



# GENERATIVE DESIGN

THE FUTURE OF BIM IS OPTIMIZATION

BILL ALLEN - PRESIDENT, EVOLVE LAB



“The world’s most valuable resource is no longer oil, but data”  
-The Economist

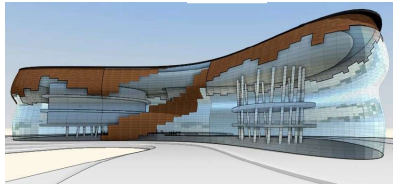
If your data is more valuable than oil how are you using it?

2002

2007

2011

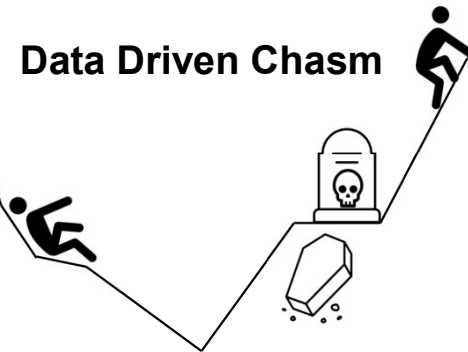
2021



**Building  
Information  
Modeling**

**Building  
Information  
Optimization**

**Data Driven Chasm**



# Passive Design

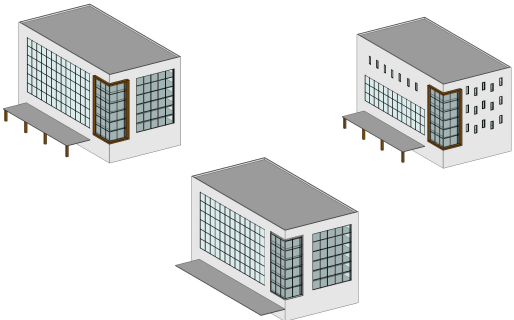
Bald Human



One Computer



Limited Options (Not Optimized)

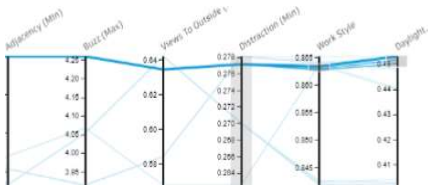


# Generative Design

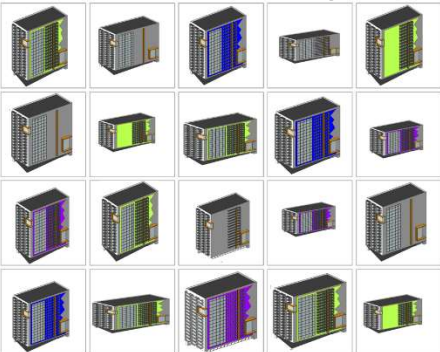
(Still) Bald Human



Logic and Parameters



Thousands of Solutions (Optimized)

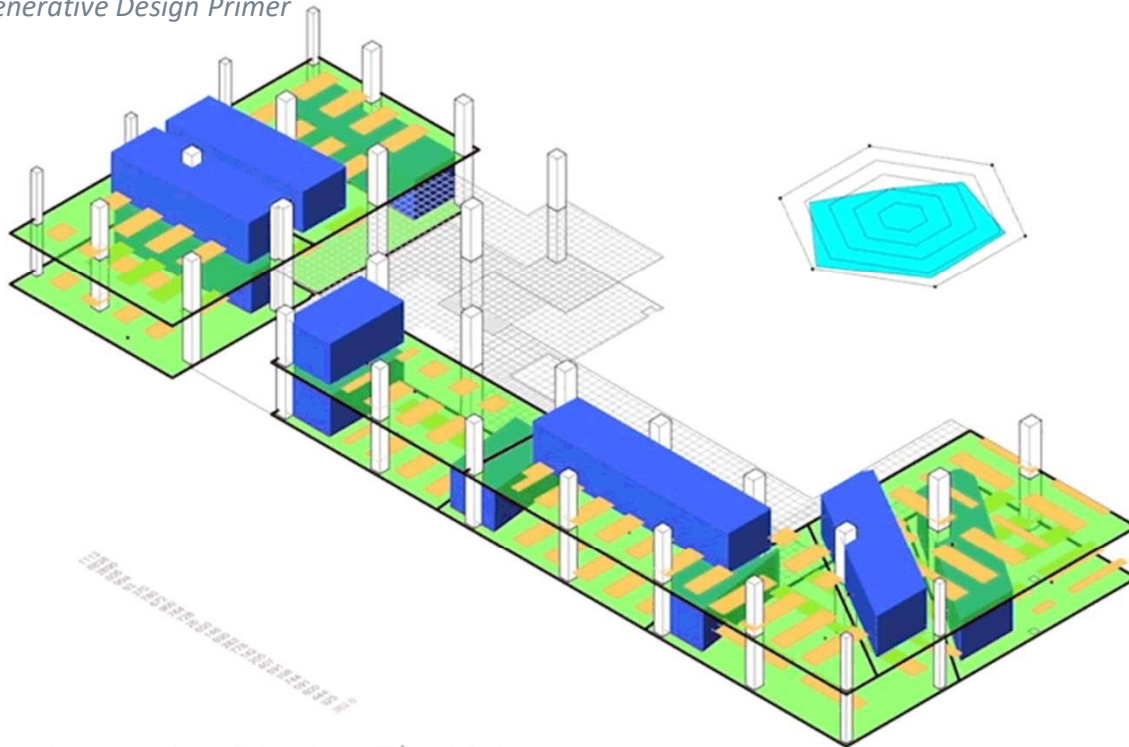




# gen·er·a·tive de·sign / noun)

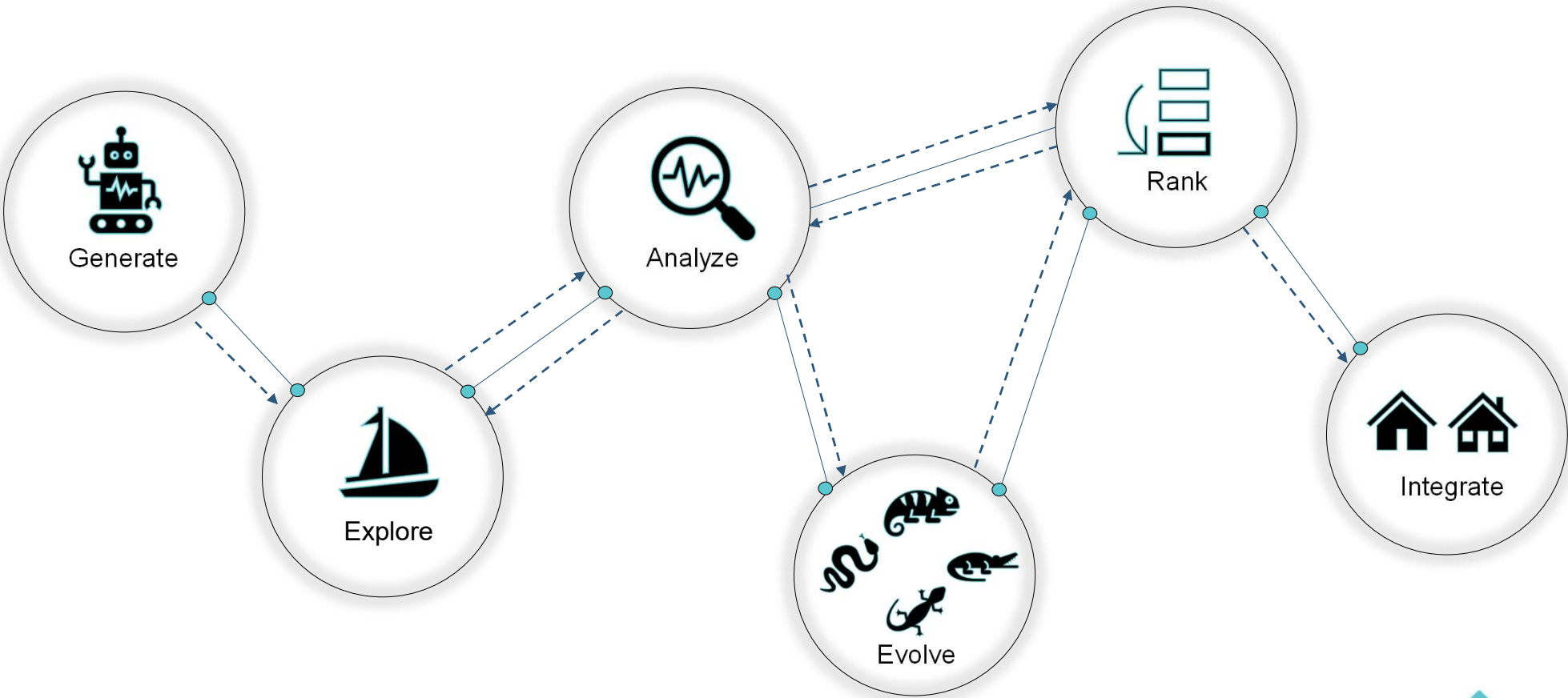
A collaborative design process between humans and computers. During this process, the designer defines the design parameters and the computer produces design studies (alternatives), evaluates them against quantifiable goals set by the designer, improves the studies by using results from previous ones and feedback from the designer, and ranks the results based on how well they achieve the designer's original goals.

*Credit Autodesk Generative Design Primer*



Mars Innovation District - The Living

# Generative Design Process



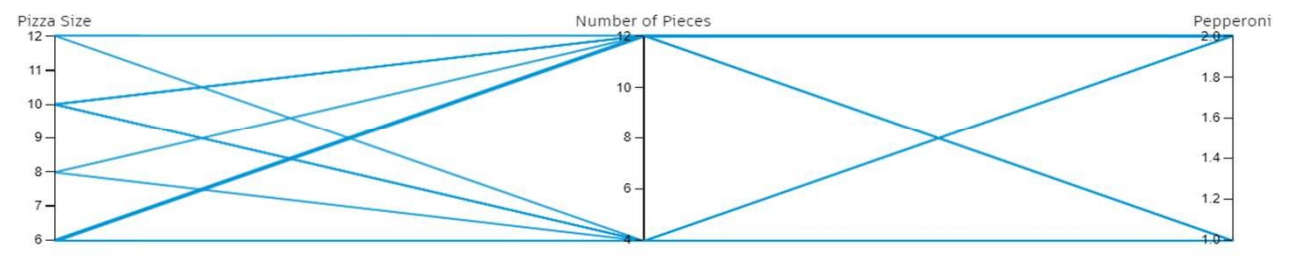
# How Do You Design a Pizza?







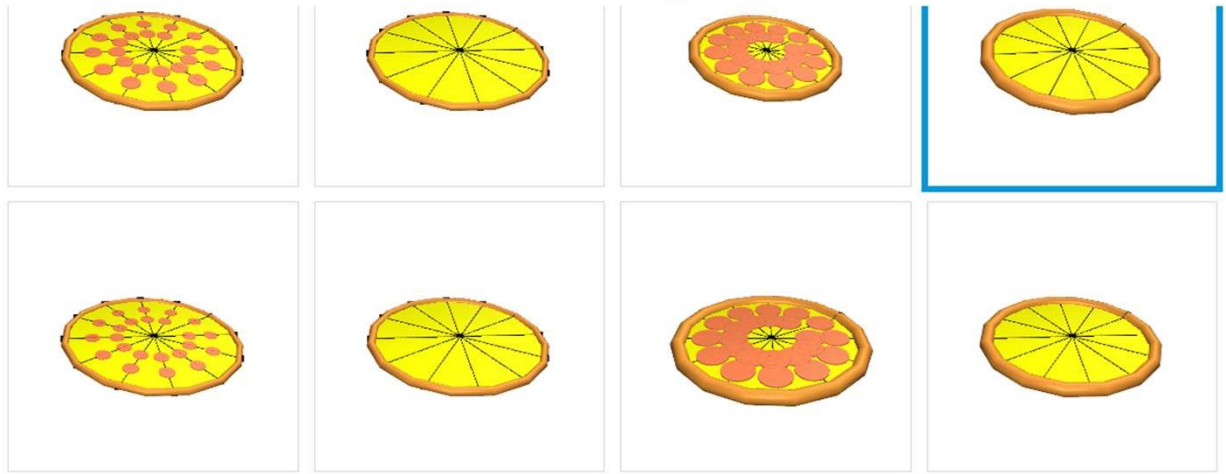
- Studies New Study
- Studies to show All
- 44450ea2-671b-4287-9eac-b87ct 28/28 ✓
  - 51c45eca-71cc-4d5f-8f04-5f2af6e 200/200 ✓
  - 019d72f9-b556-4df3-af11-673f97. 40/40 ✓
  - cba32cf3-04e3-406e-bfd0-a488c 10/10 ✓



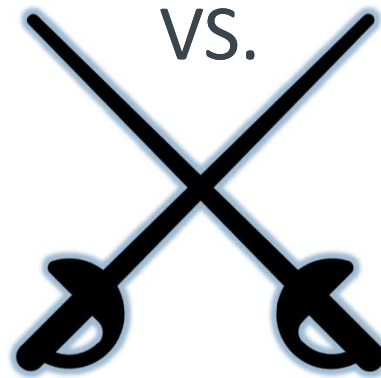
Filter  Click and drag over axes to add filters

Sort by Pizza Size ↑

1 | 2 | 3 | 4



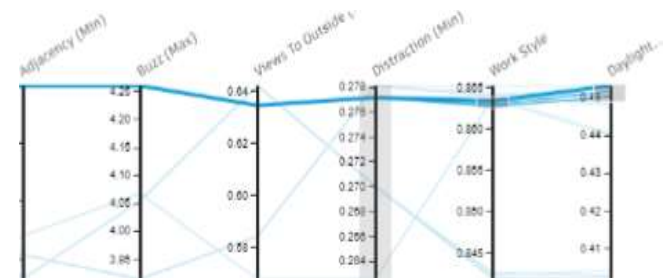
Open in Dynamo



## Single Objective Optimization



## Multi-Objective Optimization



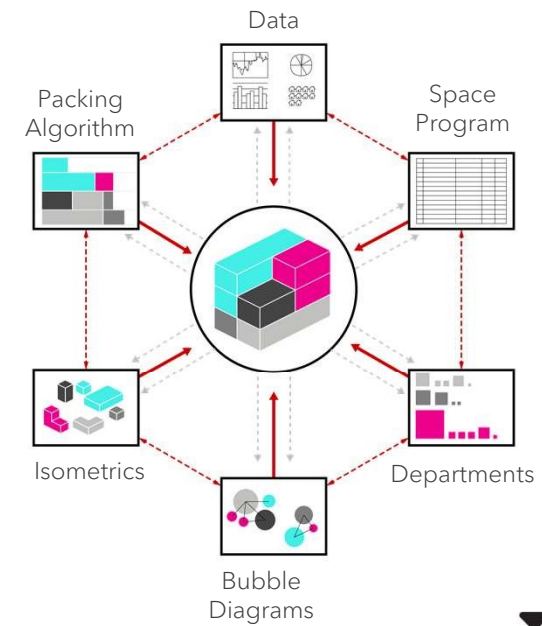
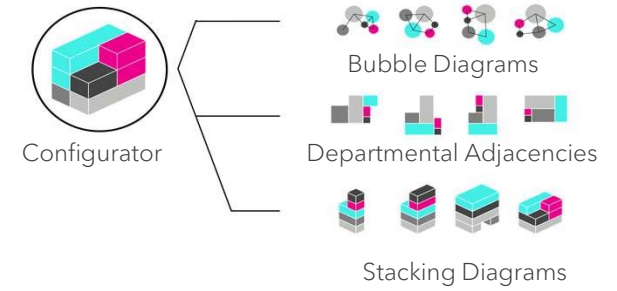
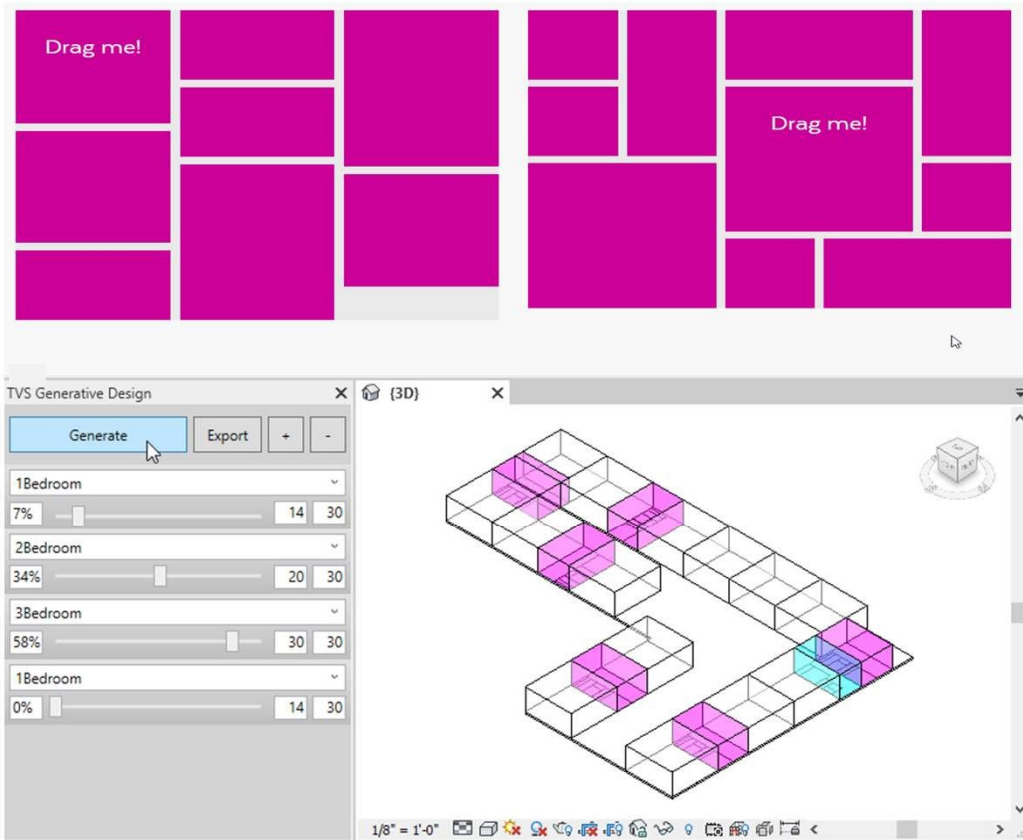
# Case Studies





# Optimization for Testfitting

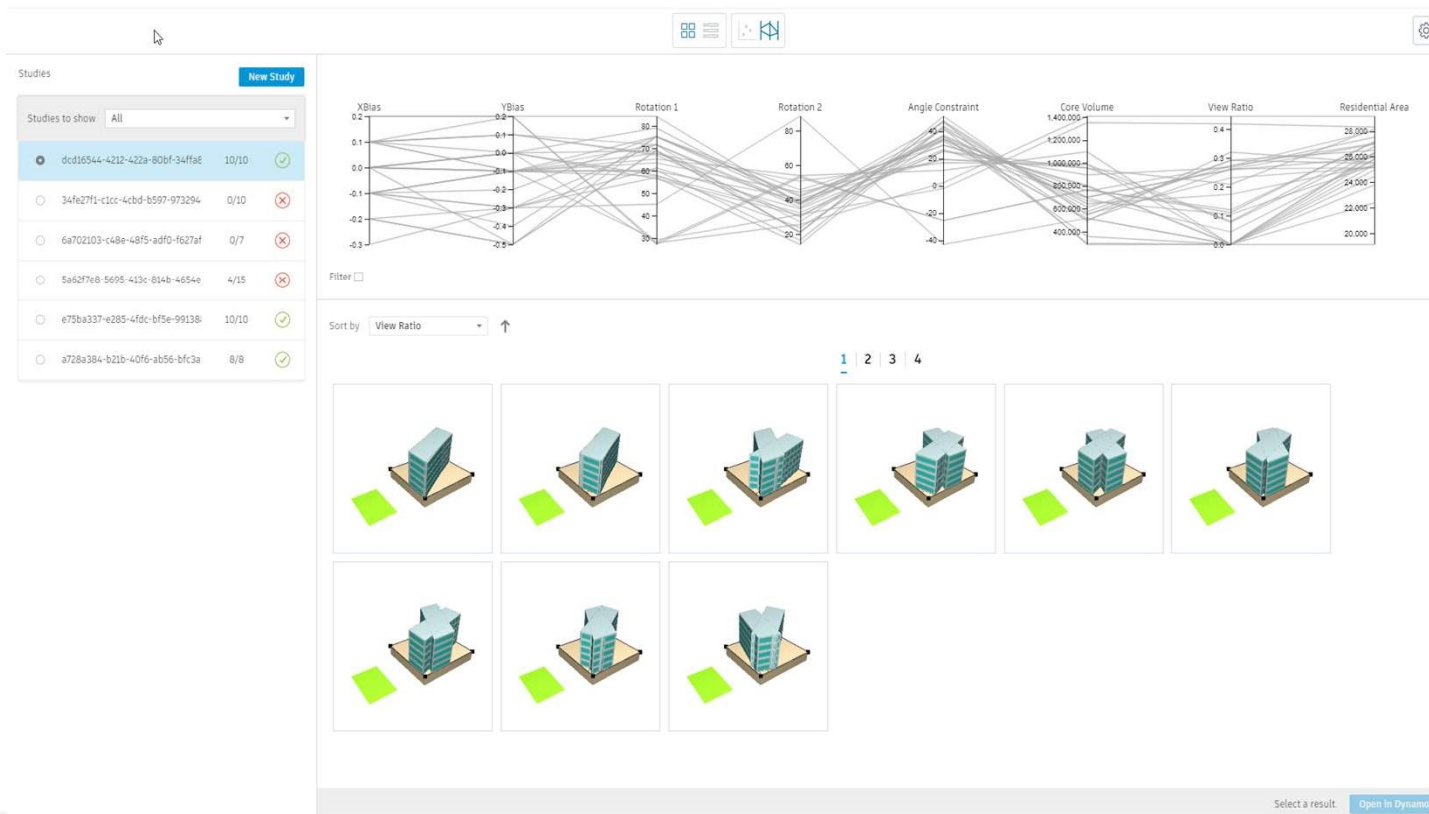
The process test fitting directly within Revit using a packing algorithm, and a co-design process paired with generative design. Utilizing packing algorithms, and programmatic design we can create multiple options of 1 bedroom, 2 bedroom, and 3 bedroom apartments.





# Optimization For View Orientation

We recently started the early stage development of an algorithm that takes a given lot and given target and optimizes building orientation on that lot for available views to the target. Working at this stage in the development, the simplified logic is giving us a good sense of what constraints and optimization goals are useful for creating real building shapes. Once this is understood, layers of complexity will be added to create a more robust algorithm.



## Fixed Constraints:

- Lot Size
- Lot Location
- View Target Size
- View Target Location

## Variables

- Floor Plate Location
- Floor Plate Rotation

## Optimized

- View Ratio

# Autodesk Mars Office

Utilizing the dynamo script that was used for the Autodesk Mars office, we brought this design into the Revit 2021 Generative Design program to look at daylighting, views to the outside, workstyle etc.

**Studies**

Filter list by study type: All

- TVS\_MaRS Modification Script\_v2\_...  
TVS\_MaRS Modification Script\_v2\_h...  
Jul 21, 2020, 9:50 AM 20/40
- TVS\_MaRS Modification Script\_v2\_...  
TVS\_MaRS Modification Script\_v2\_h...  
Jul 21, 2020, 9:42 AM 0/40
- TVS\_MaRS Modification Script\_v2\_...  
TVS\_MaRS Modification Script\_v2\_h...  
Jul 21, 2020, 9:37 AM 6/6
- TVS\_MaRS Modification Script\_v2\_...  
TVS\_MaRS Modification Script\_v2\_h...  
Jul 20, 2020, 9:00 AM 12/12
- TVS\_MaRS Modification Script\_v2\_...  
TVS\_MaRS Modification Script\_v2\_h...  
Jul 20, 2020, 8:43 AM 8/40
- TVS\_MaRS Modification Script\_v0 ...  
TVS\_MaRS Modification Script\_v0  
Jul 17, 2020, 12:59 PM 5/5
- Plan Generator v0.18 - Daniel\_extr...  
Plan Generator v0.18 - Daniel\_extru...

**TVS\_MaRS Modification Script\_v2\_hidden outputs 005**

Sort by: Adjacency (Min)

**Details**

Outputs

Adjacency (Min)	99.699
Buzz (Max)	4.066
Views To Outside (Max)	0.567
Distraction (Min)	0.263
Work Style	0.864
Daylight (Max)	0.440

Inputs

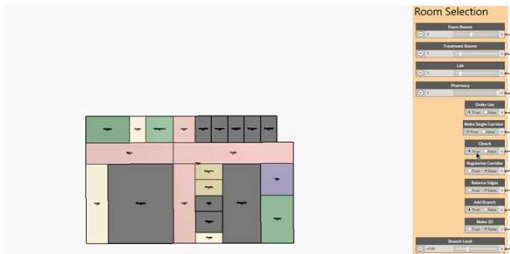
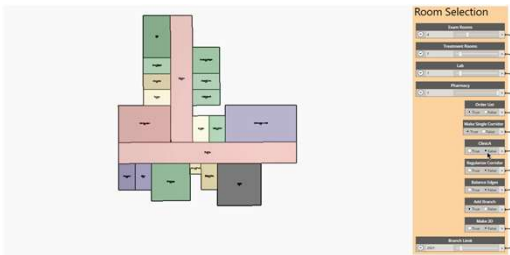
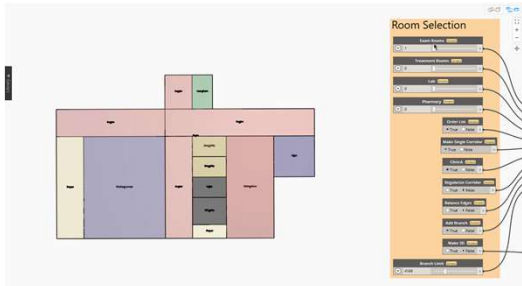
nbr1 - am side	0.100
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**Line Graph Data**

Iteration	Adjacency (Min)	Buzz (Max)	Views To Outside (Max)	Distraction (Min)	Work Style	Daylight (Max)
1	100.5	4.25	0.64	0.278	0.885	0.45
2	100.0	4.20	0.62	0.274	0.860	0.44
3	99.5	4.15	0.60	0.272	0.855	0.43
4	99.0	4.10	0.58	0.270	0.850	0.42
5	98.5	4.05	0.56	0.268	0.845	0.41
6	98.0	4.00	0.55	0.266	0.840	0.40
7	97.5	3.95	0.54	0.264	0.835	0.39

# Optimization For Healthcare

Created Generative floor plans for hospital programmatic requirements. Executed a one-to-one relationship for procurement from Revit with Oracle Unifier. Created a Forge BIM viewer

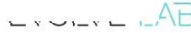
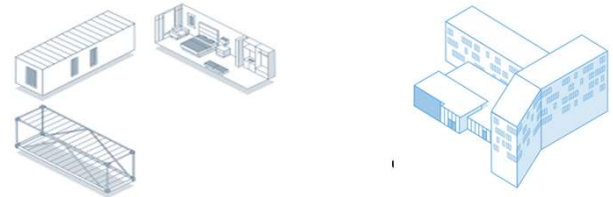
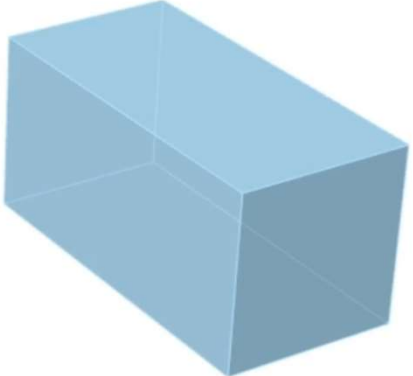


ORACLE  
for Startups



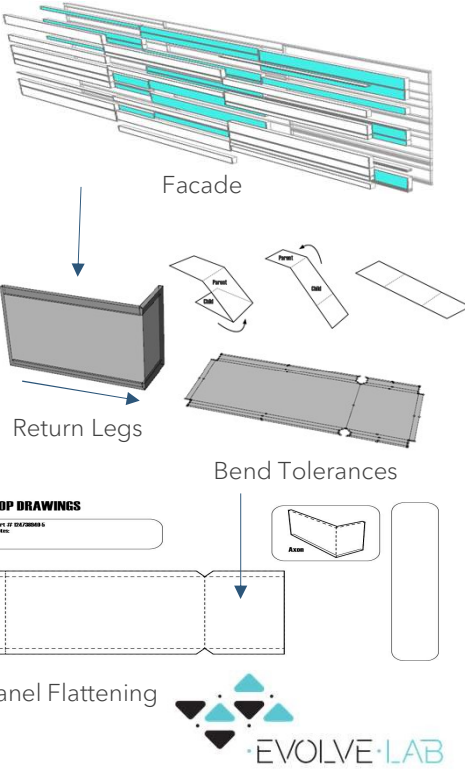
# Generative Design For Modular Construction

Assigns modular components including bracing, angles, HSS tubes, brackets, etc. for rapid building prototyping. Takes into client's unique systems, structures, and details.



# Optimization for Manufacturers

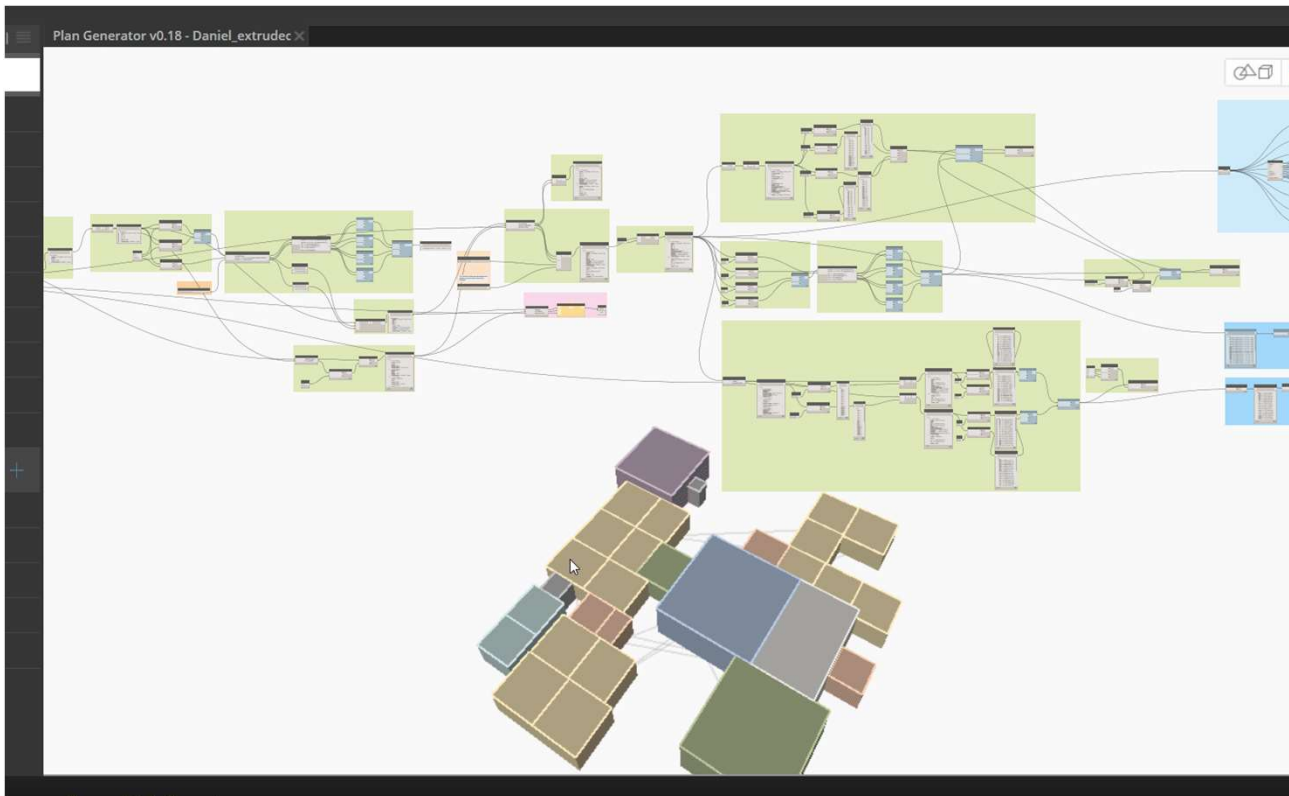
Co-Design process of assigning ACM metal panel, joints, return legs, material, colors, and grain direction. Flattens ACM panel considering bend tolerances and system materials. Upon finishing, creates a bill of materials for the designer.





# Optimal Departmental Adjacencies

We developed this Dynamo & Project Refinery example to showcase the power of Generative Design in order to quickly produce multiple design options. The dynamo script chooses a color for each tile for the wall based on the distance between the tile and a tractor point, the percentage of tiles for each color, and how much randomization is inputted. There is no optimal solution, instead the Generative Process outputs a range of options to be then evaluated by the Designers and chosen based on the desired aesthetics.



## Fixed Inputs

- Wall Face
- Face Tile Subdivision

## Variable Inputs

- Attractor point location (U & V placement at face, 0 to 1)
- Percentage of tiles to be color (20% to 80%)
- Randomness modifier (0 to 1)



# Tile Optioneering

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# Optimization For Millennium Airport

In this confidential airport project, we were hired to assist with the designing of the exterior façade based on the specified optimization criteria. The application allows flexing of curtain grid spacing, average panel height controls, and most importantly, optimizing the number of custom panels.

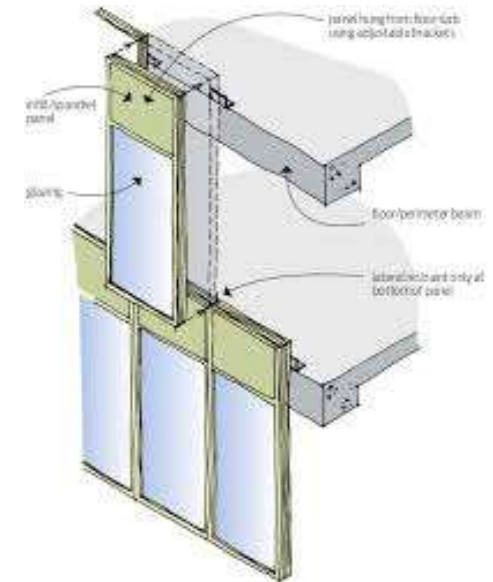
The screenshot displays the Project Fractal software interface. At the top, the browser address bar shows the URL: <https://www.fractalive/share/5993294e74a3cd26263dfb74>. The main title is "Millennium Airport - Panelize Surface (FormIT+Fractal)" by john.pierson@evolve-lab-inc.com.

The interface features several optimization parameters and controls:

- Number of Vertical Gridlines:** A slider set to 55.
- Number of Horizontal Gridlines:** A slider set to 14.
- Fast Display?** A radio button set to "True".
- Choose Facade:** A slider set to 0.
- Number of Custom Panels:** A slider set to 50.
- Average Panel Height:** A slider set to 2.5.
- Average Panel Width:** A slider set to 1.5.

Below these parameters is a "Design Options" section with a grid of 15 thumbnail images showing different panelization results, sorted by "creation time".

The main view shows a 3D model of a curved curtain wall with a green grid overlay. The interface includes a "Save" button, a "cross product" dropdown menu, and a "Stop" button. A status bar at the bottom right indicates "Powered by Autodesk Dynamo Studio".

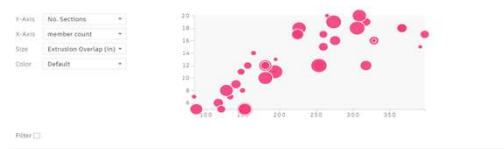
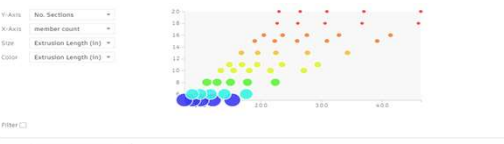


Unitized Curtainwall

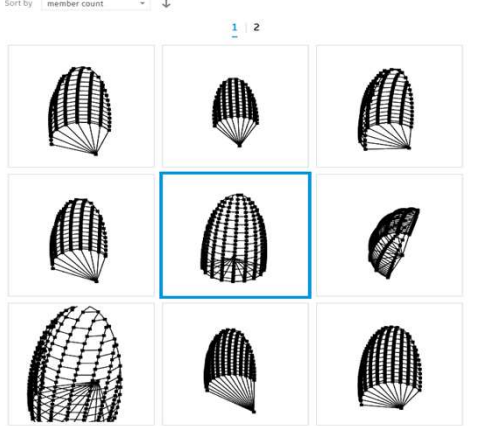
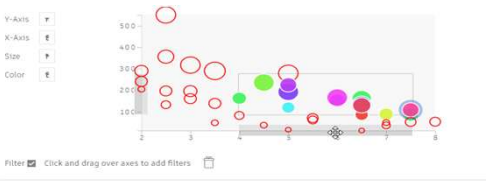


# Optimization For Structural Design

Another EvolveLAB also recently completed the Hobbs trail project for Hufft Design in Kansas City. We went through and set up the scrips to optimize standard tube lengths, bracket connections, and intersecting terminations. The whole process was executed and optimized using Refinery.

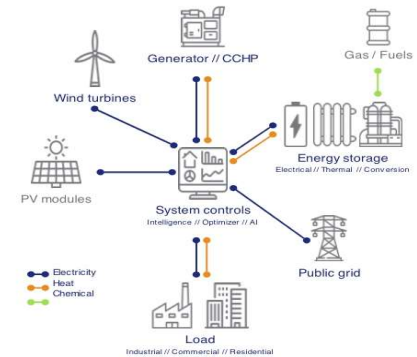
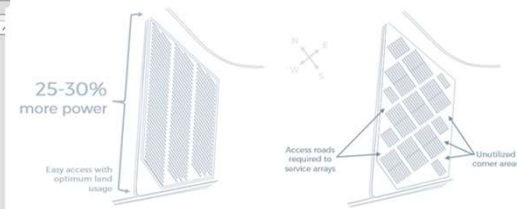
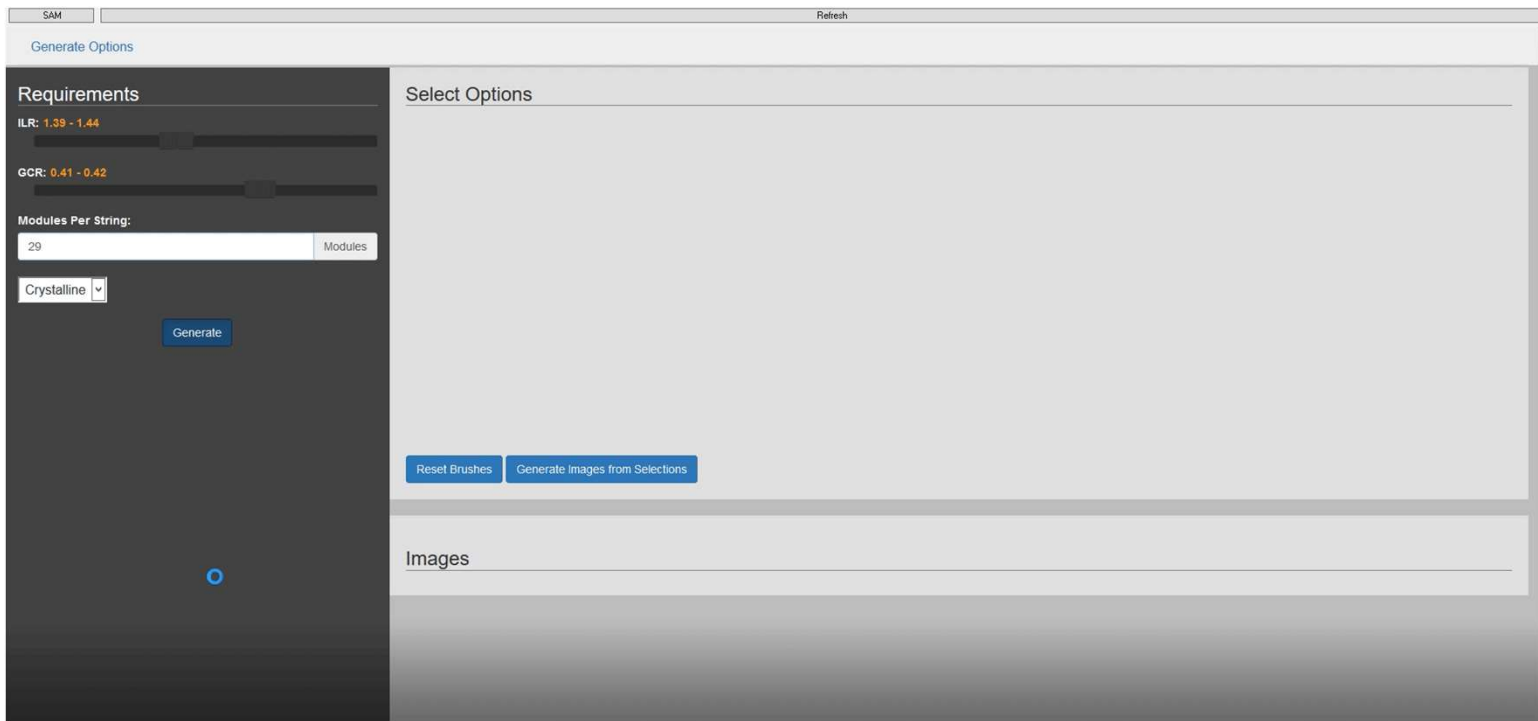


A collection of architectural drawings for the Hobbs trail project. The drawings include: 1. TRAILHEAD GRADING SECTION, 2. TRAILHEAD PLAN, 3. CAMPSITE SECTION, 4. CAMPSITE PLAN, 5. CAMPSITE FOUNDATION PLAN, 6. ENLARGED CAMPSITE PLAN @ SHELL, 7. WALL SECTION @ SHELL, 8. WALL SECTION @ PLATFORM, and 9. CAMPSITE LOCATION PLAN. The drawings are detailed and include various annotations and dimensions. A 'Hufft' logo and project information are visible on the right side of the drawings.



# Optimization For Solar Design

Another example of optioneering was a project for Mortenson Construction and their solar design group. We built a custom parallel coordination graph that displays data specific to solar design. This gave their engineers the ability to optimize their site based on the power requirements and density of solar panels.



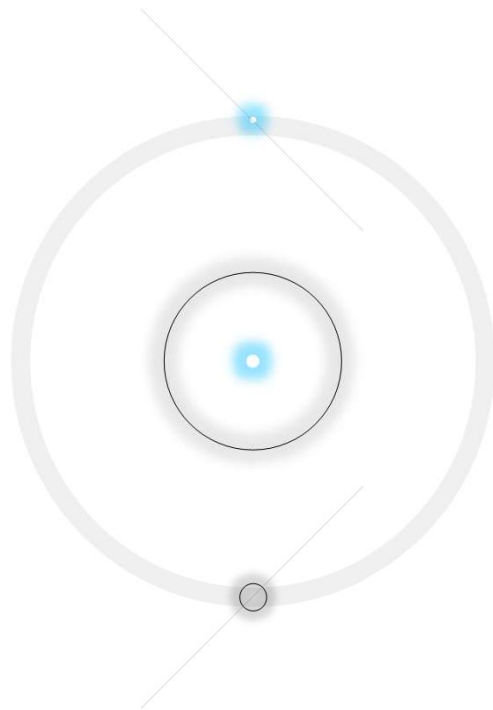
# Take-Away

## **If you are an employer**

- Invest in people. Find the best talent in the industry, and hire them. Hire people smarter than you.
- Invest in Research and Development.


## **If you are an employee**

- Invest in yourself. There are plenty of resources on website blogs, LinkedIn Learning, Lynda.com, etc.
- Learn to Code, even if it's only visual programming.
  - Digital Fabrication and Robotics
  - Data Driven Design
- Become the expert, and bring the information back to your firm
- Don't wait for someone to ask you



# Thank You

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