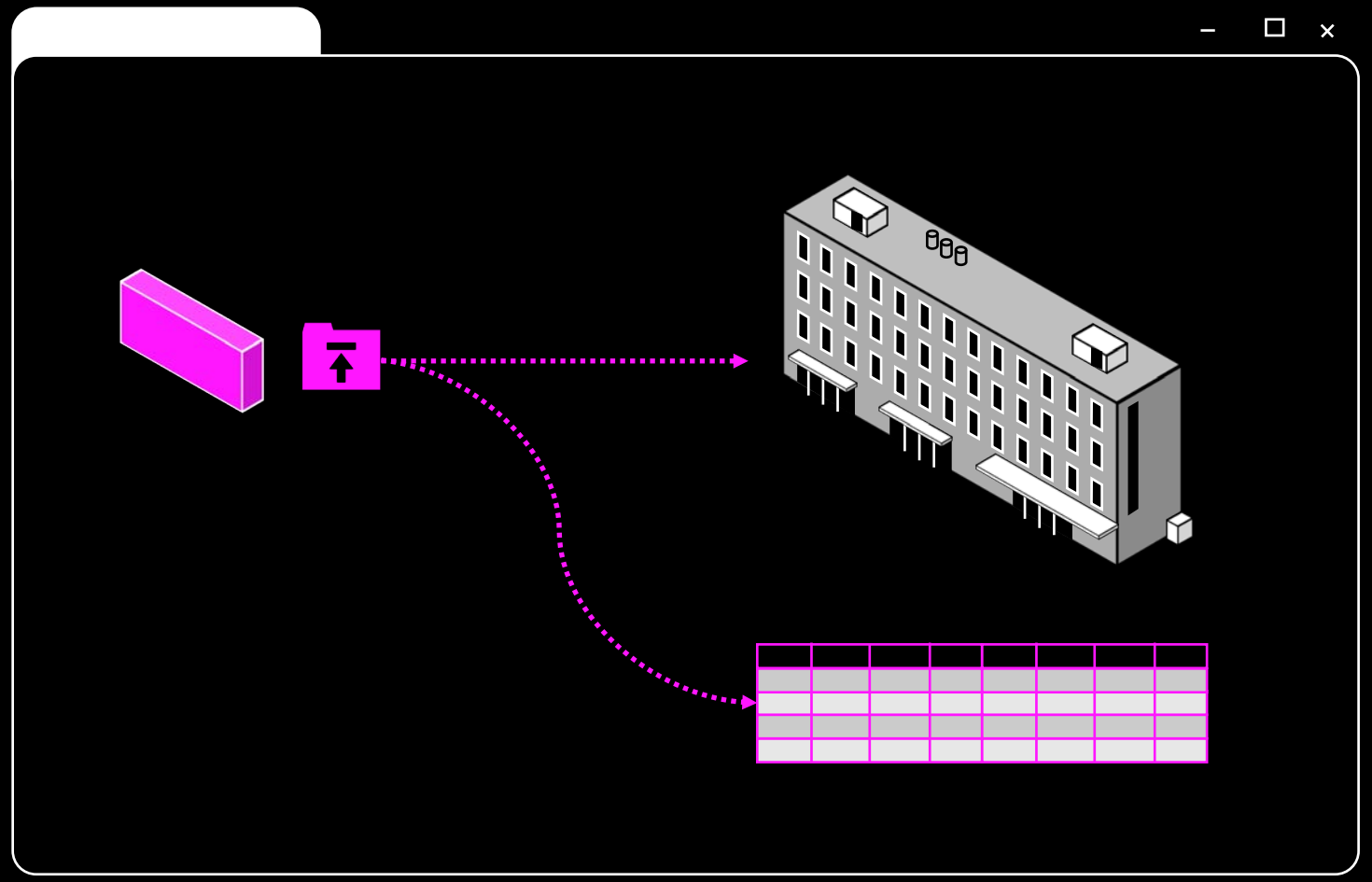
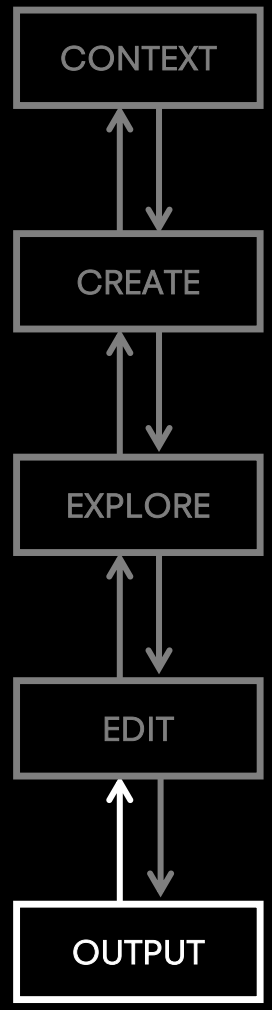
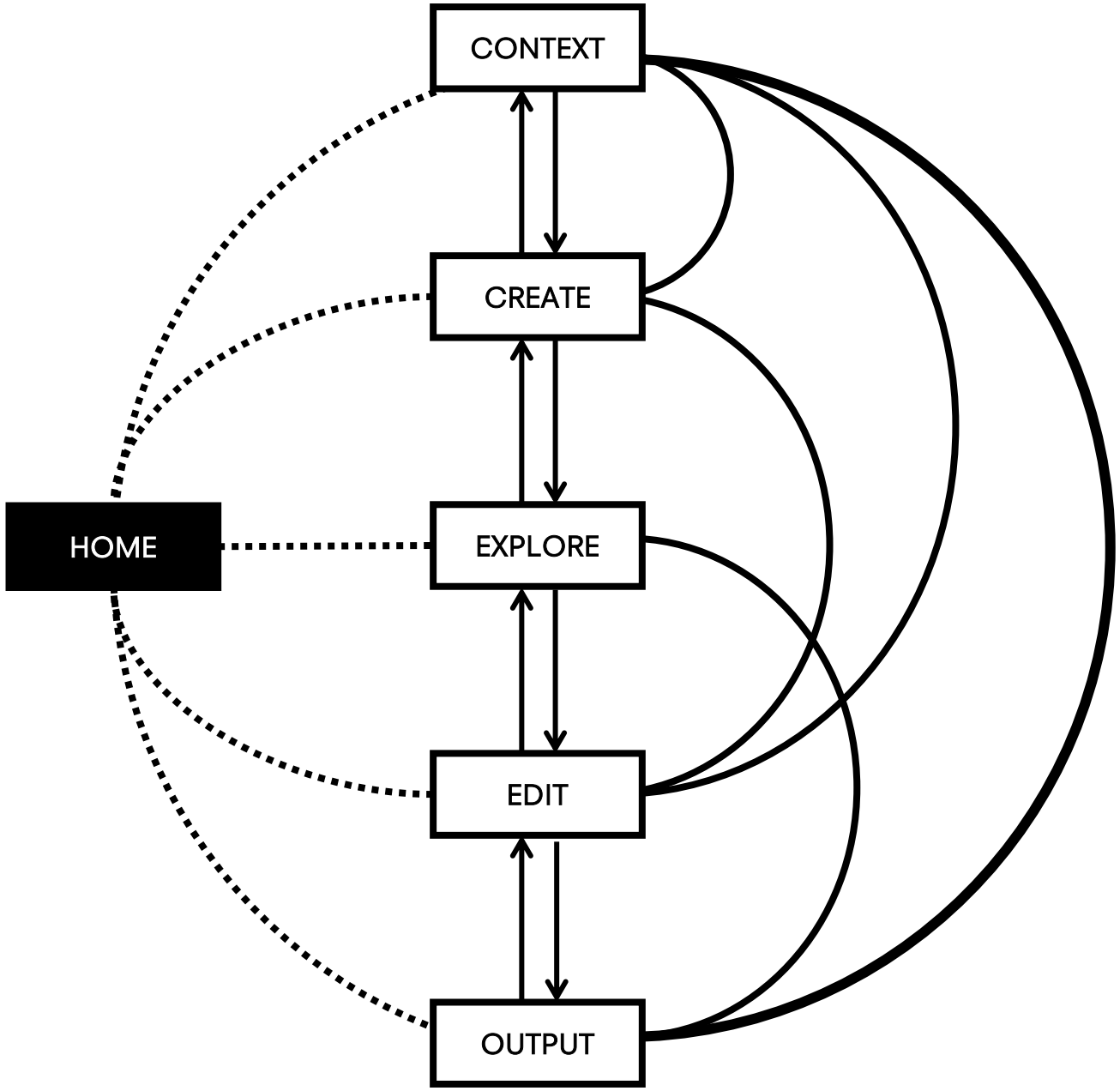
Generate standard design content





Bryden Wood



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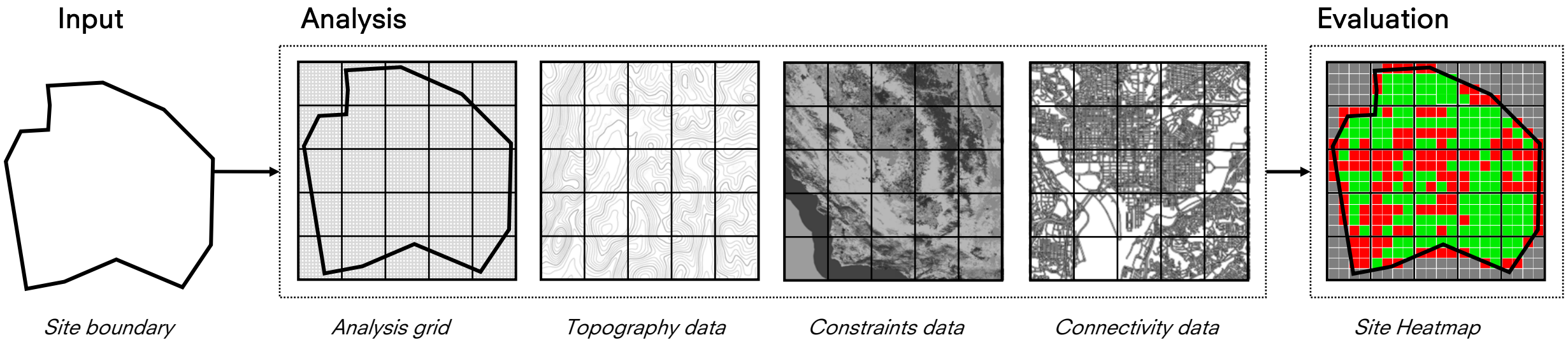
Define project constraints



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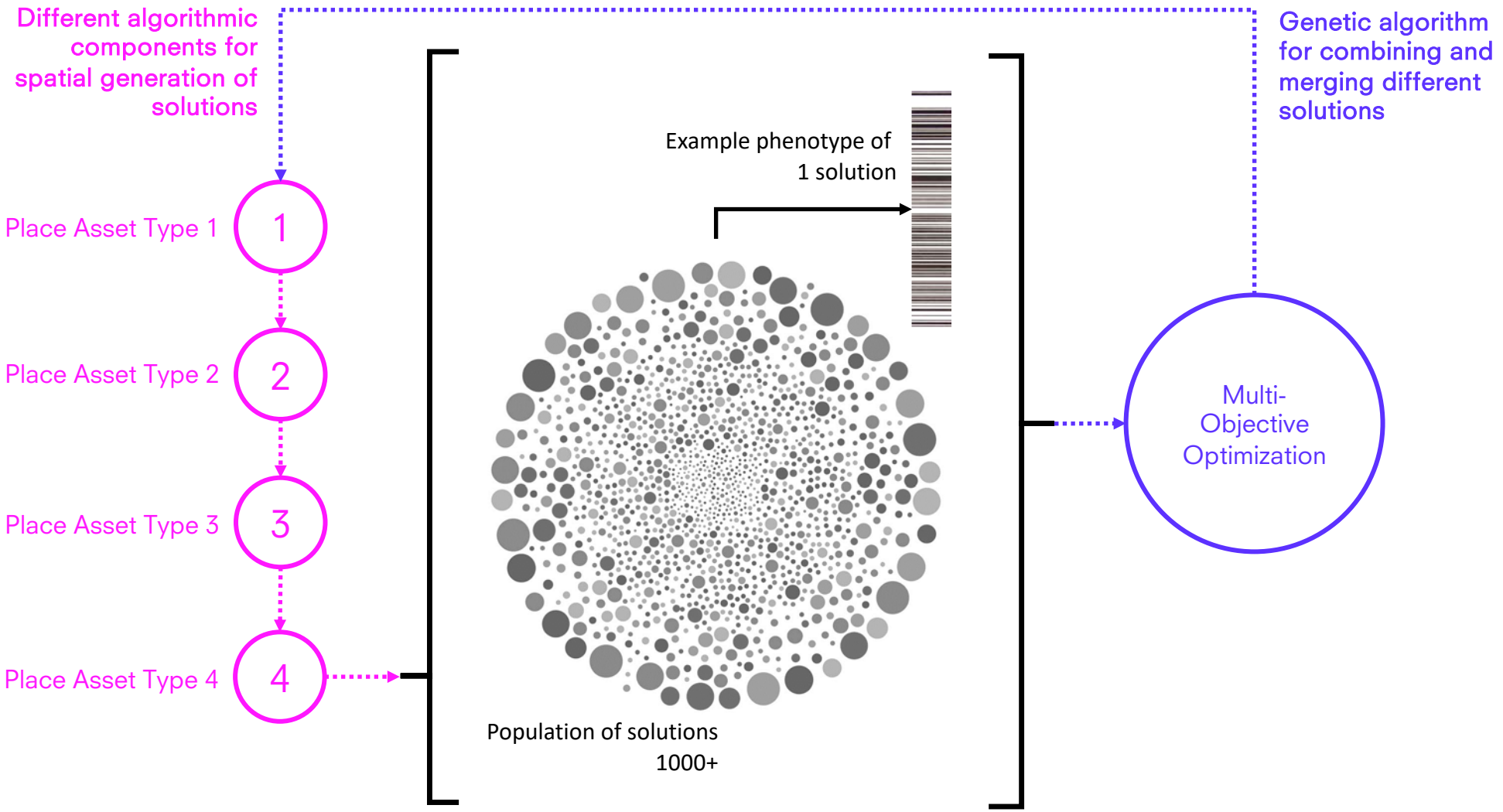
Run configuration algorithms



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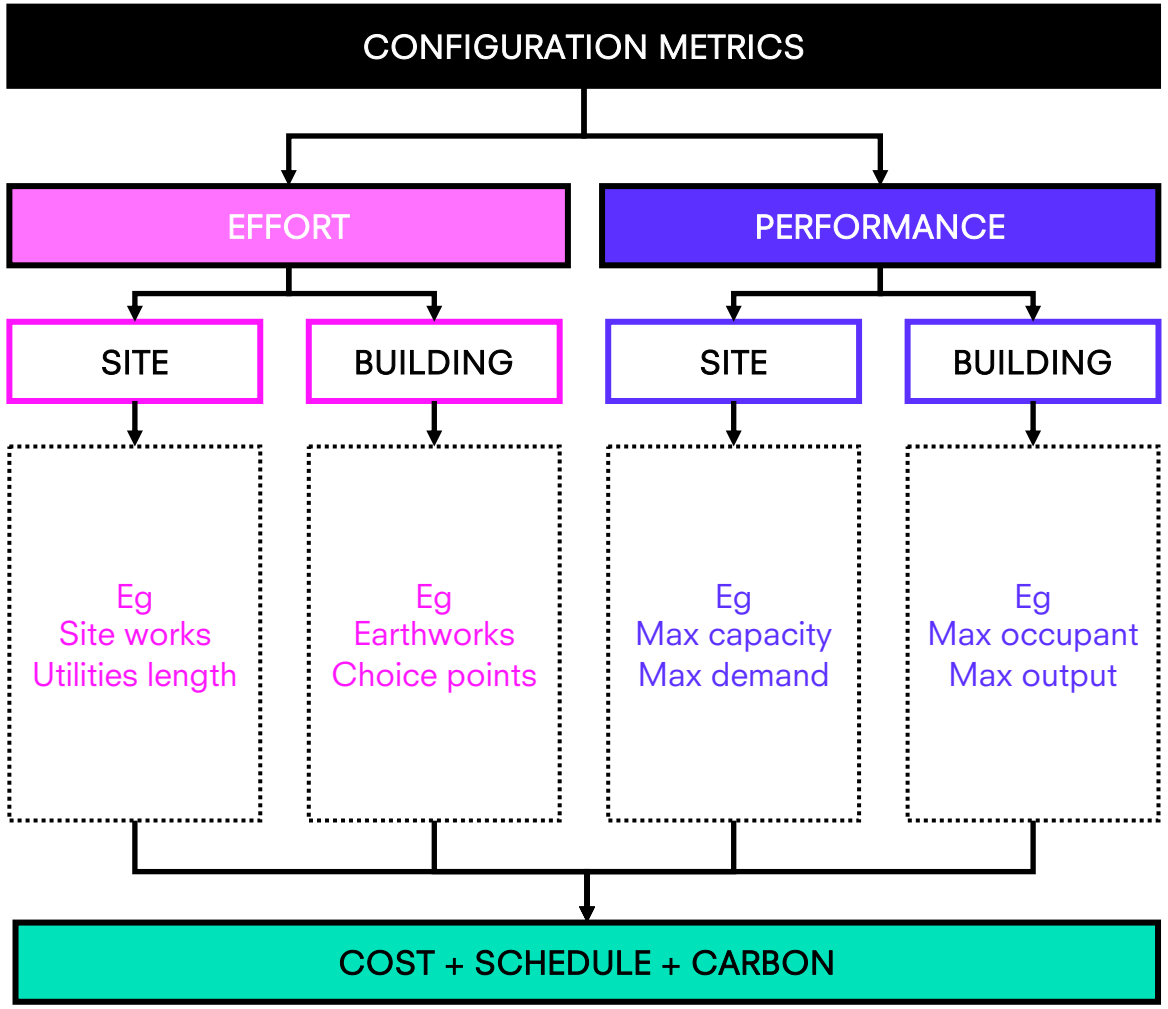
Enable evidence based decision making



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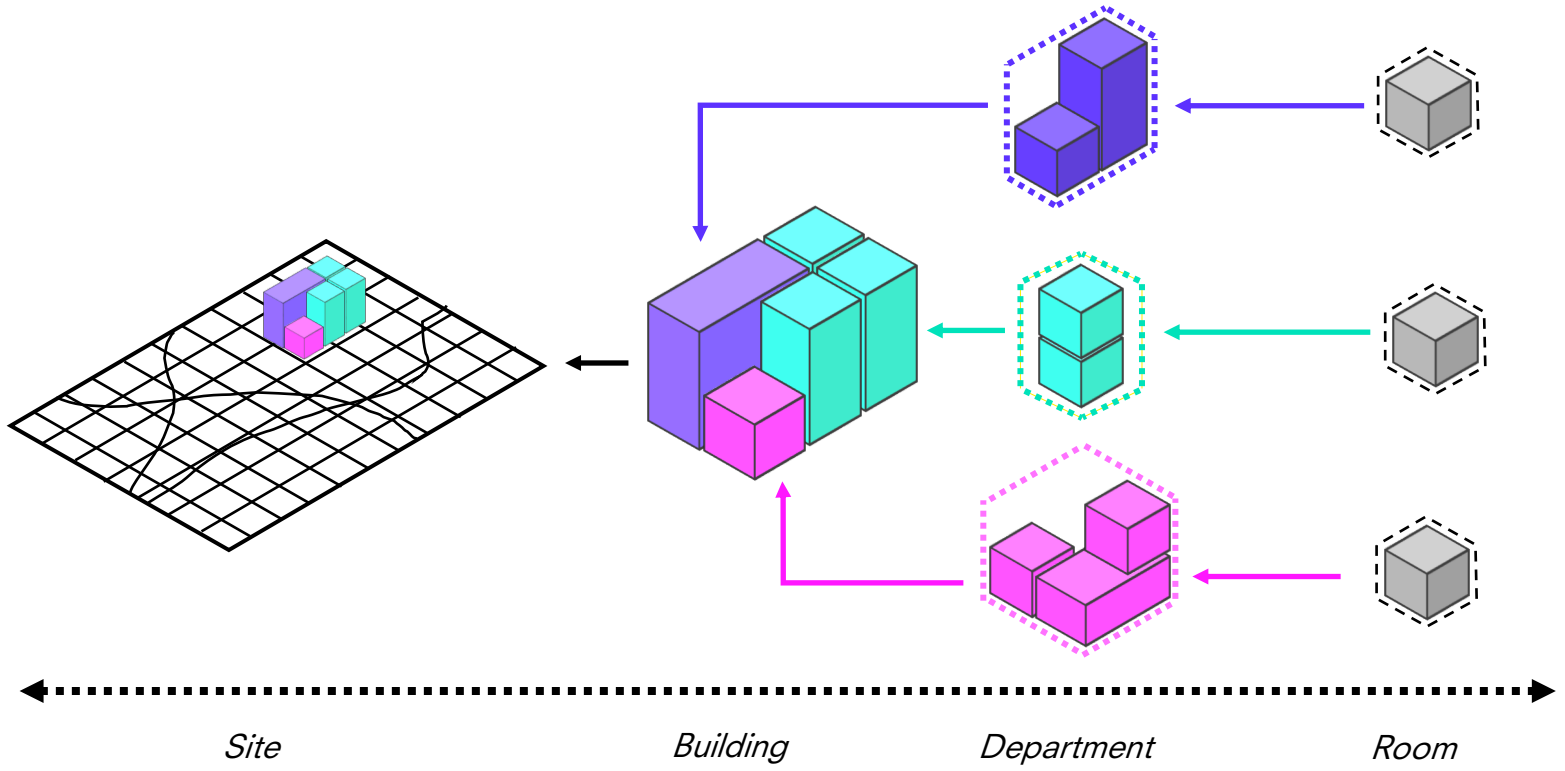
Allow for human intervention



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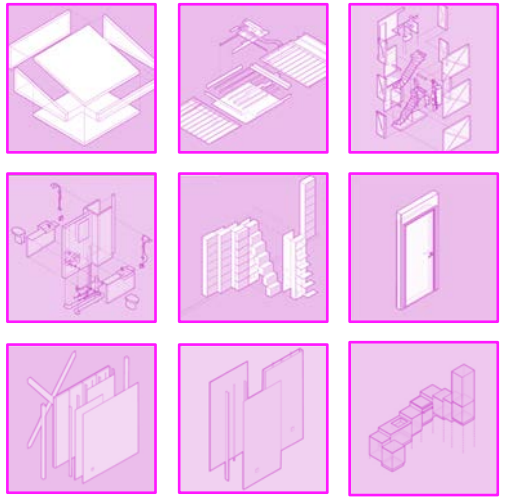
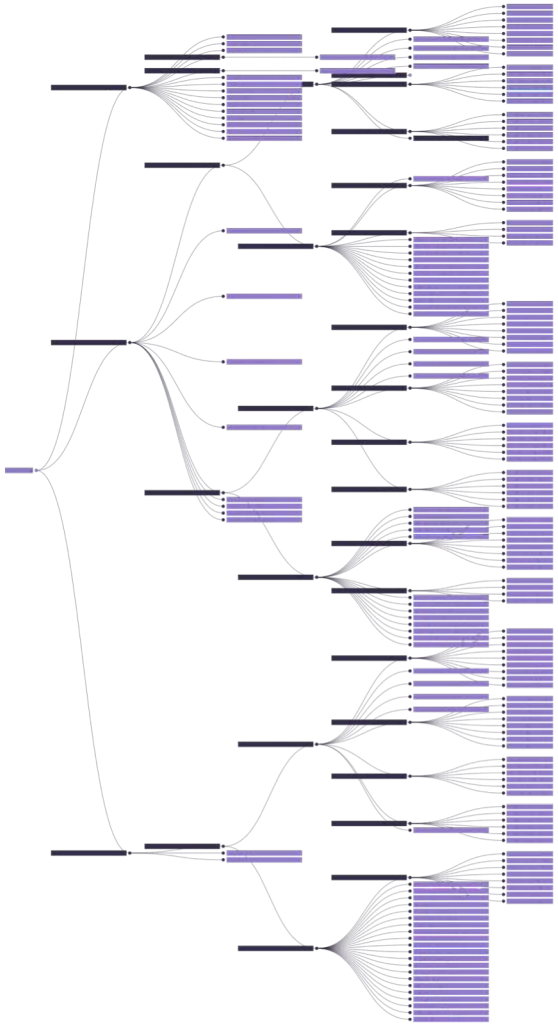
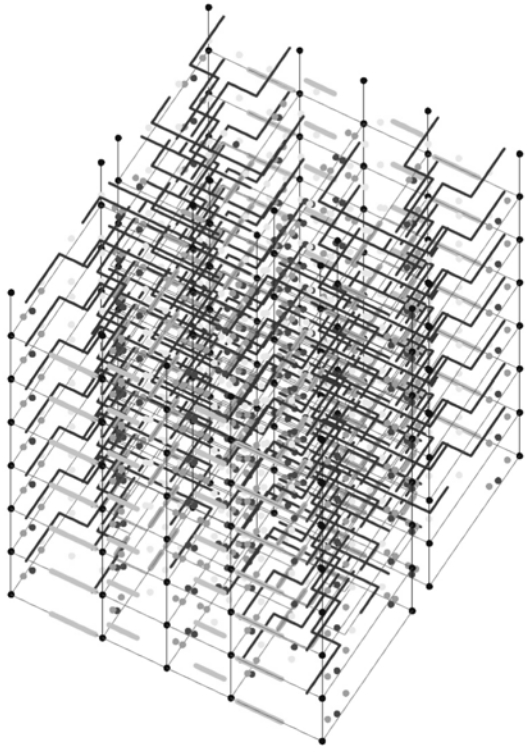
Generate standard design content







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An out of this world example of

Design automation + configuration

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Sustainable development

on the MOON!

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Maximize performance

research potential, food growth, work/life balance

Minimize effort

material use, construction activity, operational cost

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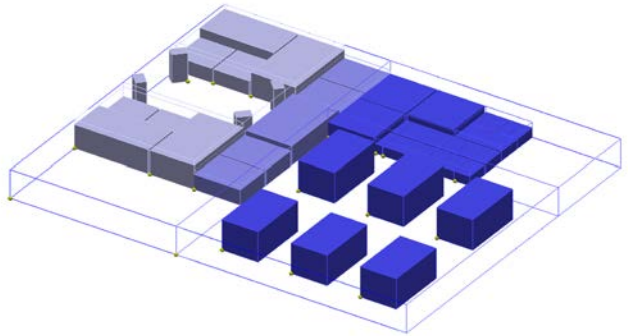
Building typologies – reference design

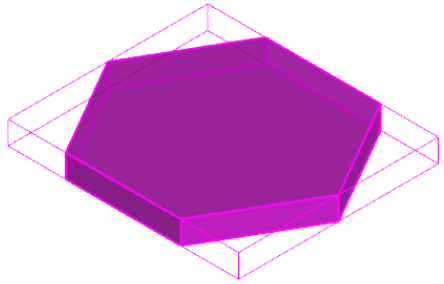


WORK

Research lab + medical center

X: 430m
Y: 350m

Robot Yard: 21%
Admin: 8%
Science Centre: 51%
Uncovered space: 20%

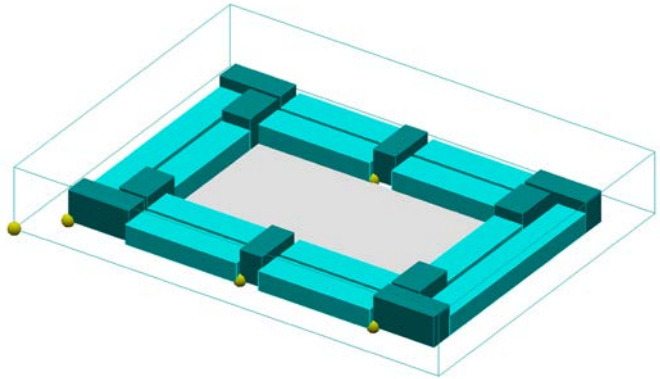


EAT

Lunar farming facilities

X: 50m
Y: 43m

Harvest from single module
12 metric tons
(supports 4 people per year)



SLEEP

Homes for residents

X: 143.7m
Y: 107.7m

Flexible accommodation
(160-320 people per building)

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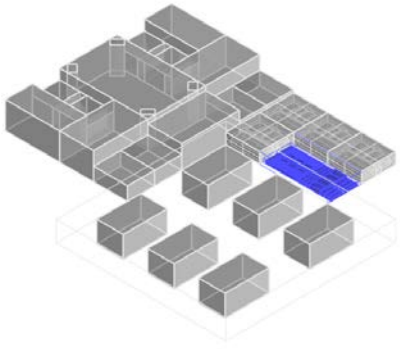
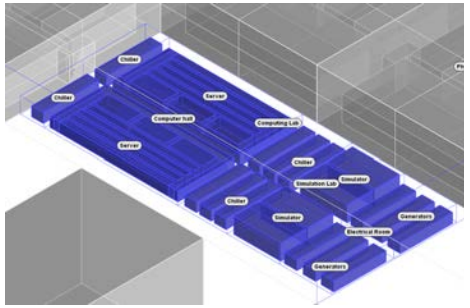
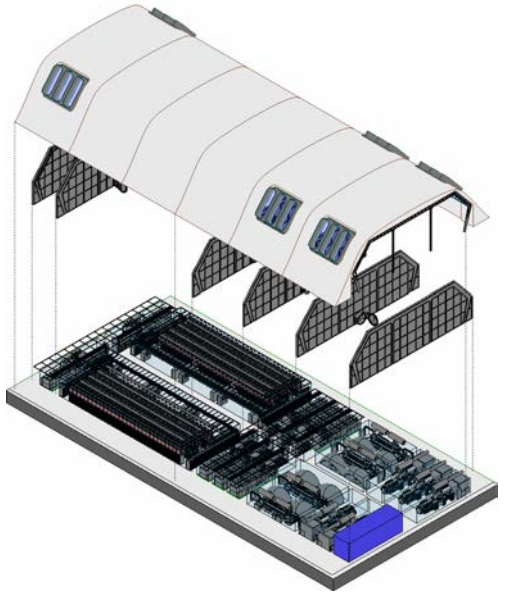
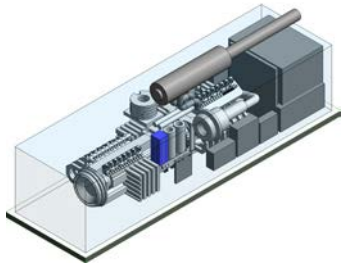
Building typologies – reference designs

Hierarchical scales









Facility *Department* *Room* *Equipment* *Part*

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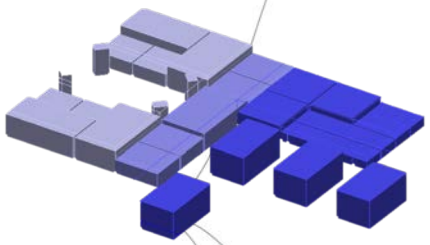
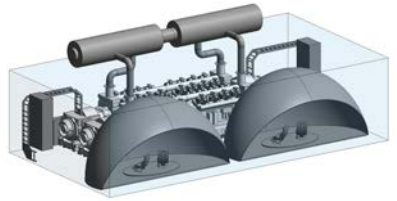
Building typologies – reference designs

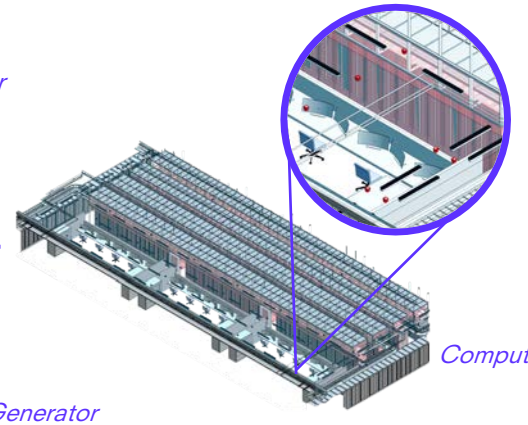
WORK facility



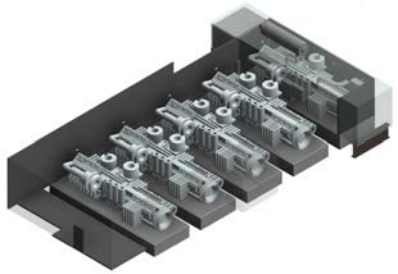
- Science Centre
  - Medical Facility
    - Emergency
      - Operation Unit
      - Intensive Care Unit
    - Non-Emergency
      - Outpatient Unit
      - Doctor's Office
    - Diagonstics
      - Laboratory
      - Technician's Office
  - Research Lab
    - Physics Lab
      - Lab - Equipment 1
      - Lab - Equipment 2
    - Biology lab
    - Geology Lab
    - Computing Lab
      - Air Cooling
      - Water Cooling
  - Observatory
    - Antenna Shroud 1
      - Antenna - ALMA1
      - Antenna - ALMA2
      - Antenna - MONA
    - Antenna Shroud 2
      - Antenna - ALMA1
      - Antenna - ALMA2
      - Antenna - MONA
    - Antenna Shroud 3
      - Antenna - ALMA1
      - Antenna - ALMA2
      - Antenna - MONA
    - Antenna Shroud 4
      - Antenna - ALMA1
      - Antenna - ALMA2
      - Antenna - MONA
    - Antenna Shroud 5
      - Antenna - ALMA1
      - Antenna - ALMA2
      - Antenna - MONA
    - Antenna Shroud 6
      - Antenna - ALMA1
      - Antenna - ALMA2
      - Antenna - MONA
- Robot Yard
  - Geological Exploration
    - Yard
    - Light Tower
    - Light Tower
    - Light Tower
    - Light Tower
  - Support Areas 1
    - Hangar
    - Hangar
    - Wood-Metal Workshop
    - Robot Engineering
  - Support Areas 2
    - Hangar
    - Hangar
    - Mechanical Workshop
    - Robot Engineering
- Admin
  - Workspace 1
    - Workspace - 200
    - Workspace - 500
    - Workspace - 750
  - Workspace 2
    - Workspace - 200
    - Workspace - 500
    - Workspace - 750
    - Conference
    - Utility
    - Canteen



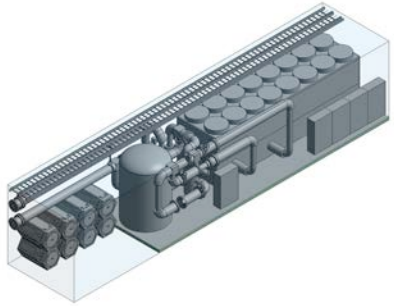
Simulator



Computer Lab



Energy Generator



Chiller / Water Storage

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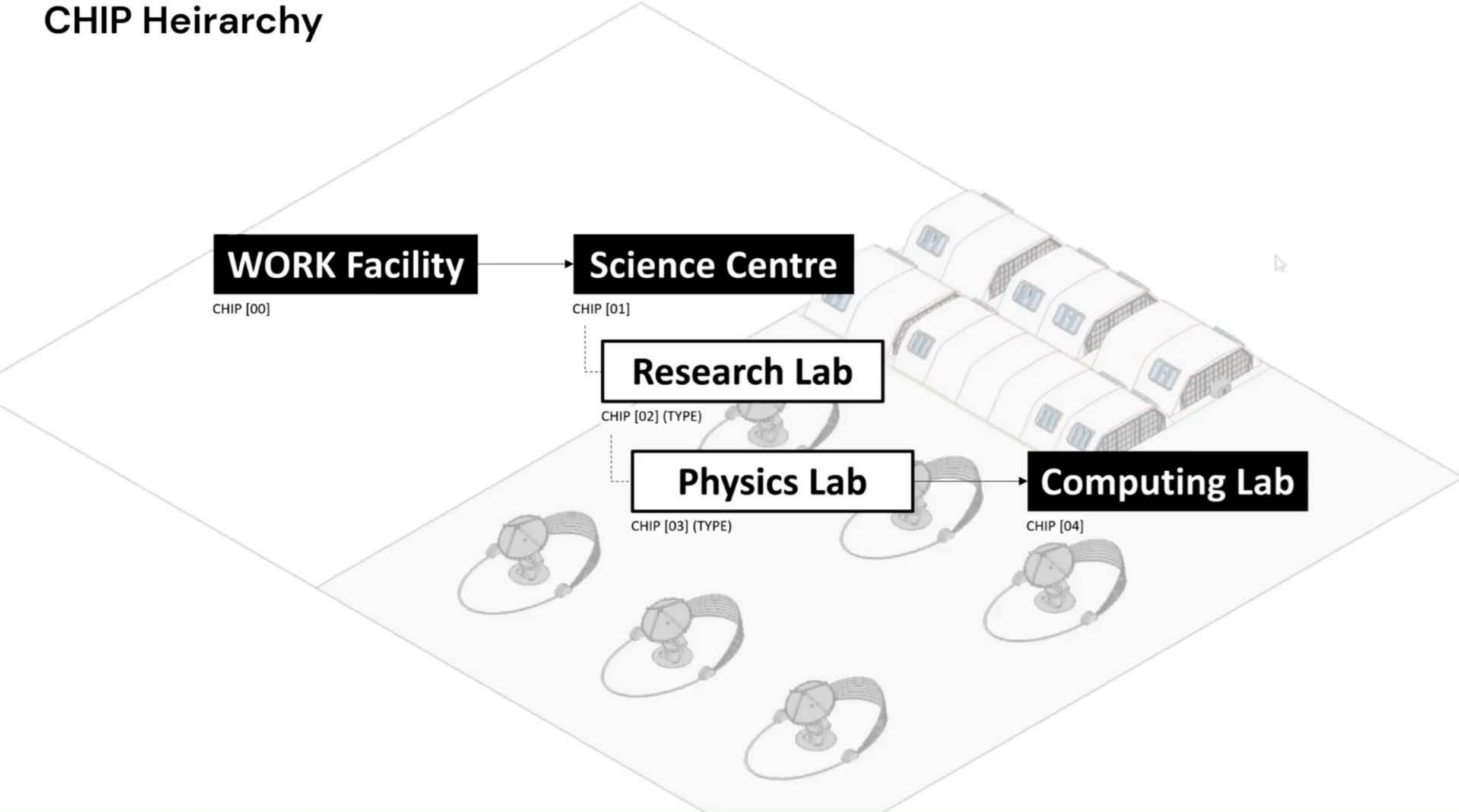
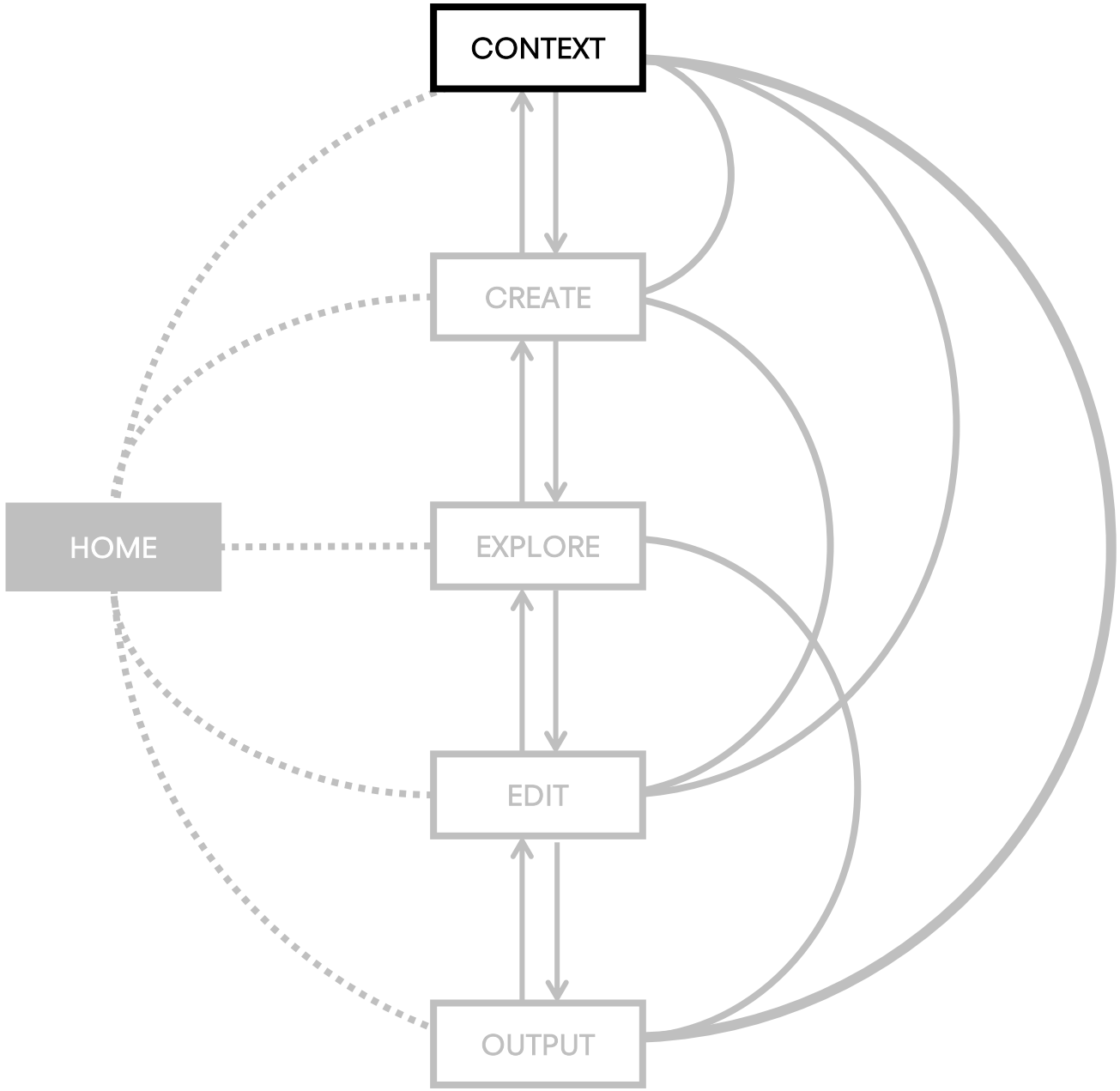
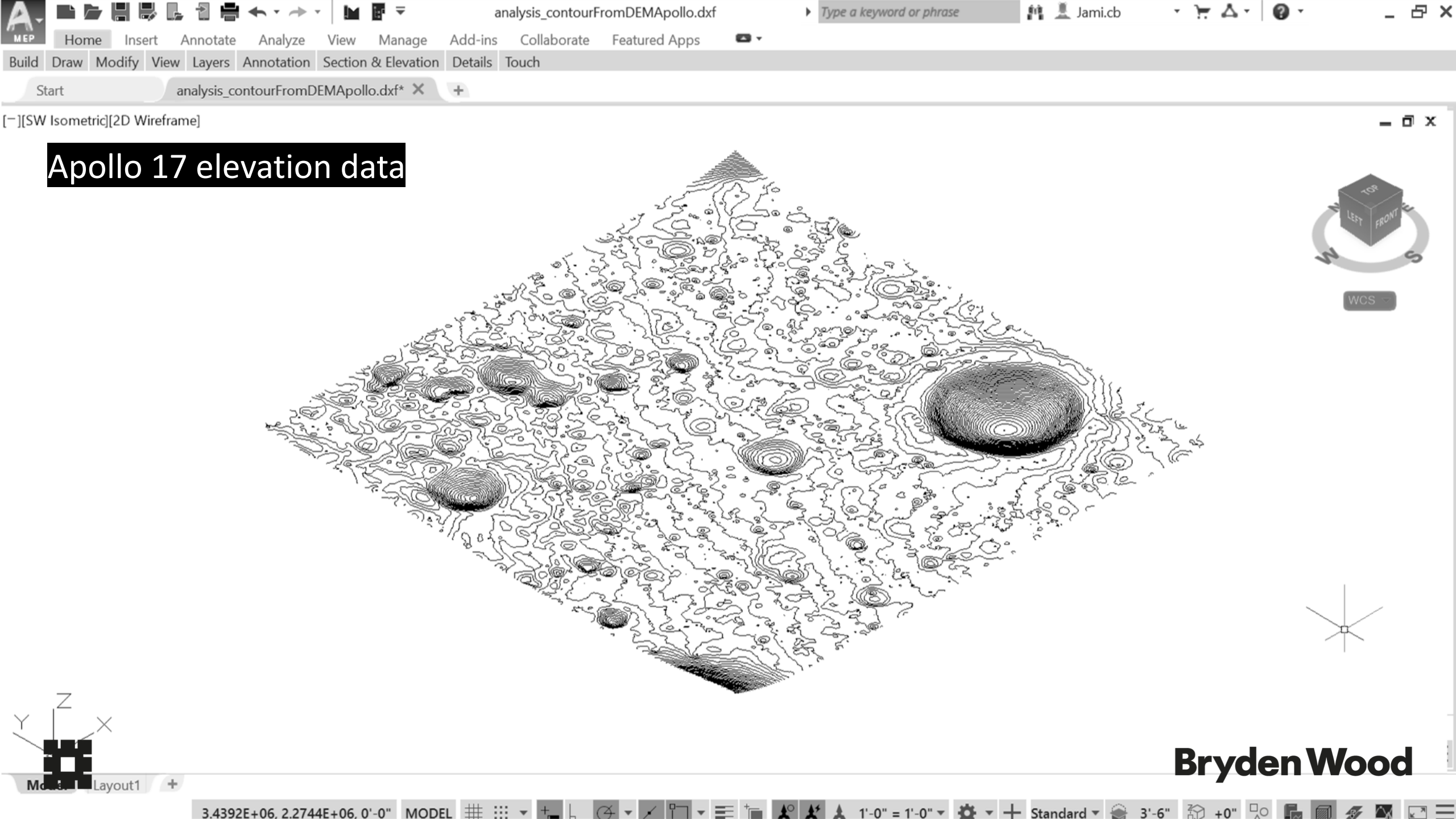
CHIP Heirarchy

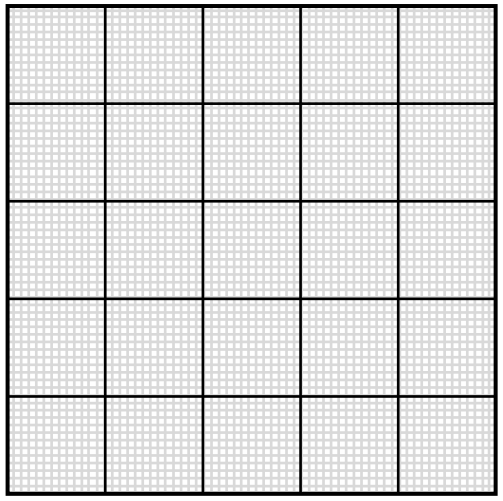




Bryden Wood

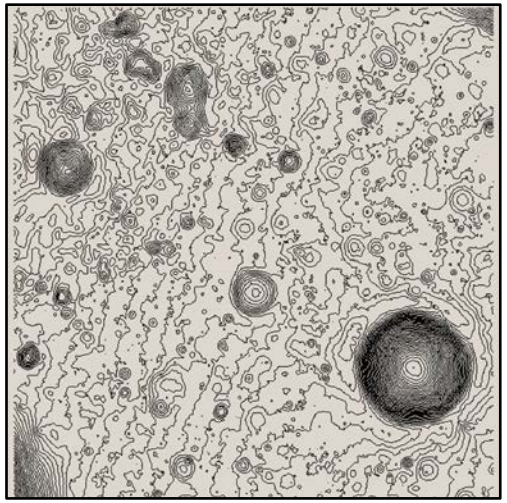

analysis_contourFromDEMApollo.dxf
Type a keyword or phrase
Jami.cb
Home
Insert
Annotate
Analyze
View
Manage
Add-ins
Collaborate
Featured Apps
Build
Draw
Modify
View
Layers
Annotation
Section & Elevation
Details
Touch
Start
analysis_contourFromDEMApollo.dxf*
[−][SW Isometric][2D Wireframe]
Apollo 17 elevation data
TOP
LEFT
FRONT
WCS
Z
Y
X
Layout1
3.4392E+06, 2.2744E+06, 0'-0"
MODEL
1'-0" = 1'-0"
Standard
3'-6"
+0"
Bryden Wood

Analyze input data - topography



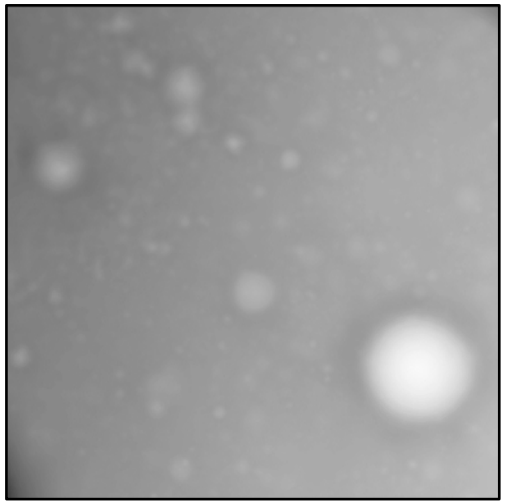
Analysis grid

Grid extents: 5000m x 5000m
Grid X: 10m
Grid Y: 10m



Apollo 17 Landing Site Contours

Source: MoonTrek

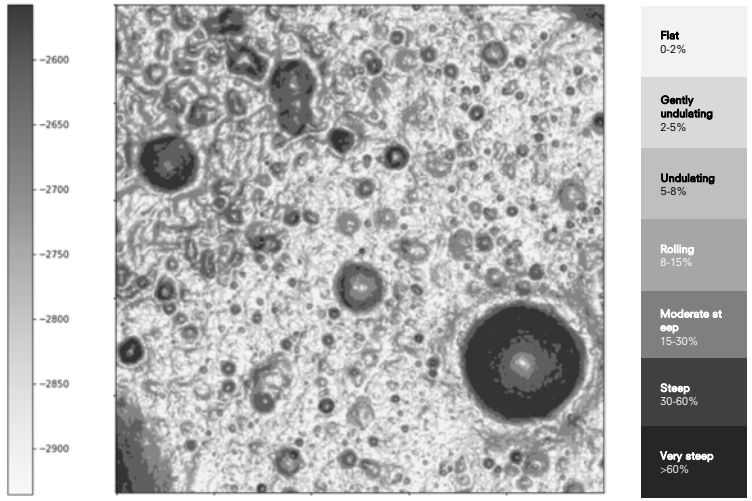


Apollo 17 DEM

Source: MoonTrek
Resolution: 5m

CRS: Equirectangular Moon reprojected to EPSG:4087

MinValue: -2935.62
MeanValue: -2724.09
MaxValue: -2557.59



Apollo 17 Slope Categorization

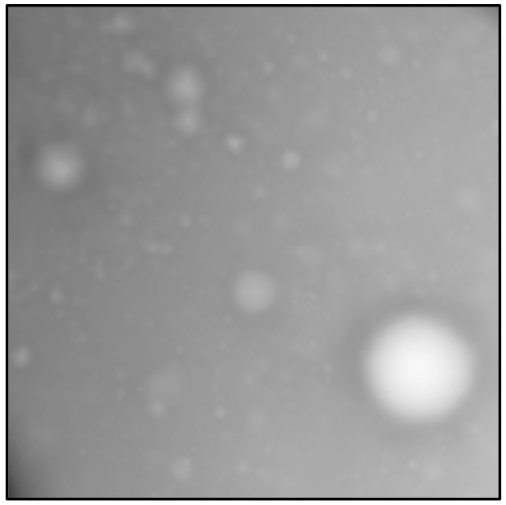
Input: Apollo 17 DEM

Analysis: Regional slope categorization

Values: 7 discreet slope bands

Bryden Wood

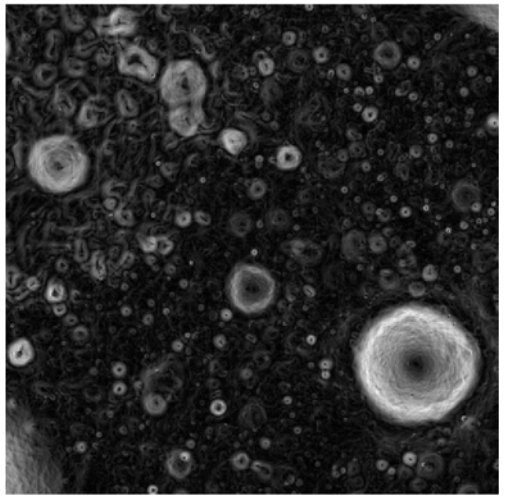
Analyze input data – solar exposure



Apollo 17 DEM

Source: MoonTrek
Resolution: 5m
CRS: Equirectangular Moon reprojected to EPSG:4087

MinValue: -2935.62
MeanValue: -2724.09
MaxValue: -2557.59

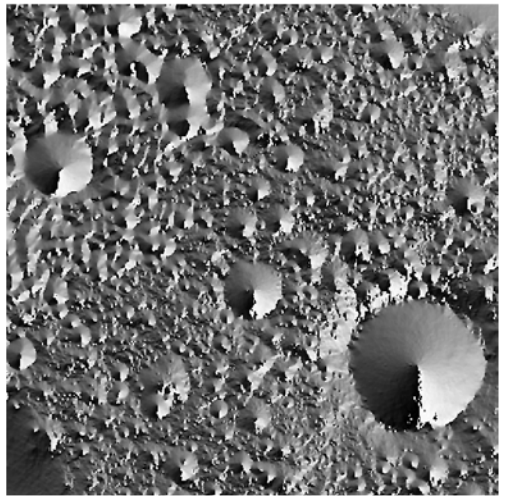


Slope (degrees)

Input: DEM

Analysis: Slope calculated using gdal by the DEM layer in degrees.

MinValue: 0.0015
MeanValue: 5.69
MaxValue: 36.32

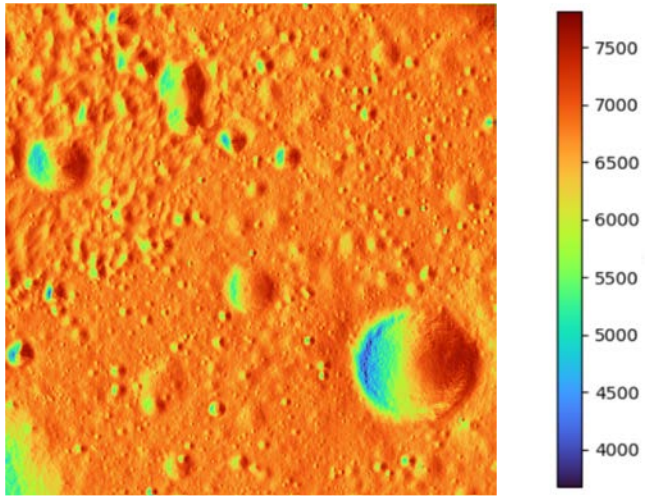


Aspect (directional slope)

Input: Slope (degrees)

Analysis: compass direction or azimuth that a terrain surface faces.

MinValue: 0
MeanValue: 154.20
MaxValue: 359.99



Solar Irradiation

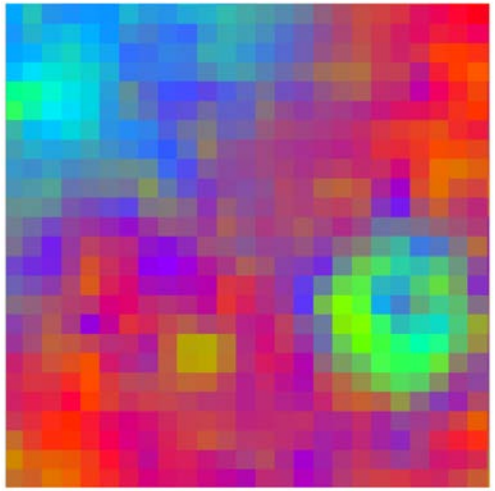
Input: Aspect (directional slope)

Analysis: The incident radiation effect per unit area (W/m²/d)

MinValue: 3672.00
MaxValue: 7812.00
MeanValue: 6716

Bryden Wood

Analyze input data – soil content

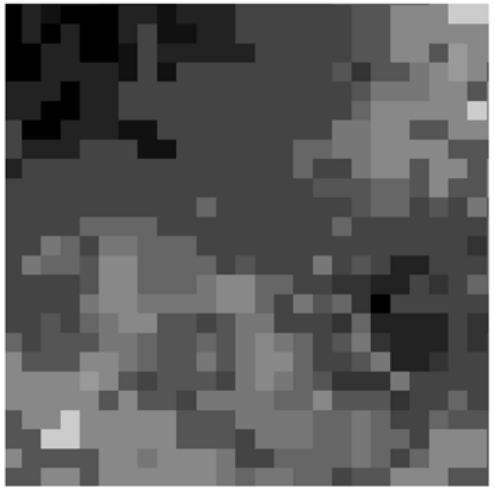


Mineral soil content

Input: Moon Clementine UVVIS Warped Colour Ratio Mosaic

Analysis: Surface reflectance in three spectral bands, to infer the mineral content of the surface

Red Channel: high glass content

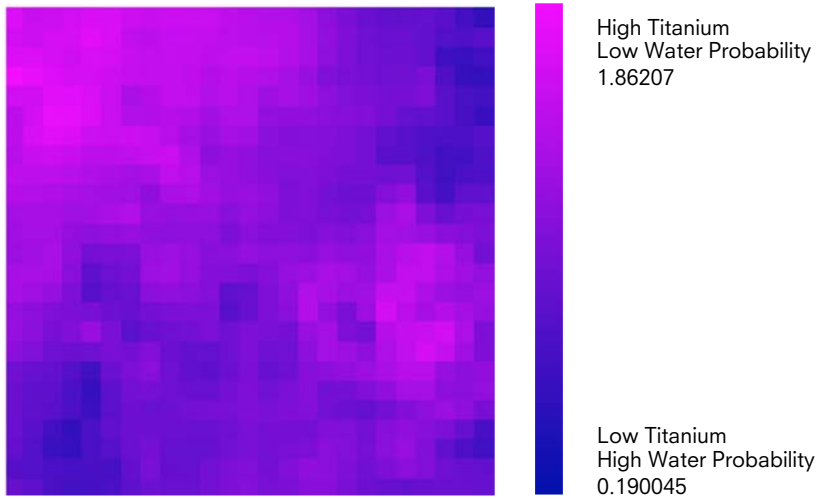


Mineral texture class

Input: Mineral soil content

Analysis: Pixels falling within one of the 16 classes of the mineral textural classes are clustered together.

Values: 13 discreet classes



Glass/titanium ratio

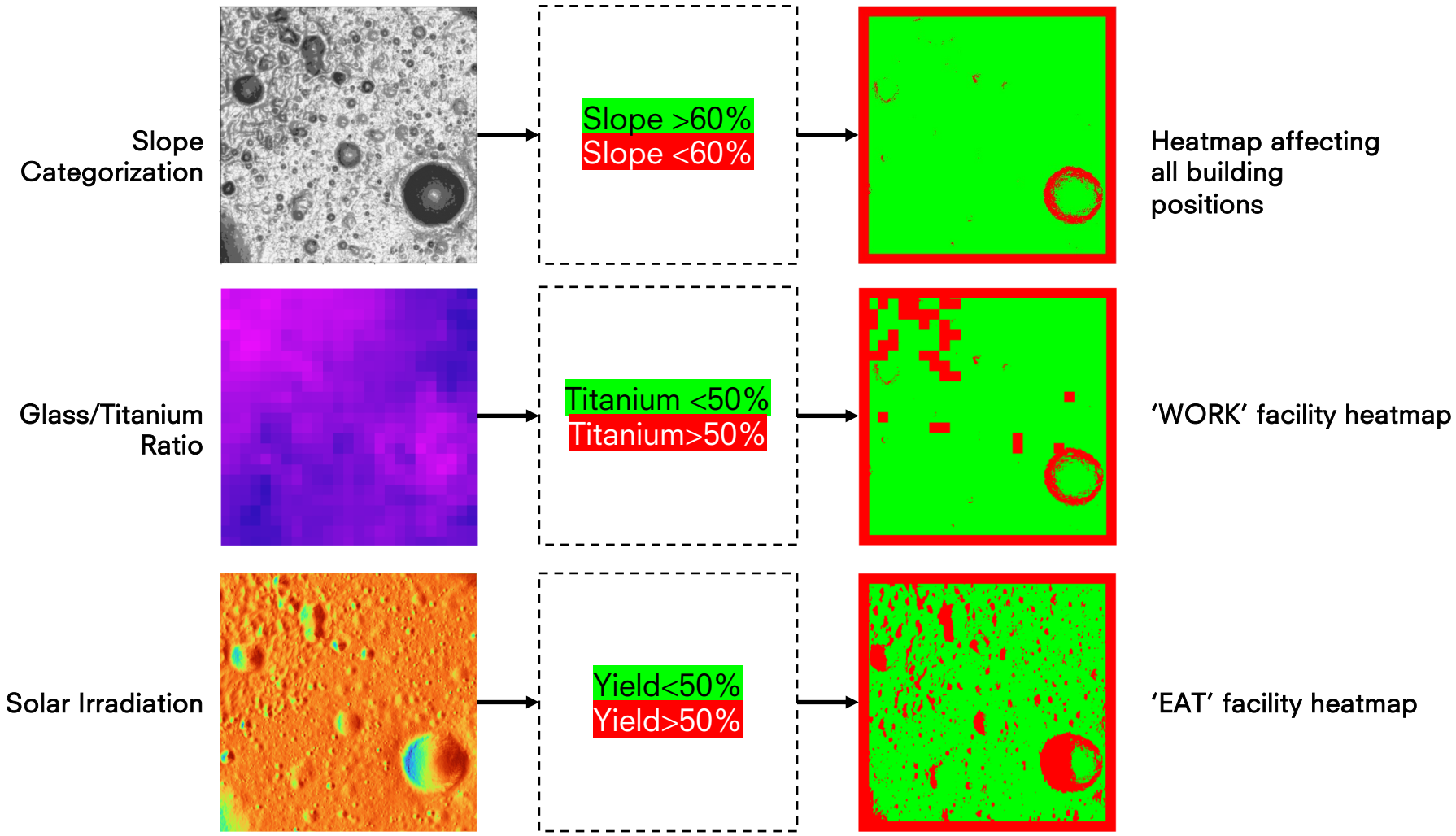
Input: Mineral texture class

Analysis: Ratio of the red:blue band values per pixel

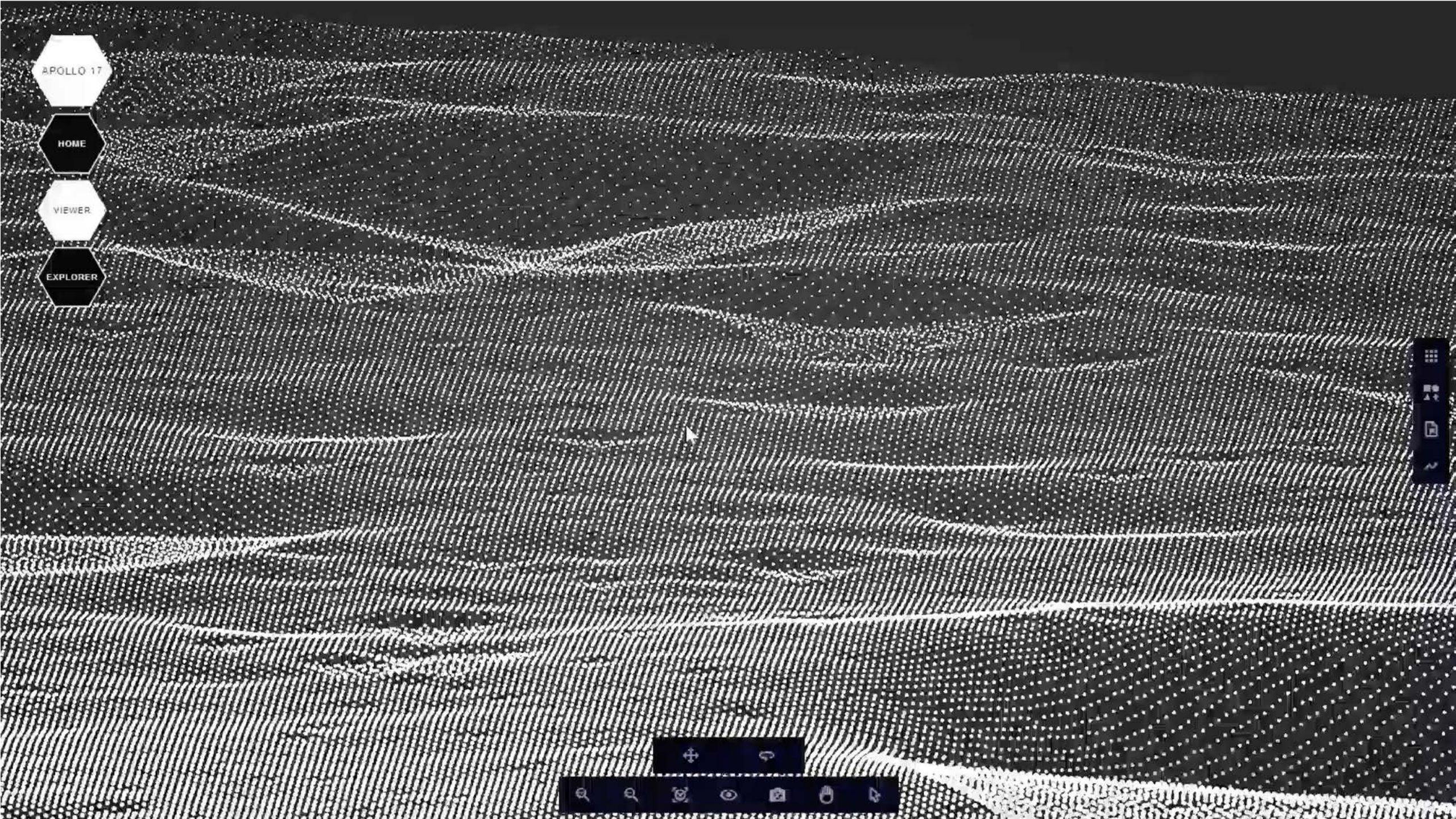
MinValue: 0.93076920509338
MeanValue: 0.50797395040554
MaxValue: 0.93076920509338

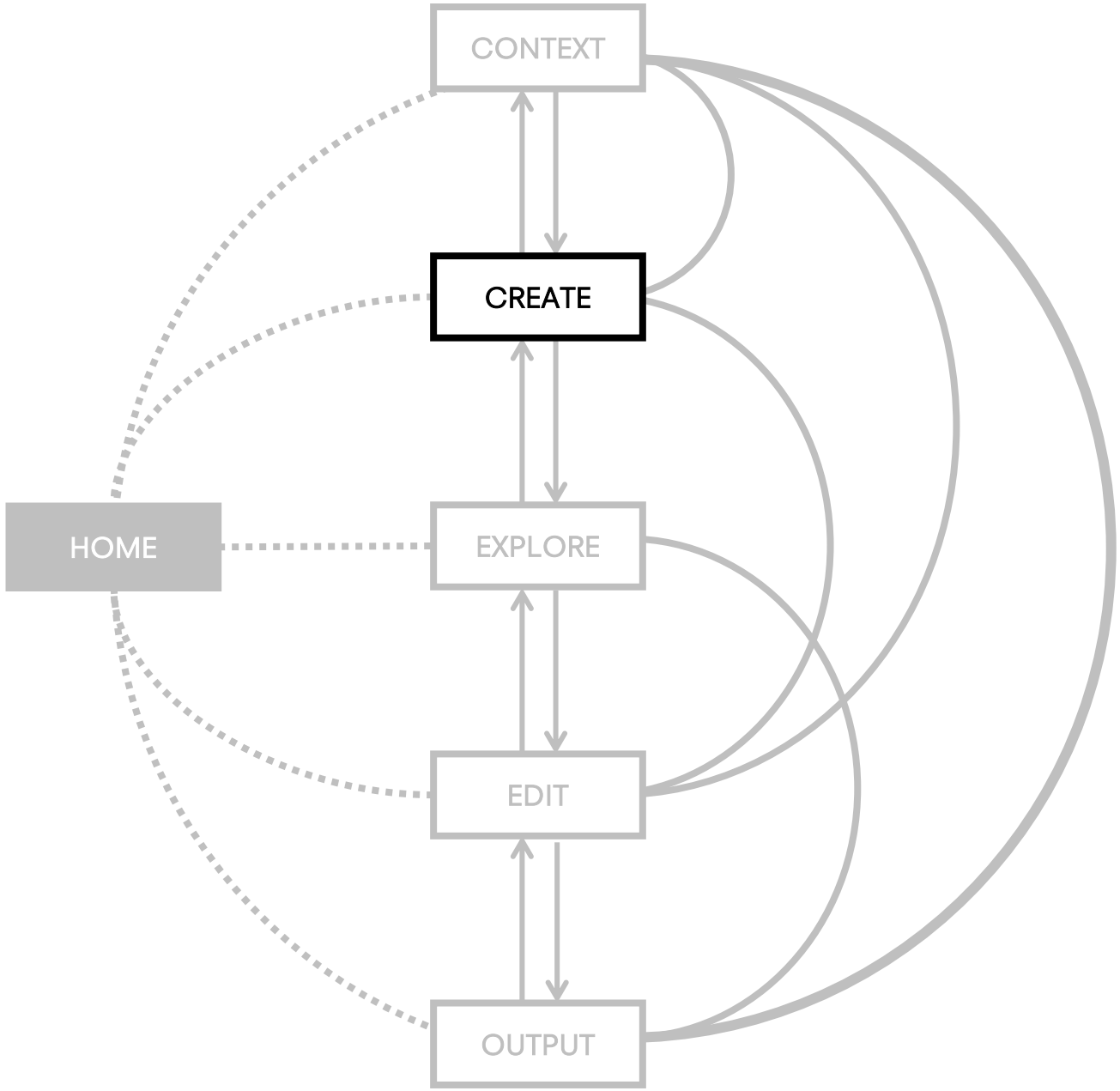
Bryden Wood

Evaluate analysis data



Bryden Wood


APOLLO 17
HOME
VIEWER
EXPLORER



Bryden Wood

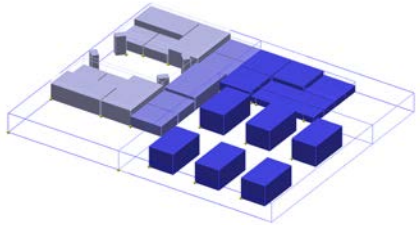
Run configuration algorithms - place different asset types

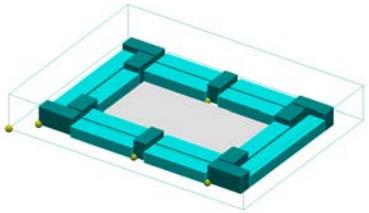
A Apollo 17

Target population

250,000,000m^2

1000 10000 12000

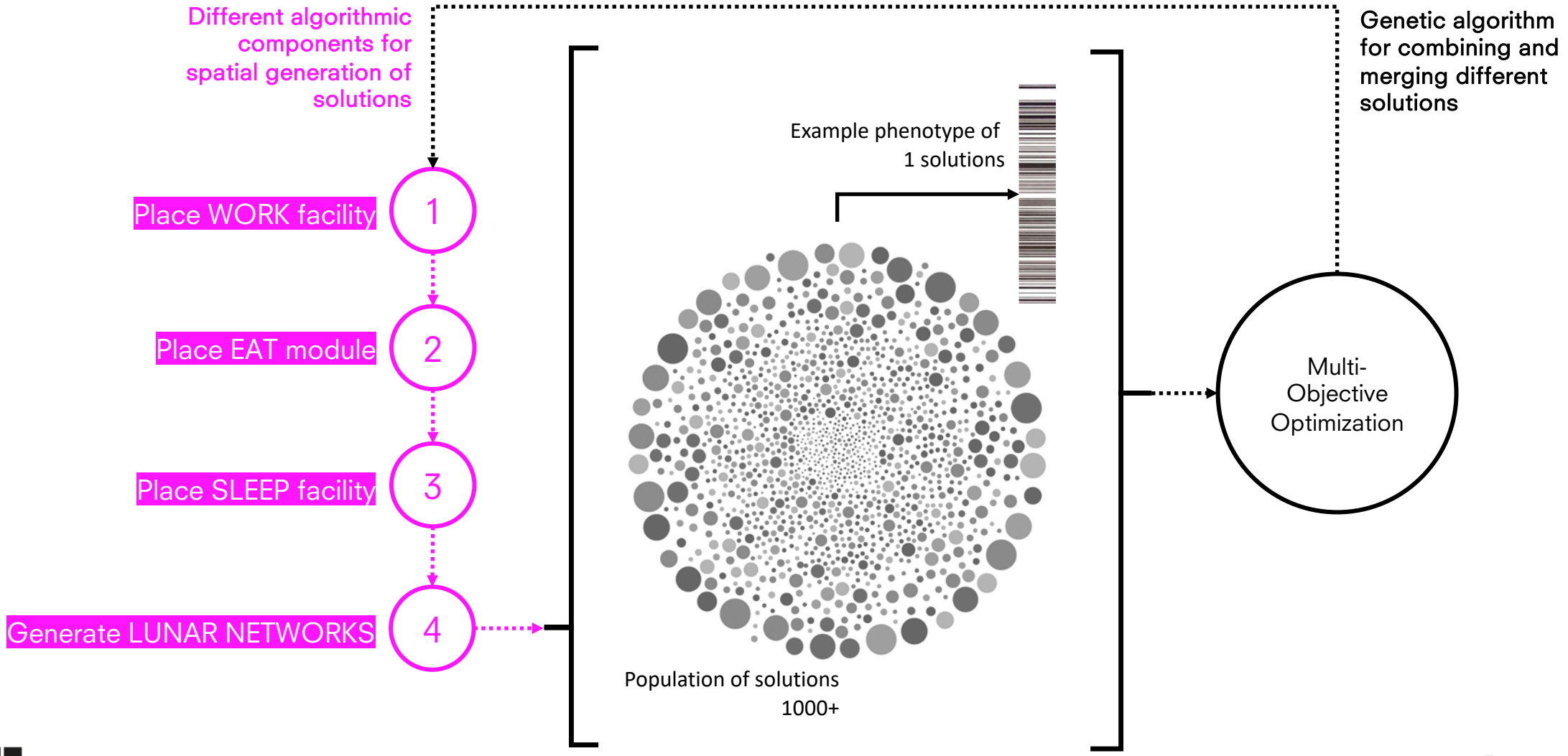




Work facilities	Target harvest / yield	Sleep facilities
2	4000	22
*Prioiritizing search for water (ground conditions containing glass)	*3.2 metric tons/person/year	*Max occupancy 320 per facility

Bryden Wood

Run configuration algorithm - place different asset types



Bryden Wood

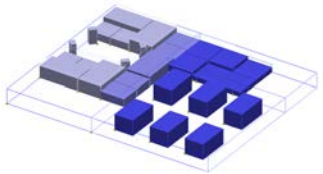
Run configuration algorithm - place different asset types

Place WORK facility

1

SINGLE OBJECTIVE - Hill Climbing

Find positions based on soil content



Place EAT module

2

DIFFERENTIAL GROWTH - Crystal Growth

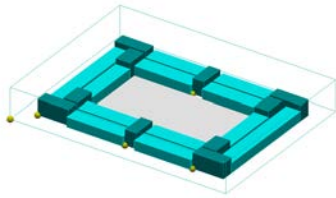
Grow based on solar exposure

Place SLEEP facility

3

PHYSICS SIMULATION - Dynamic Relaxation

Balance positions between facilities



Generate LUNAR NETWORKS

4

SHORTEST PATH

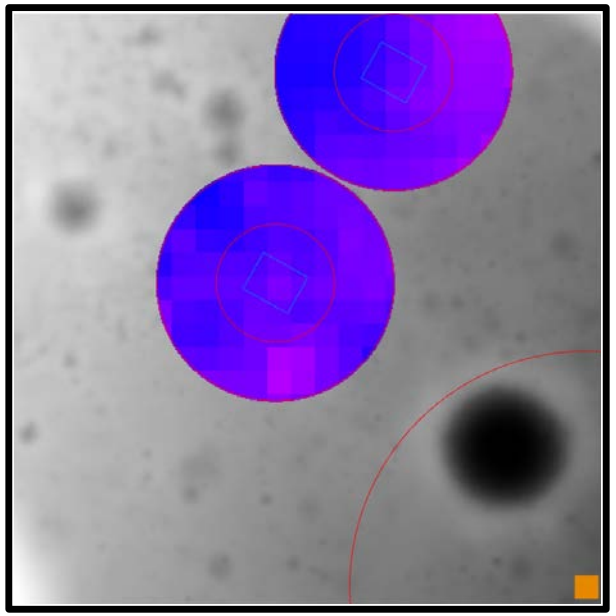
Connect buildings through suitable areas

Bryden Wood

Run configuration algorithm – Place different Asset Types

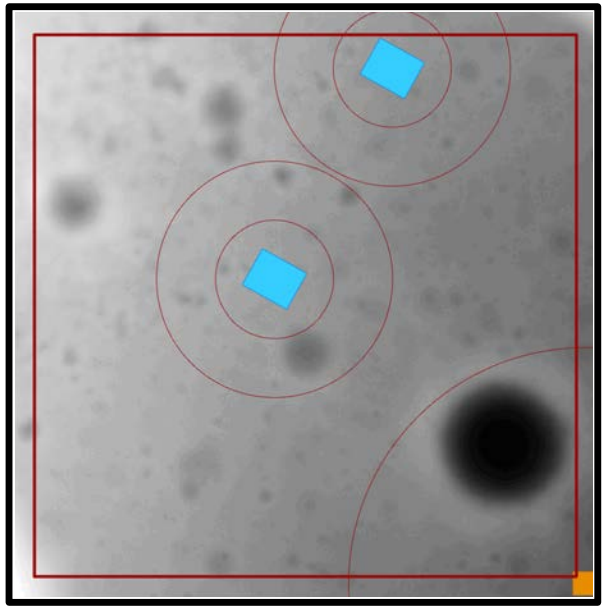
Different algorithmic components for spatial generation of solutions

1 Place Work Facility



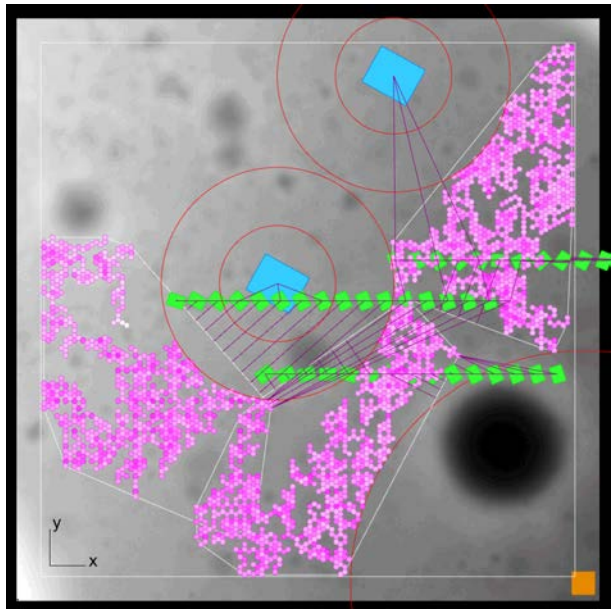
Find positions based on soil content

2 Place Eat Modules



Grow based on solar exposure

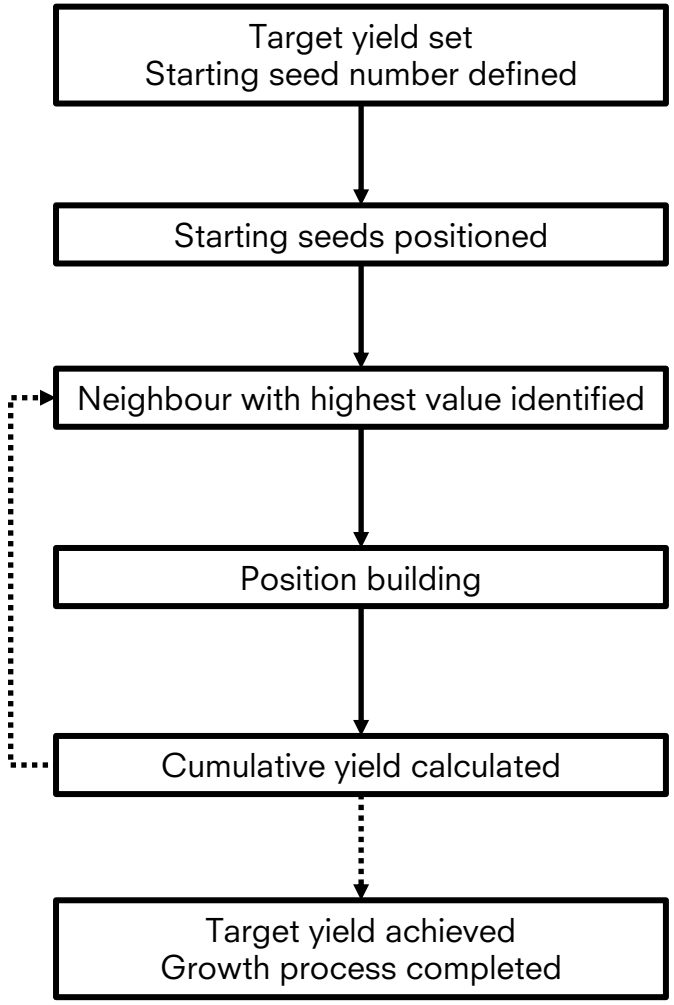
3 Place Sleep Facilities

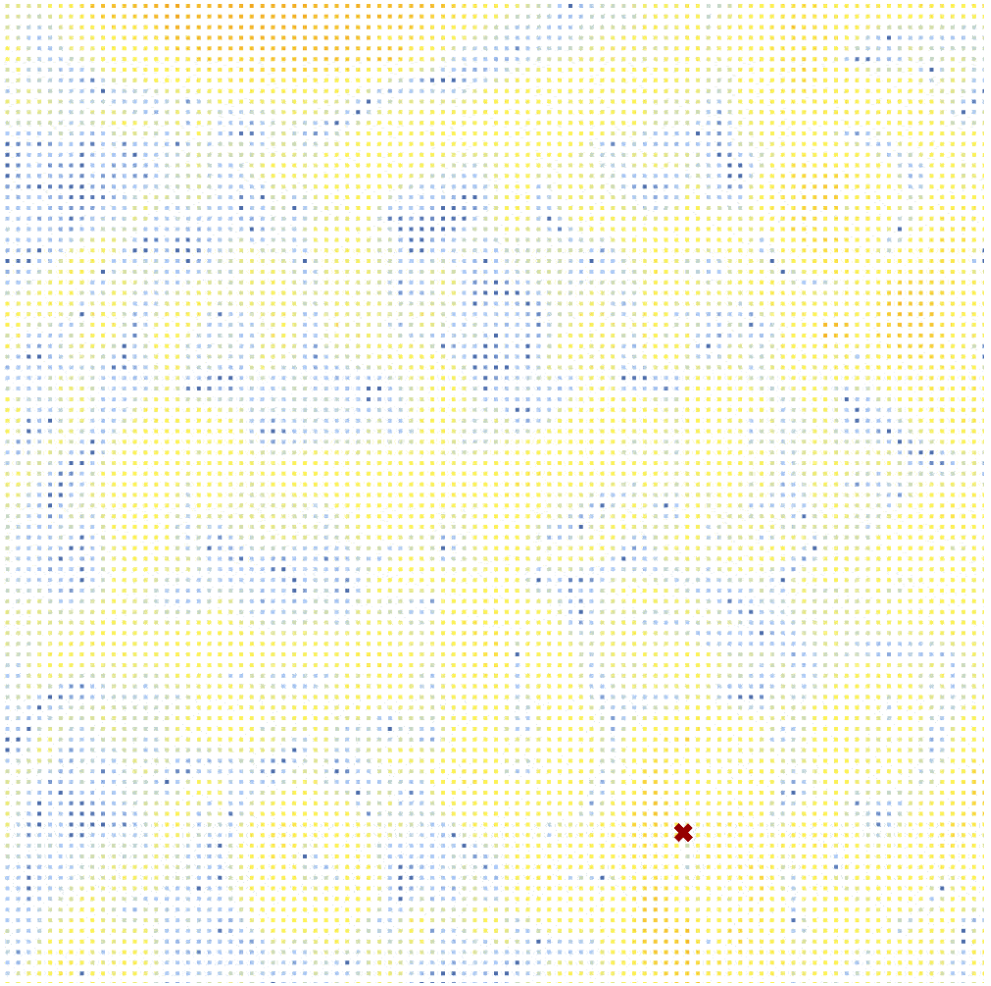


Balance positions between facilities

Bryden Wood

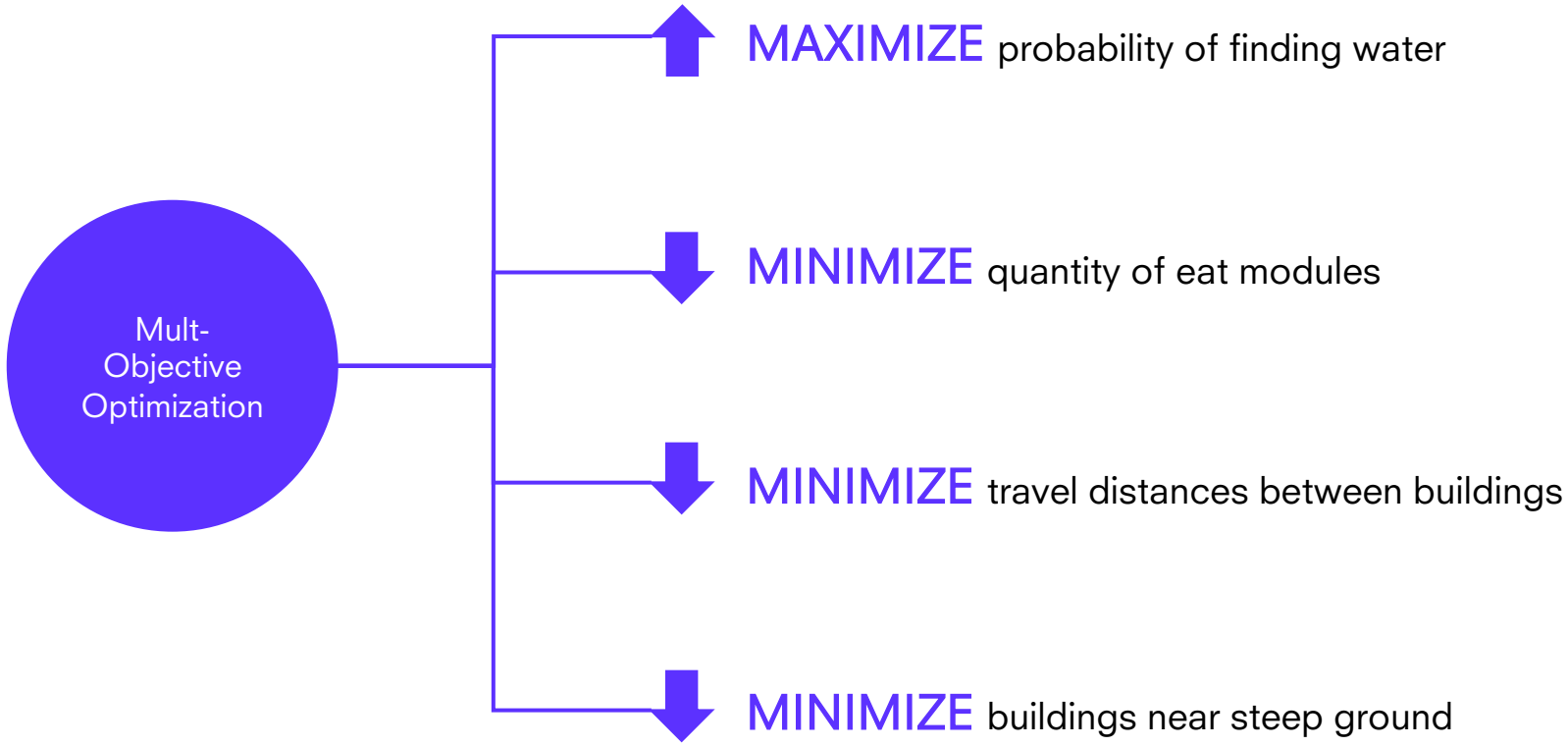
Run configuration algorithm - Place Asset Type 2 EAT

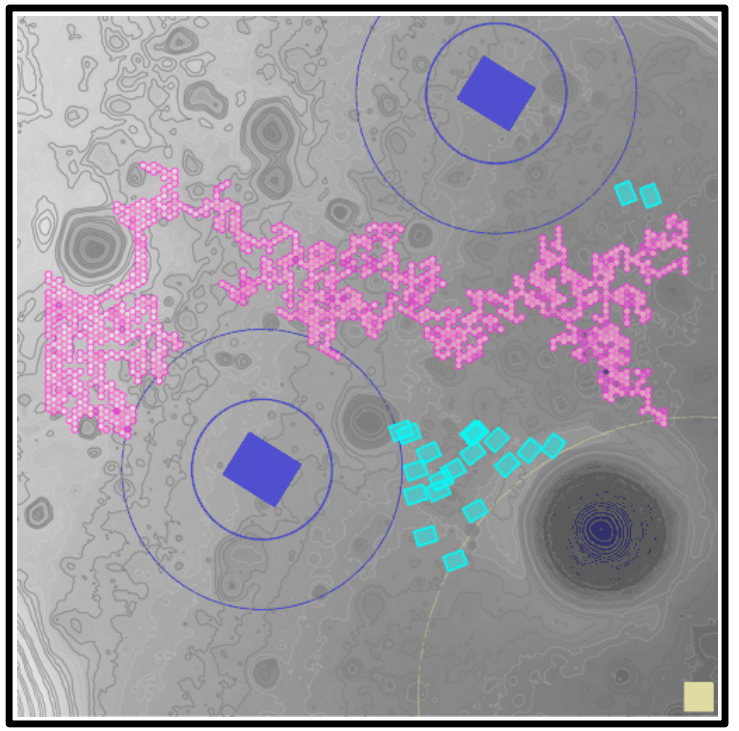




Run configuration algorithm - Multi-objective optimization

Non-dominated sorting genetic algorithm 2





Bryden Wood

APOLLO 17

HOME

VIEWER

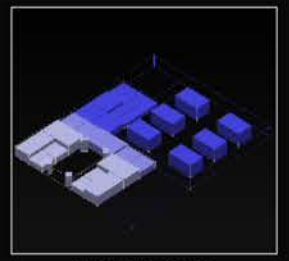
EXPLORER

Optimization settings

Site brief

TARGET POPULATION

12000

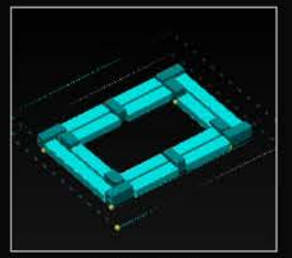


Work facilitites

5

Target harvest / yield

2000



Sleep facilitites

10

Scenario Constraints

Maximum site coverage

% 35

offset from site boundary

m 50

Avoid craters below this depth

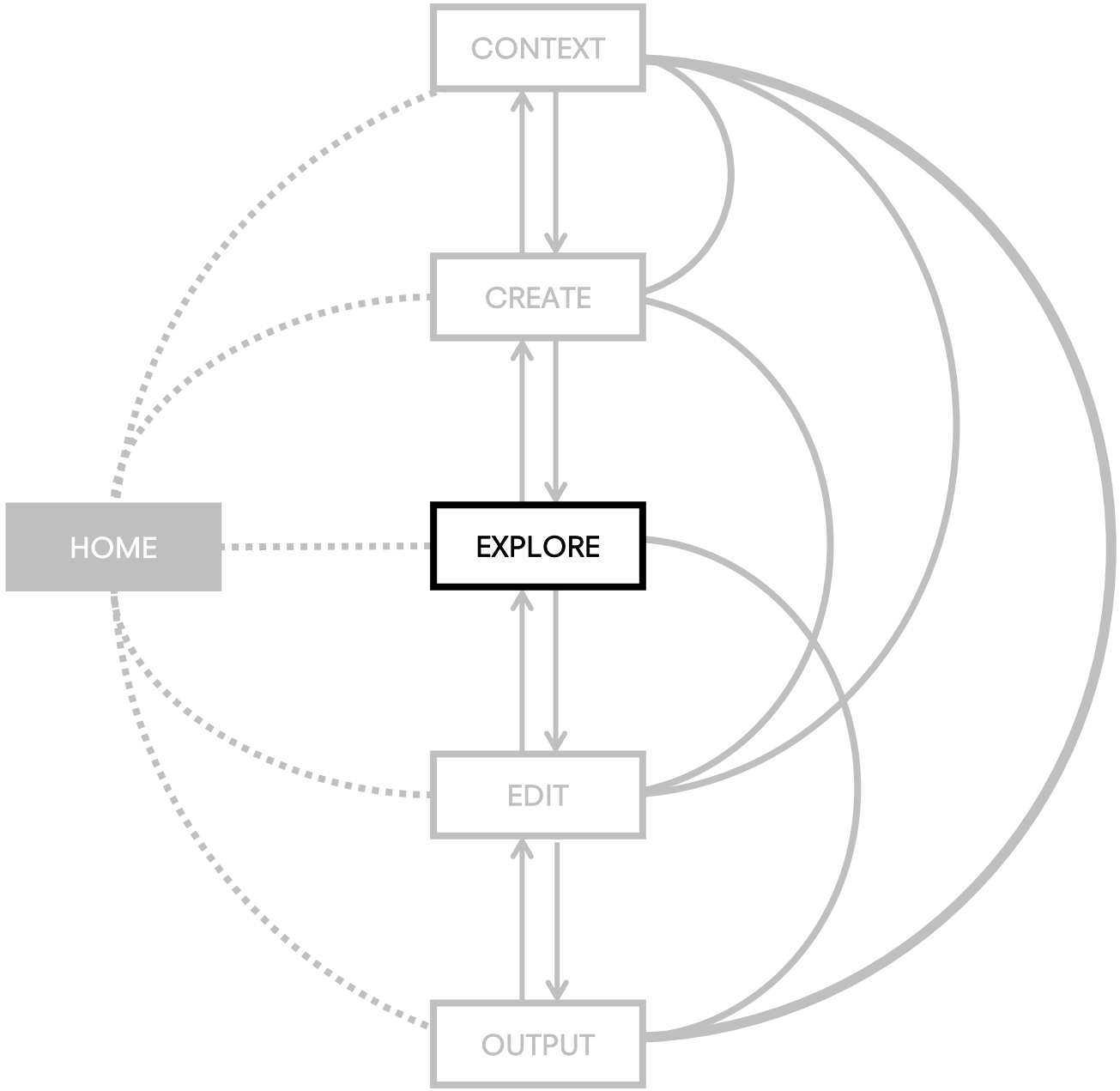
m 8

Optimize layouts for

- [ ] Find work facility locations most likely to contain glass
- [ ] Maximize harvest/yield
- [ ] Minimize inter-facility travel time
- [ ] Minimize eat modules

- (•) Fast (25 solutions)
- ( ) Medium (100 solutions)
- ( ) Slow (1000 solutions)

GENERATE



Bryden Wood

APOLLO 17

HOME

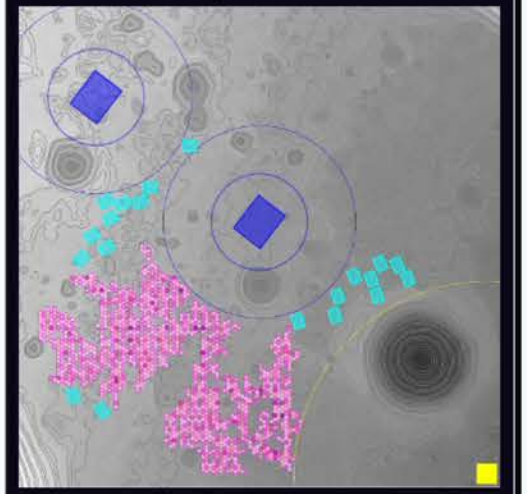
VIEWER

EXPLORER

GALLERY PERFORMANCE EVALUATION

Layout 0
87ea1696-b7fe-4820-a376-03716f2d2865

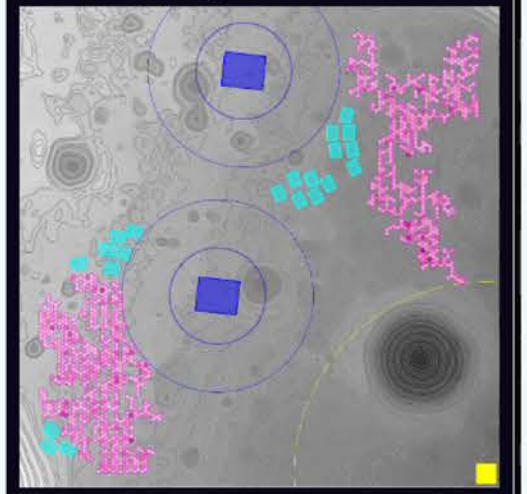
Sort Order - index: 0;
Colour Value - index: 0;



DETAILS

Layout 1
17046e64-f97c-4355-9075-ecc1529d31c9

Sort Order - index: 1;
Colour Value - index: 1;



DETAILS

Layout 2
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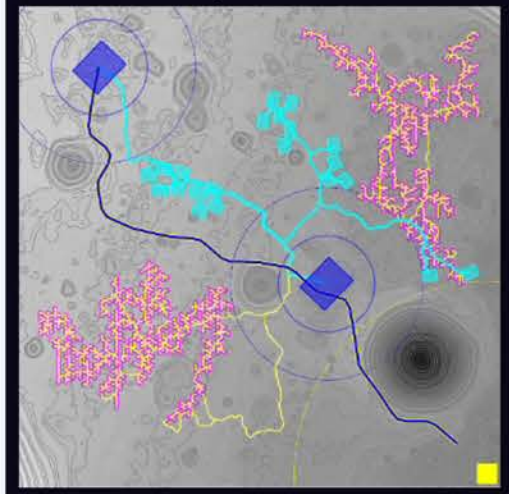
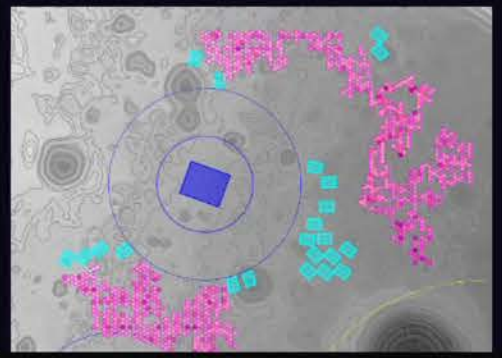
Sort Order - index: 2;
Colour Value - index: 2;



DETAILS

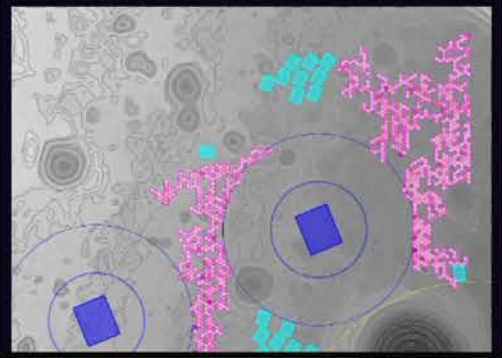
Layout 3
cb465073-c94b-4ca9-89f8-8739d1e811f8

Sort Order - index: 3;
Colour Value - index: 3;



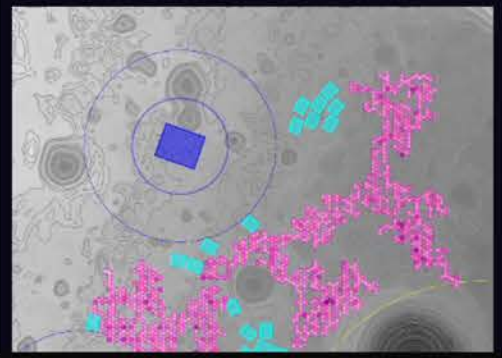
Layout 4
65afada9-94ee-4ce8-9080-5a0f31c61a42

Sort Order - index: 4;
Colour Value - index: 4;



Layout 5
8658c5fa-1b03-48d8-9927-96dbd3f373f7

Sort Order - index: 5;
Colour Value - index: 5;



COMPARE
61

Sort Options

Sort By
index

Colour By
index

Min 0
Max 60

Filter Options

Actual site coverage
9.02 — 9.56

Actual population
4788 — 4824

Total facade area of eat modules
41999.9 — 875000.

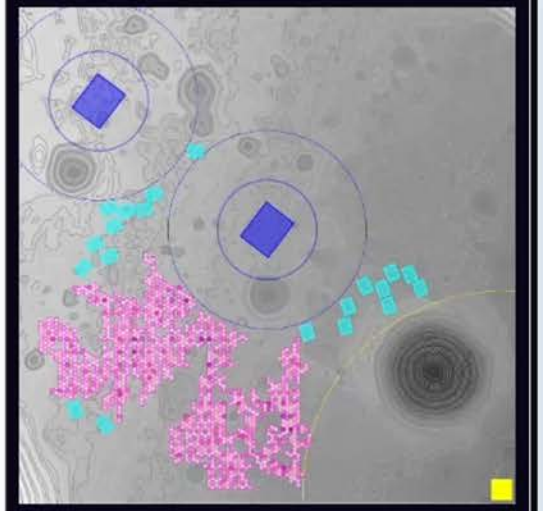
Total foundation length (work facilities)

APPLY FILTERS

CLEAR FILTERS

Layout 0
87ea1696-b7fe-4820-a376-03716f2d2865

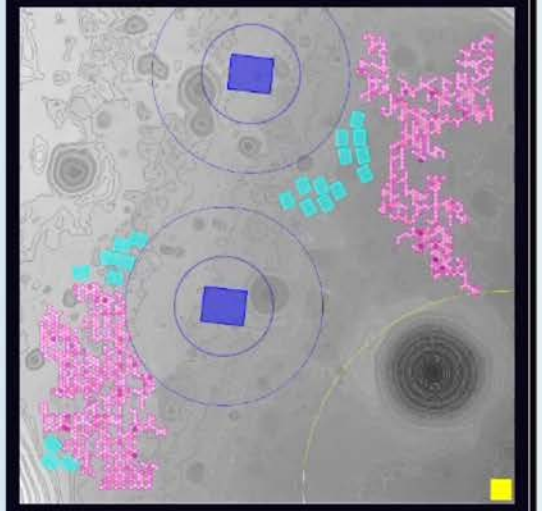
Sort Order - index: 0;
Colour Value - population: 4788;



DETAILS

Layout 1
17046e64-f97c-4355-9075-ecc1529d31c9

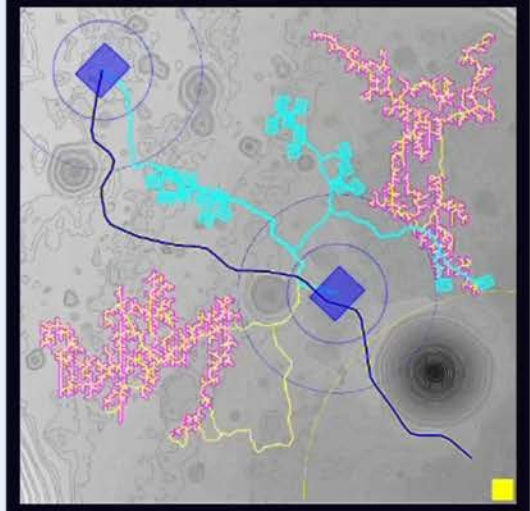
Sort Order - index: 1;
Colour Value - population: 4794;



DETAILS

Layout 2
bbb5bc55-1ec5-4c66-a5af-b8709e666ad9

Sort Order - index: 2;
Colour Value - population: 4792;



DETAILS

Layout 3
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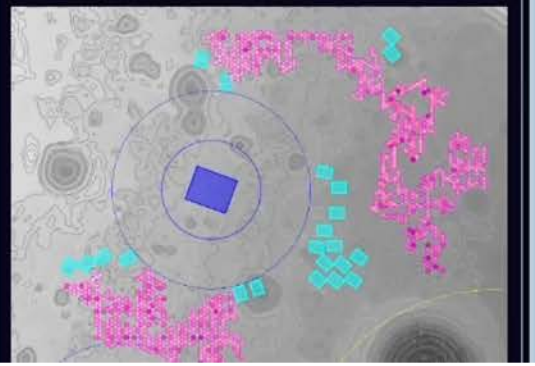
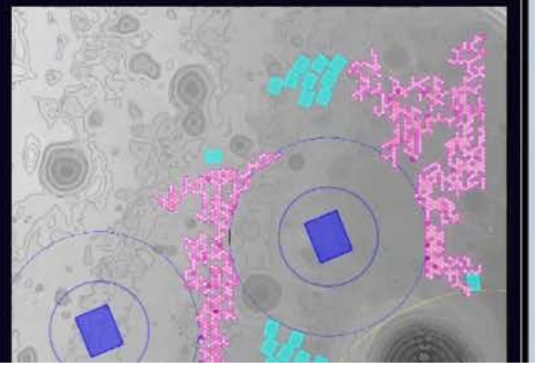
Sort Order - index: 3;
Colour Value - population: 4803;



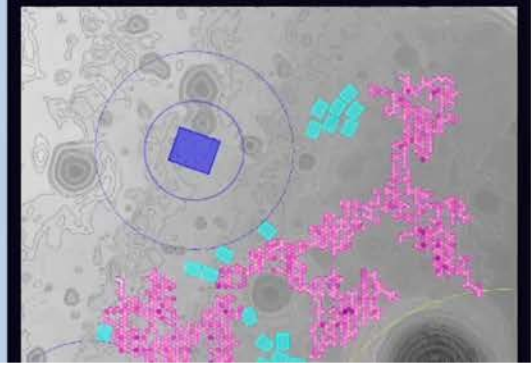
Layout 4
65afada9-94ee-4ce8-9080-5a0f31c61a42

Sort Order - index: 4;
Colour Value - population: 4800;



Layout 5
8658c5fa-1b03-48d8-9927-96dbd3f373f7

Sort Order - index: 5;
Colour Value - population: 4799;



Sort Options

Sort By
index

Colour By
Actual population

Min 4788 — Max 4824

Filter Options

Actual site coverage
9.02 — 9.56

Actual population
4788 — 4824

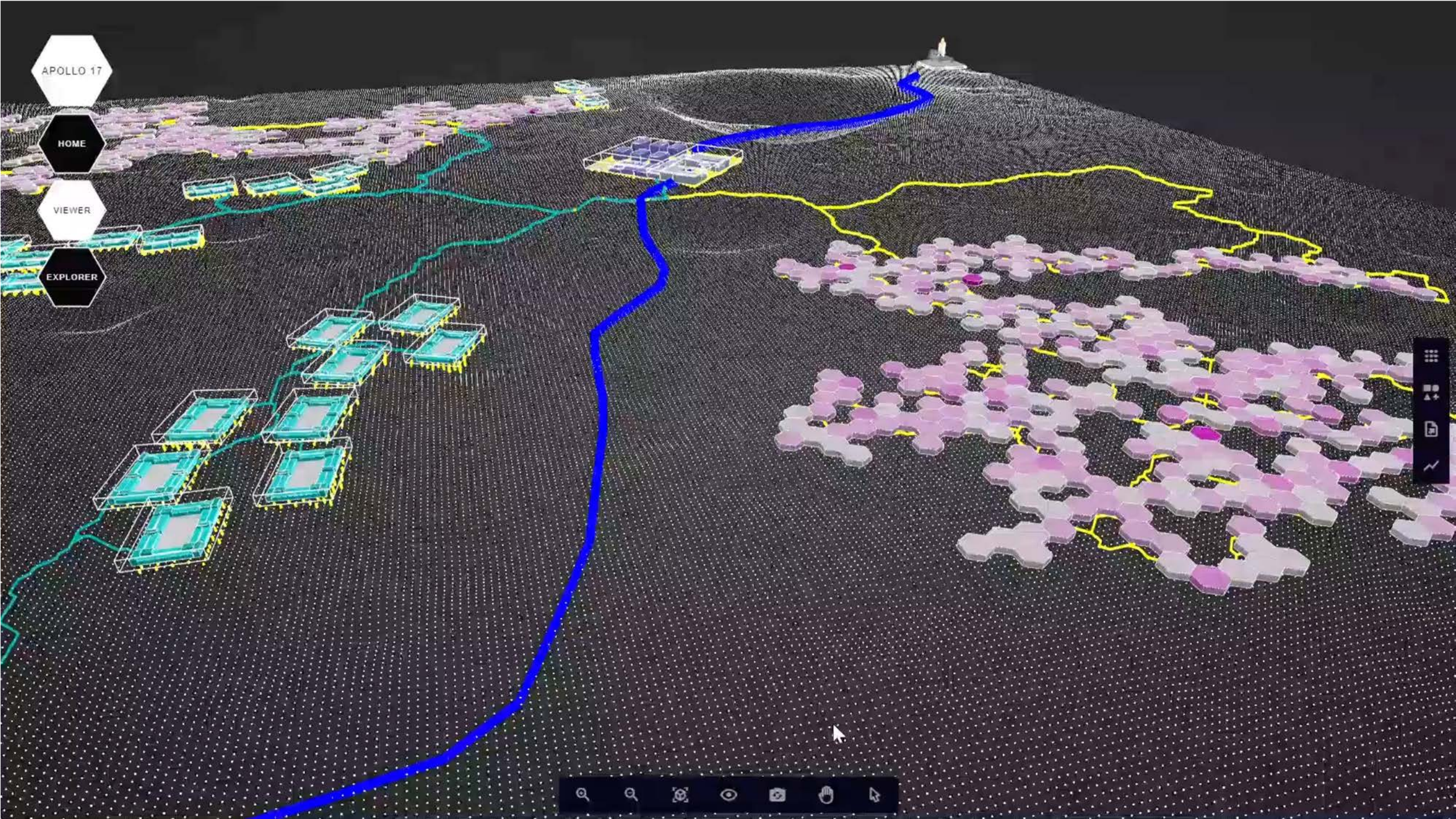
Total facade area of eat modules
41999.9 — 875000.

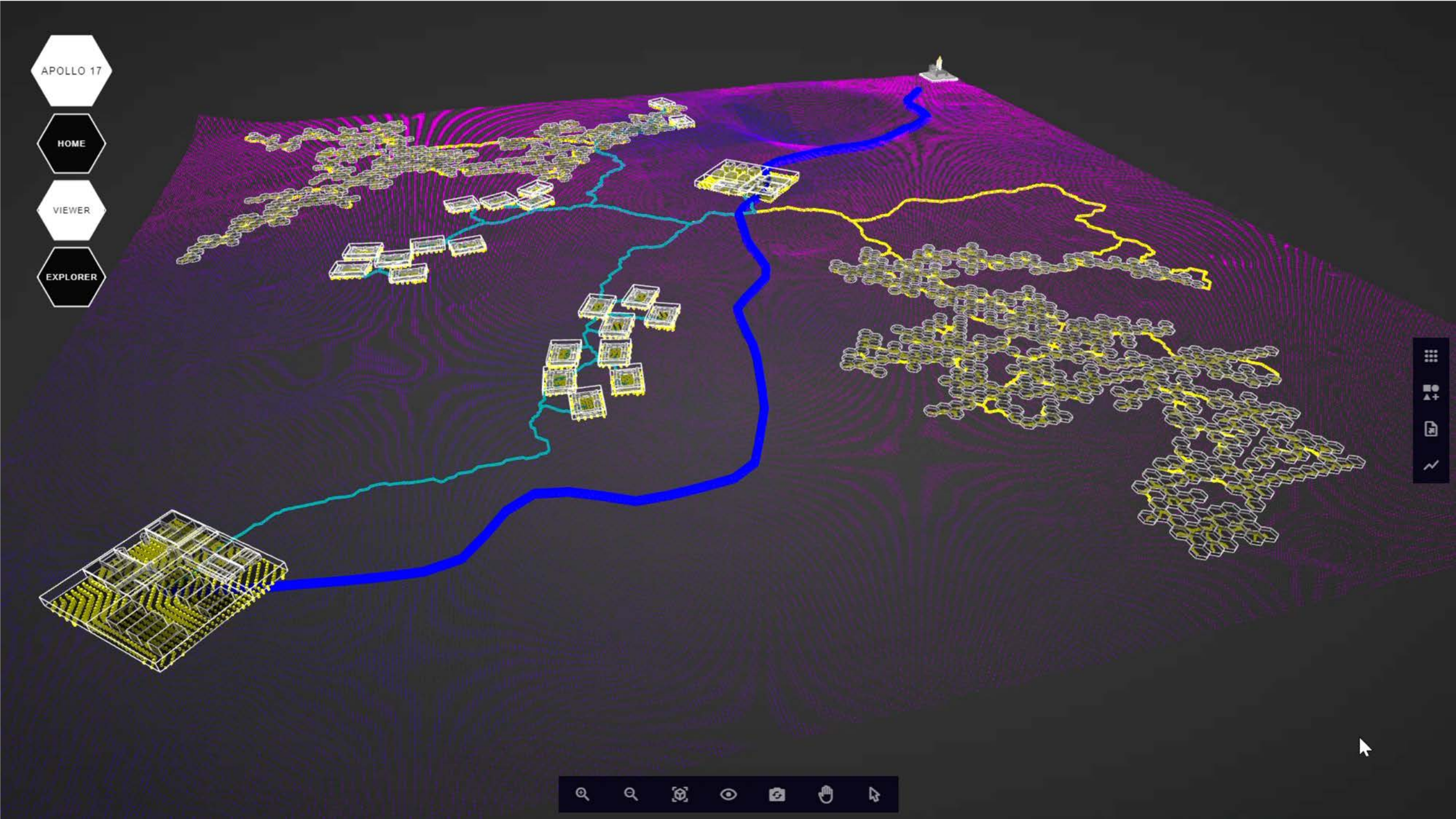
Total foundation length (work facilities)

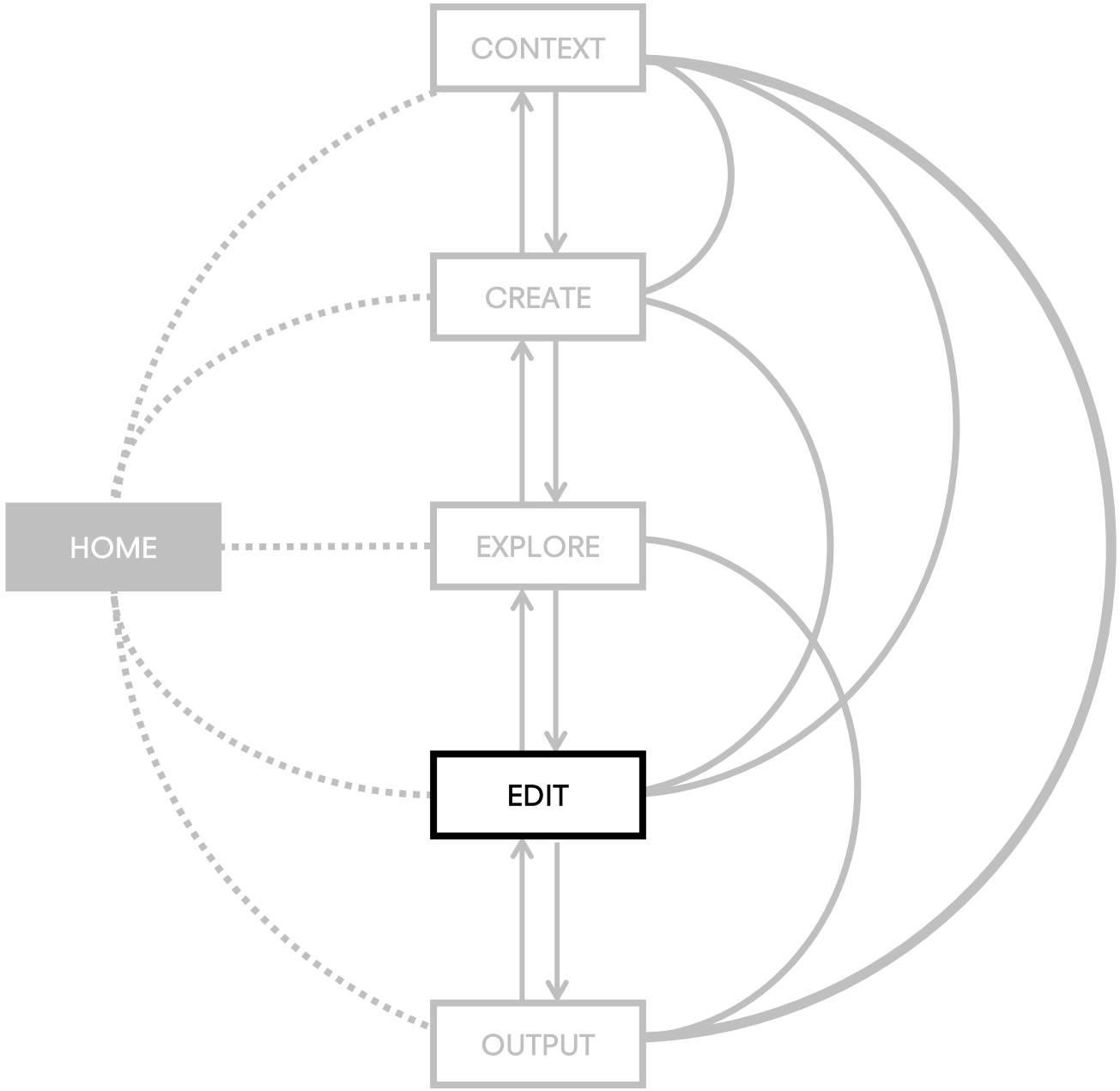
APPLY FILTERS

CLEAR FILTERS

COMPARE
61


APOLLO 17
HOME
VIEWER
EXPLORER


APOLLO 17
HOME
VIEWER
EXPLORER



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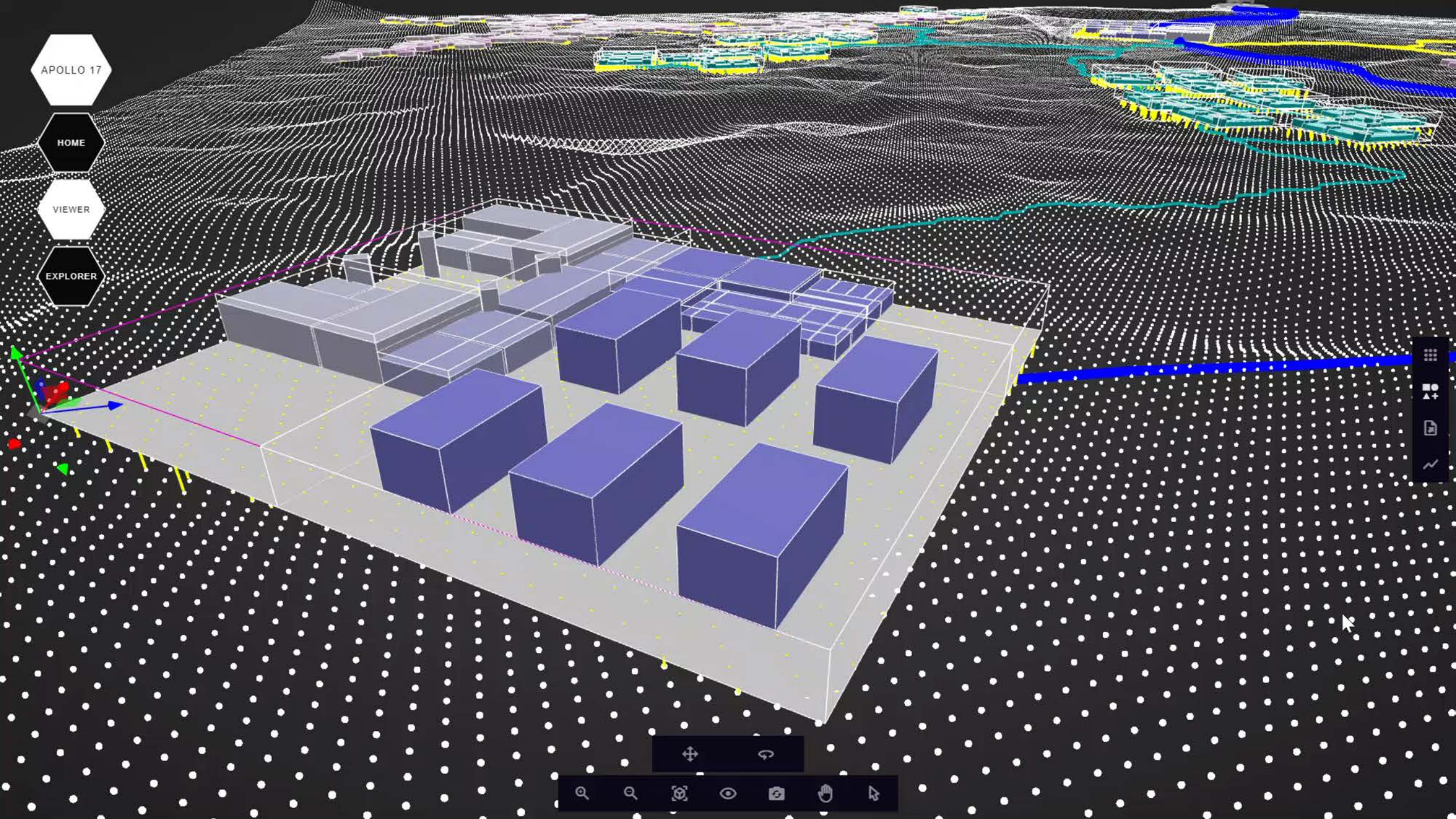
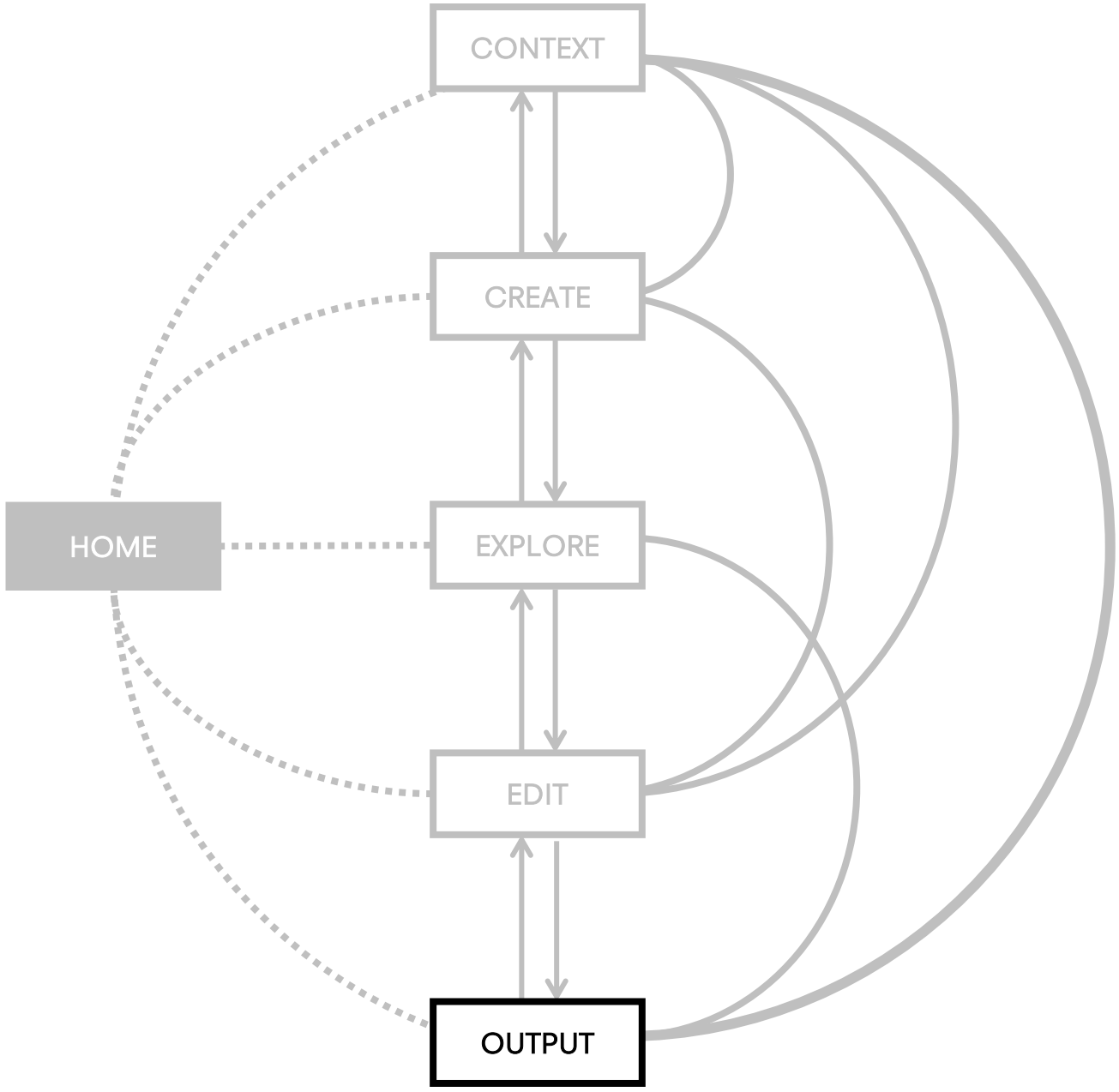

APOLLO 17
HOME
VIEWER
EXPLORER



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Moon Pixel | BIM 360 Document Management

docs.b360.autodesk.com/projects/d8919e69-33ed-4484-99bd-0f1d26cc4aa7/folders/urn:adsk.wipprod:fs.folder:co.b3FuFQIhRzi1avmtHxCtOQ/d...

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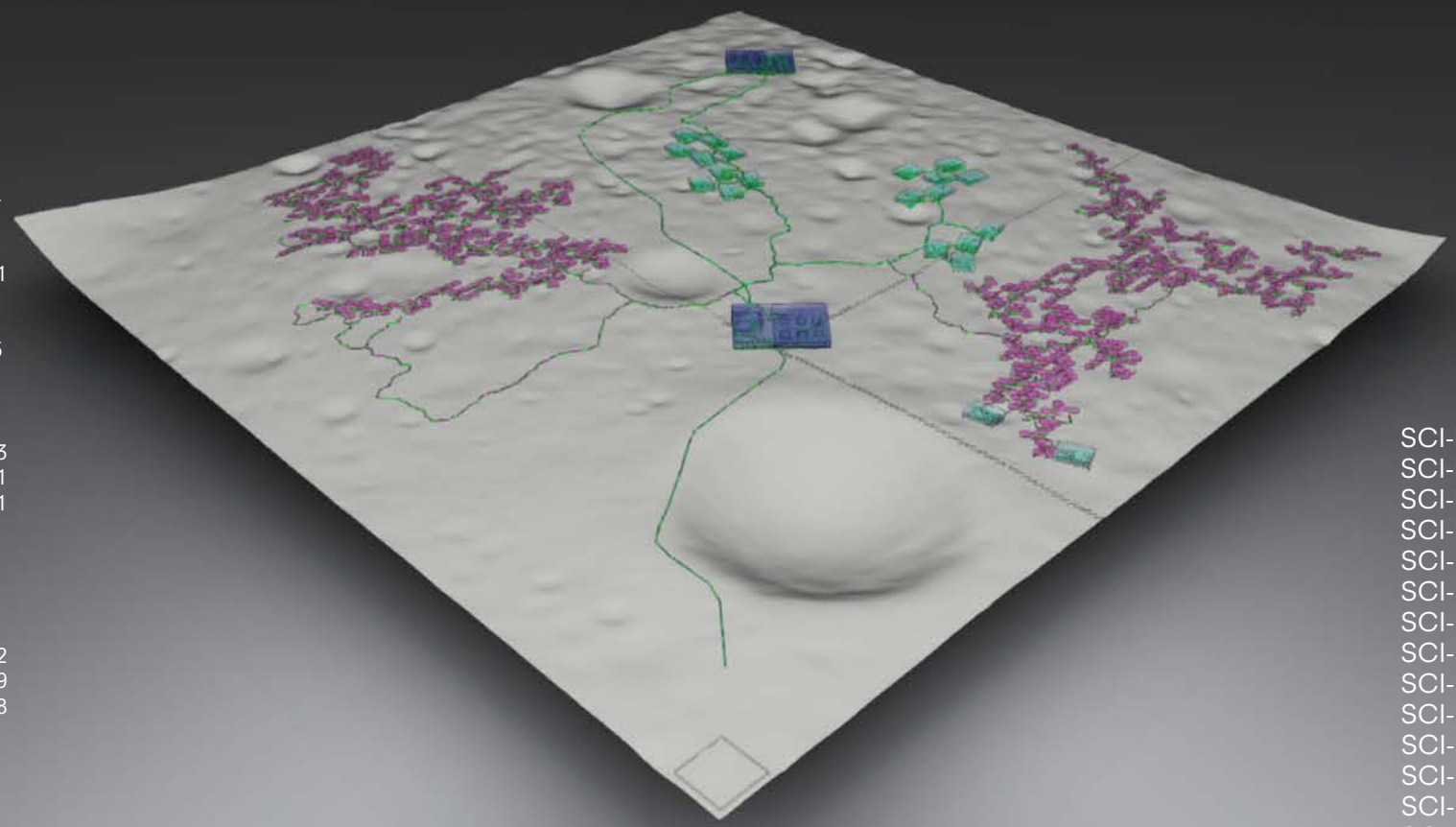
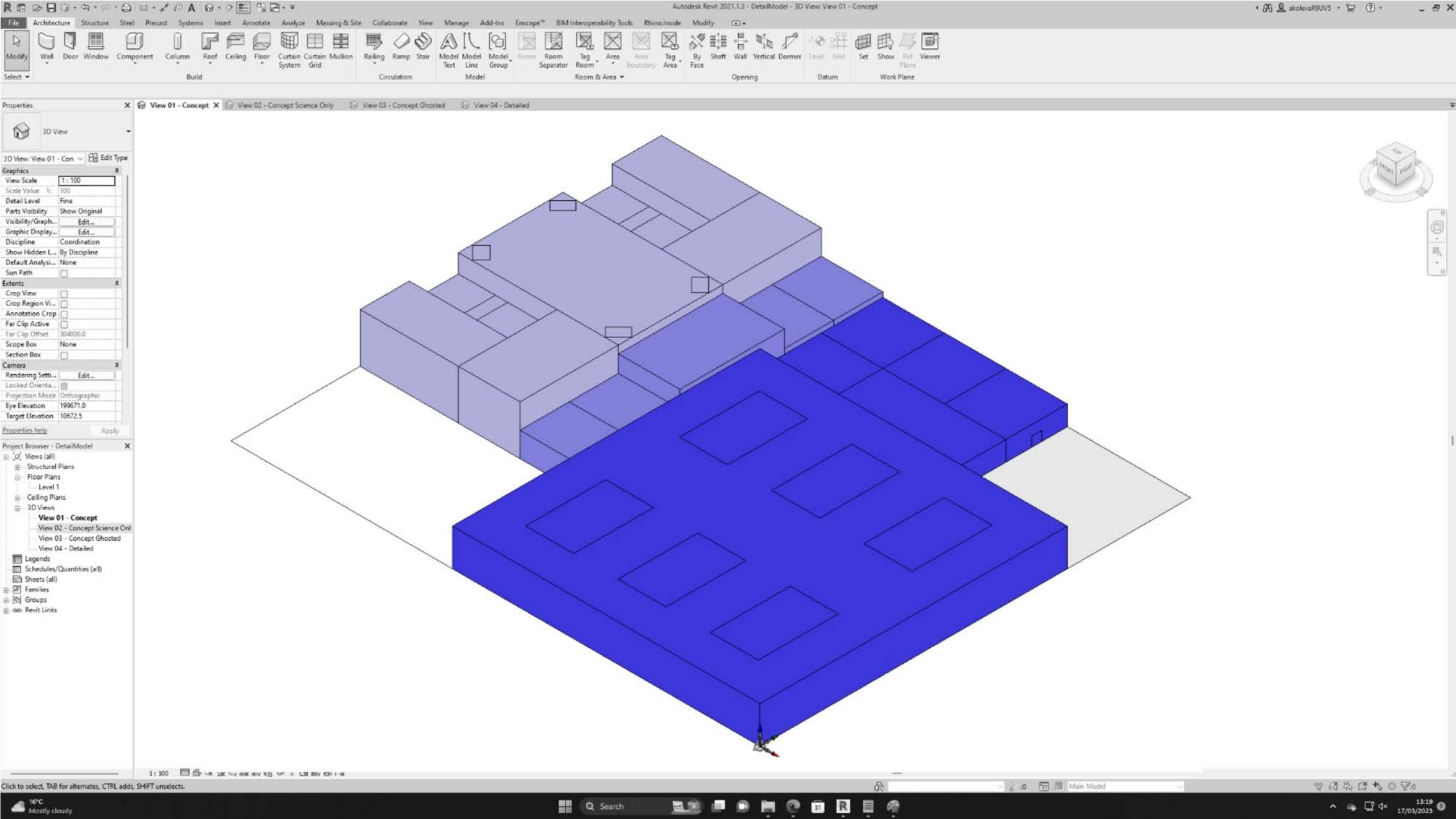


Seed - 202
Total Area - 2272474
Site Coverage - 9.09
Population - 4792
Façade area (eat facilities) - 748000.1
Foundation length (work facilities) - 11286.2
Foundation length (sleep facilities) - 5775.69
Glass probability score - 6.15E-05
Glass probability volume (facility 1) - 0
Glass probability volume (facility 2) - 16252
Glass probability volume (site)- 16252
Yield score - 0.280843
Yield volume (site) - 3610.561
Yield volume (average per module) - 3.560711
Eat - maximum cluster size - 511
Eat - minimum cluster size - 503
Eat - average cluster size - 507
Eat - total clusters - 2
Eat - total modules - 1014
Average distance - sleep to work - 1470.162
Average distance - sleep to eat - 1388.769
Average distance - sleep to sleep - 299.4378
Facilities near craters score - 5
Sleep maximum cluster size - 9
Sleep minimum cluster size - 1
Sleep average cluster size - 4
Sleep - total clusters - 5
Sleep - total units - 21
Layout score - 0

SCI-RSC-COMP-XX:	1
SCI-RSC-COMP-BAY:	2
SCI-RSC-COMP-CHL1:	2
SCI-RSC-COMP-HALL:	2
SCI-RSC-COMP-CHL2:	2
SCI-RSC-COMP-SML:	2
SCI-RSC-COMP-ELE:	2
SCI-RSC-COMP-CHEQP:	8
SCI-RSC-COMP-HALLDSK:	6
SCI-RSC-COMP-HALLSRV:	8
SCI-RSC-COMP-HALLCAB:	4
SCI-RSC-COMP-SMLEQP:	4
SCI-RSC-COMP-GEN	6
SCI-OBS-SHR-XX	6
SCI-OBS-SHR-ALMA1	6


Autodesk Revit 2021.1.3 - DetailModel - 3D View: View 01 - Concept
File
Architecture
Structure
Steel
Precast
Systems
Insert
Annotate
Analyze
Massing & Site
Collaborate
View
Manage
Add-Ins
Enscape™
BIM Interoperability Tools
Rhino.Inside
Modify
Modify
Wall
Door
Window
Component
Column
Roof
Ceiling
Floor
Curtain System
Curtain Grid
Mullion
Railing
Ramp
Stair
Model Text
Model Line
Model Group
Room
Room Separator
Tag Room
Area
Area Boundary
Tag Area
By Face
Shaft
Wall
Vertical
Dormer
Level
Grid
Set
Show
Ref Plane
Viewer
Select
Build
Circulation
Model
Room & Area
Opening
Datum
Work Plane
Properties
3D View
3D View: View 01 - Con
Edit Type
Graphics
View Scale
1 : 100
Scale Value 1:
100
Detail Level
Fine
Parts Visibility
Show Original
Visibility/Graph...
Edit...
Graphic Display...
Edit...
Discipline
Coordination
Show Hidden L...
By Discipline
Default Analysi...
None
Sun Path
Extents
Crop View
Crop Region Vi...
Annotation Crop
Far Clip Active
Far Clip Offset
304800.0
Scope Box
None
Section Box
Camera
Rendering Setti...
Edit...
Locked Orienta...
Projection Mode
Orthographic
Eye Elevation
199671.0
Target Elevation
10672.5
Properties help
Apply
Project Browser - DetailModel
Views (all)
Structural Plans
Floor Plans
Level 1
Ceiling Plans
3D Views
View 01 - Concept
View 02 - Concept Science Onl
View 03 - Concept Ghosted
View 04 - Detailed
Legends
Schedules/Quantities (all)
Sheets (all)
Families
Groups
Revit Links
View 01 - Concept
View 02 - Concept Science Only
View 03 - Concept Ghosted
View 04 - Detailed
1 : 100
Click to select, TAB for alternates, CTRL adds, SHIFT unselects.
Main Model
16°C
Mostly cloudy
Search
13:19
17/05/2023

Thank you!

Bryden Wood

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