GENERATIVE DESIGN & OPTIONEERING
Understanding the use of Project Refinery + Dynamo Sandbox

Kashif Dafedar    Himani Shah
Digital Technology Specialist    BIM Specialist/Coordinator/Designer
Himani Shah
BIM Coordinator / Designer
CallisonRTKL (Arcadis N.V.), U.A.E.

- Architect
- Autodesk Certified Professional
- LEED Green Associate
- M.Sc. in BIM & Management at Oxford Brookes University.
Kashif Dafedar
Design Technology Manager
CallisonRTKL (Arcadis N.V.), U.A.E.

- Architect
- LEED AP
Learning Objectives

1. What is Generative Design & Design Optimization


3. Use of Refinery for Design Exploration
What is Generative Design & Design Optimization
Typical Expectations for Any Project

- **Productivity**: Increase
- **Time**: Decrease
- **Cost**: Decrease
Need for Automation
Design, A Challenge For Automation
Generative Design is an Automation Tool for Designers
How Does Generative Design Work?

Parametric Design  Optimization Algorithm  Option Evaluation

Save Option, Repeat Until Perfect

30/30 Score

Balance GFA?
Views From Unit?
Adequate Parking?
Autodesk + Van Wijnen Project

design ID: 27-10

Views: 0.3
Variety: 12
Solar Gain: 0.4
Yard Size: 0.9
Program: 1.4
Total Cost: $7,175,273.40
VW Revenue: $775,426.60
input1: 0.919509248
input2: 0.284410564
input3: 0.298260484
input4: 1
input5: 0.22177916
Visual Scripting for Generative Design using Dynamo
1. **Node Based, Intuitive, Visual Programming Tool**
2. **Create Parametric Dependencies** Between Multiple Elements
3. **Automate and Expedite** repetitive processes
4. **Exchange Information** with other Design Tools
Part 1 - 3 Step Approach to Scripting

1- Parameters

Factors That Influence Design
- Plot Area
- Number of Floors
- Road Width
- Structural Loading
- Occupants

2 - Dependencies

Conditional Associations Between Elements
- Parameters with Parameters
- Parameters with Geometry
- Geometry with Parameters

3 – Output Value

Final Output of the Script
- Geometric Output
- Numerical Output
- Other Data

Refinery
Step 1 – Setup Parameters
Step 2 – Create Dependencies

**Height is Half of Perimeter**

\[ Z = \frac{[2 \times (X+Y)]}{2} \]
Step 3 – Identify Outputs
3 Step Breakdown

1- Parameters

2 - Dependencies

3 – Output Value
L-Shaped Building Script

1- Parameters

- Bay Counts
- Individual Bay Depth
- Floor Height
- Number of Floors
- Corridor Width

3 – Output Value

- Gross Floor Area
- Building Footprint
- Building Height

04_Building_Massing.dyn
L-Shaped Building Script

04_Building_Massing.dyn
Dynamo - 04A_Building_Massing.dyn
Video - 04A_Building_Massing_Base.mp4
X2 & Y2 = (Bay Size x Bay Count)

Dynamo - 04A_Building_Massing.dyn
Video - 04A_Building_Massing_Base.mp4
Input Set 1

Point A

Point ByCoordinates

Formula-S1

Formula-S2

X1, Y1

AX & AY

Geometry.Translate

game

direction

distance

AX

AY

BX & BY

Geometry.Translate

game

direction

distance

BX

BY

Point B

Point ByCoordinates

Formula

Bay

Cor

X1 + X2

Y1 + Y2

Vx

Vy

Dynamo - 04A_Building_Massing.dyn

Video - 04A_Building_Massing_Base.mp4
Input Set 1
- No Bays - Side X
- No Bays - Side Y
- Bay Size
- Corridor

AX & AY
- Geometry.Translate
  - direction
  - distance
  - AY 5

BX & BY
- Geometry.Translate
  - direction
  - distance
  - BX 2

Point A
- Point.ByCoordinates
  - x
  - y
  - z
  - A 0

Point B
- Point.ByCoordinates
  - x
  - y
  - z
  - B 3

Vector.XAxis
- Vector

Vector.YAxis
- Vector

Dynamo - 04A_Building_Massing.dyn
Video - 04A_Building_Massing_Base.mp4
L-Shaped Building Base

Vector X

Vector Y

AY 5

BY 4

BX 2

AX 1

Y2

Y1

2 no of BAYS

2 x BAY + CORRIDOR

BAY 1

BAY 2

6 no of BAYS

X1 - CORRIDOR

X2

0
L-Shaped Building

Input Set 1
- No Bays - Side X
- No Bays - Side Y
- Bay Size
- Corridor

Point A
- Point By Coordinates
  - x
  - y
  - z
- Formula-S1
  - no
  - no bay
- Bay Size
- Corridor

Point B
- Point By Coordinates
  - x
  - y
  - z
- Formula
  - bay
  - cor

AX & AY
- Geometry Translate
  - geometry
  - direction
  - distance
- AX
- AY

BX & BY
- Geometry Translate
  - geometry
  - direction
  - distance
- BX
- BY

Dynamo - 04A_Building_Massing.dyn
Video - 04A_Building_Massing_Base.mp4
Height Parameters & GFA Calculations

Input Set 2

FFL - Floor Height

No Floors

Output 01

Balance GFA

GFA

Floor Area

Surface.Area

Surface.ByPatch

closedCurve

Surface

double

04B_Building_Massing.dyn
Height, Floors & 3D Massing

Step 1 - Base Curve

Step 2 - GFA Calculations

Input Set 1

Input Set 2

04C_Building_Massing.dyn
Height Limit & Conditional Coloring

**IF** (Maximum Height) is GREATER THAN (Building Height), **Correct**, Color Yellow or **Incorrect**, Color Red.
Data Types

**TEXT**
- STRING
  - NAMES
  - DESCRIPTION
  - CATEGORIES
  - MARK
  - TYPE MARK

**NUMBERS**
- DOUBLE
- INTEGER
  - LENGTH
  - HEIGHT
  - AREAS
  - COUNT

**BOOLEAN**
- TRUE/FALSE
  - ON / OFF
  - YES / NO
  - CONDITIONAL CALCULATIONS
  - LOGIC OPERATIONS

**REFINERY ONLY UNDERSTANDS NUMBERS**

All Input / Output Nodes from the Script are Numbers
3 Step Breakdown

1- Parameters

- No Bays - Side X
  - 0
- No Bays - Side Y
  - 0
- Bay Size
  - 8.75
- Corridor
  - 1.5
- FFL - Floor Height
  - 3.5
- No Floors

2- Dependencies

Step 1 - Basic Cuts

Step 2 - Plan Cuts

Step 3 - 3D Calculations

3 - Output Value

- Balance GFA
  - 1247.5
- Building Height
  - 35
- GFA
  - 15427.5
- Height Diff
  - 0
Use of Refinery for Design Exploration
Connect Input & Output Values to Refinery

Right Click respective nodes and make them 'Is Input' or 'Is Output' Respectively, Do this for ALL applicable Nodes
Filtering Options in Refinery

### Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>New Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>GFA</td>
<td></td>
</tr>
</tbody>
</table>

#### X-Axis

- Building Height

#### Size

- Balance GFA

#### Color

- Default

#### Filter

- Filter [ ]

#### Sort by

- GFA
Optimize Design

Launch ‘Refinery’, Click – ‘New Study’

- **OPTIMIZE** – Finds best options based on multiple objectives
- **CROSS PRODUCT** – Using all minimum & maximum values for input parameters, creates variable design options
- **RANDOMIZE** – Creates desired number of random options
- **LIKE THIS** – Uses the current graph settings to spawn options around the same parameter values.
Questions

- Get in touch with us