Custom Computational Workflows for BIM Design Implementation

Eckart Schwerdtfeger

BIM Associate | Zaha Hadid Architects

AUTODESK UNIVERSITY

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Introduction

Introduction . Speaker

Eckart Schwerdtfeger is an architect with 12 years of experience in all project phases and in implementing large-scale, high-profile international projects in Europe, Russia, the Middle East and China.

During his time at Behnisch Architects, Coop Himmelb(l)au and LAVA he parametrically designed, optimised and implemented several remarkable **facades**. His main fields of work were **computational design**, **BIM management** and **programming**.

Currently, Eckart is BIM Associate at **Zaha Hadid Architects** and responsible for managing the office's BIM team. Besides leading and implementing several large-scale **BIM projects**, he focuses on developing the ZHA global **BIM workflows**.

He develops and writes proprietary software, plugins and scripts to effectively facilitate, optimise and automate BIM and cross-application tasks and to enable the design team to contribute to the BIM models more directly and fluently.

ETFE membrane facade
Unilever Germany HQ
Behnisch Architects

Introduction . Aims

Effective cross-application workflows from design to BIM

- Be able to use content created in 3rd party software
- Prevent duplicated work

Parametrise and automate as much as possible

- Enable + accelerate creation of design iterations and implementation of changes
- Save time spent on repetitive tasks

Custom...

- BIM Elements
- Visual Scripts / Scripts / Macros
- Software / Plugins

Introduction . Customisation Options

Revit

	Modelling	
Family	Parametric geometry + conditions + formulas	Revit family editor
	Scripting [e.g. C#, VB.Net, Python, Ruby]	
Macro	Access to Revit programming interface	Integrated editor, SharpDevelop
	Programming [e.g. C#, VB.Net]	
Plugin	Standalone library with advanced capabilities	External editor, e.g. Visual Studio

Dynamo

	Visual Scripting	
Visual Script	Graphical access to the programming interface	Dynamo
	Scripting [e.g. DesignScript, Python]	
Script	Access to Dynamo + Revit programming interface	Integrated script nodes
	Programming [e.g. C#, VB.Net]	
	Standalone library with advanced capabilities	
Zero Touch Node	Simple user-defined functions	
Custom Node	Custom user interface possible	
Extension	Global access and extension of Dynamo possible	External editor, e.g. Visual Studio

Project 1

Project BIM Team
Eckart Schwerdtfeger

Project 1

- Master plan with extent of about 800 x 300 m
- Around 40 buildings with varying size and typology

Project 1

Aims

- Parameterisation and automation of the design process
- Effective use of freeform geometry in BIM

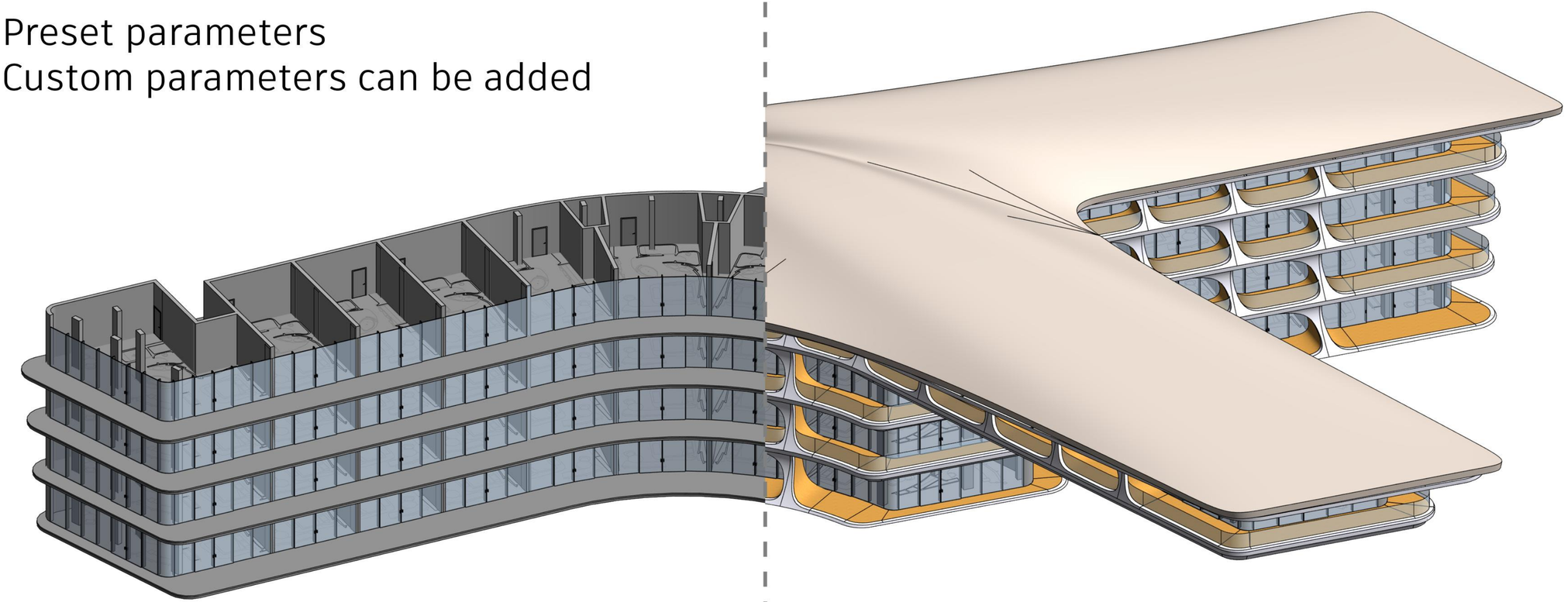
Native Elements

Native Elements

- E.g. floors, walls, columns, beams, curtain walls, doors, furniture, etc.
- Preset constraints and restrictions for every category
- Preset parameters
- Custom parameters can be added

Creation

- Manual drawing
- Manual conversion of pre-existing CAD lines
- Automated custom workflow

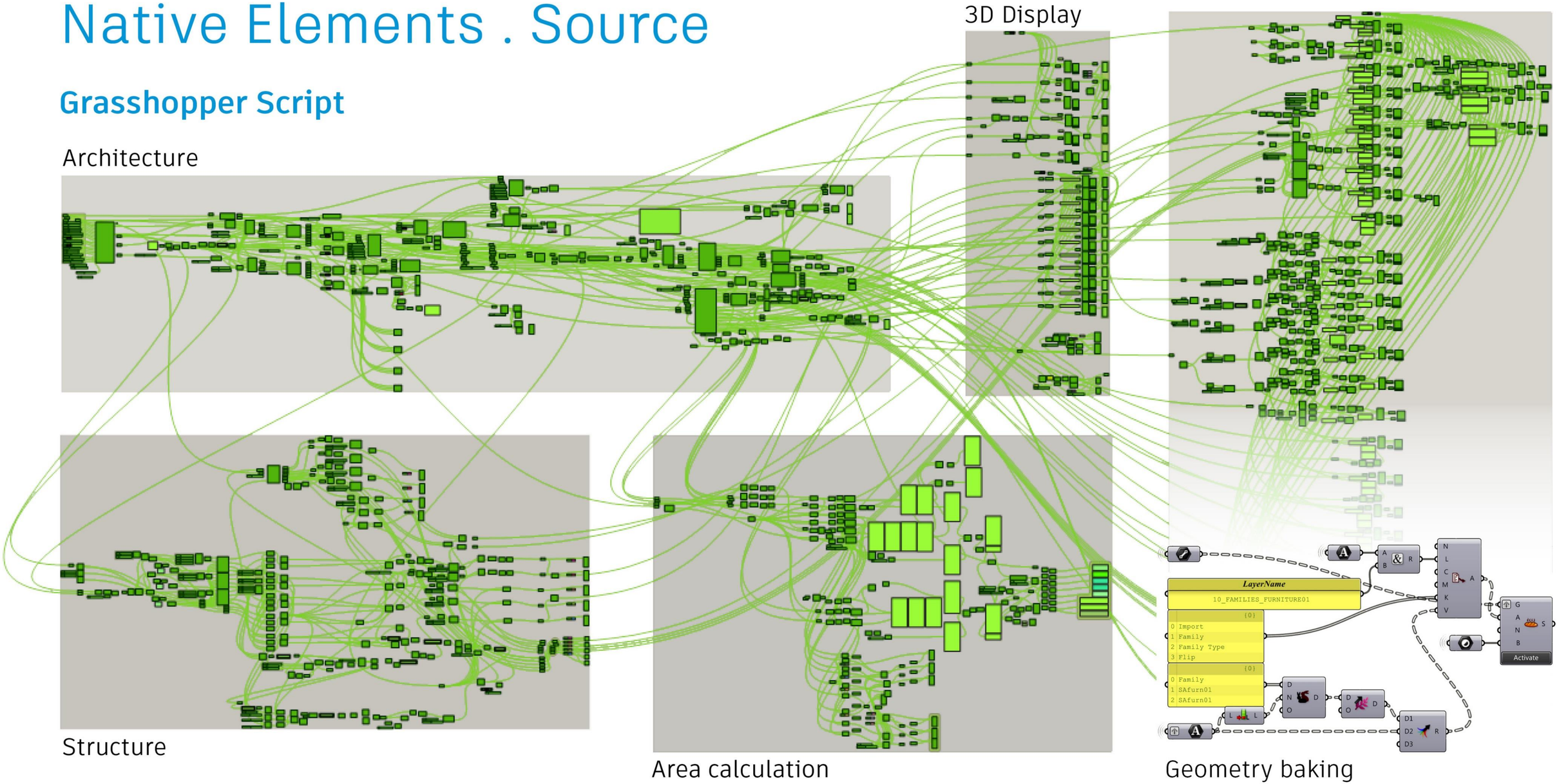


Native Elements

190 Floors
5760 Walls
4000 Doors
1725 Furniture groups
940 Apartments
2925 Text tags
Etc.

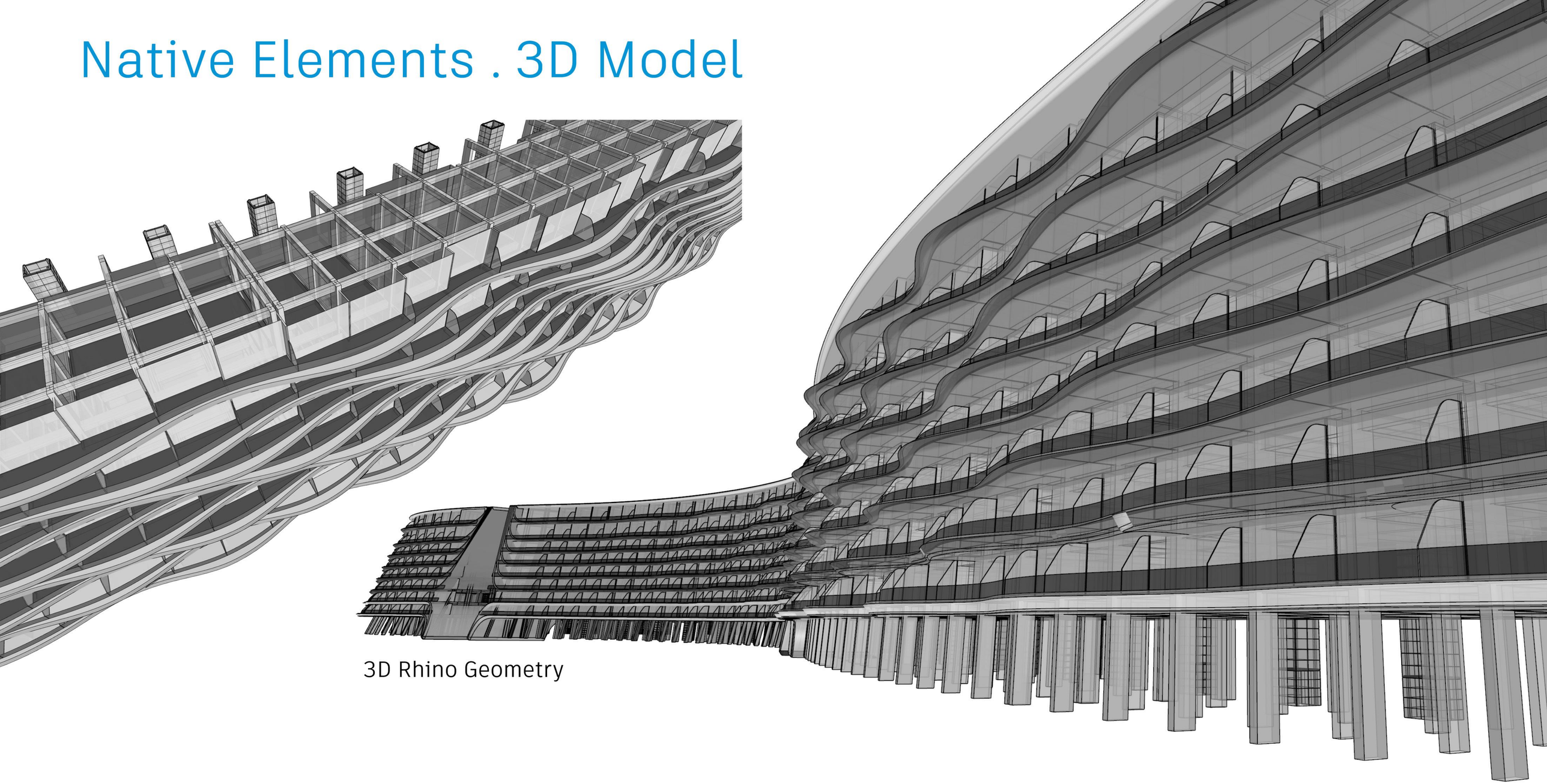
Native Elements . Source

Grasshopper Script



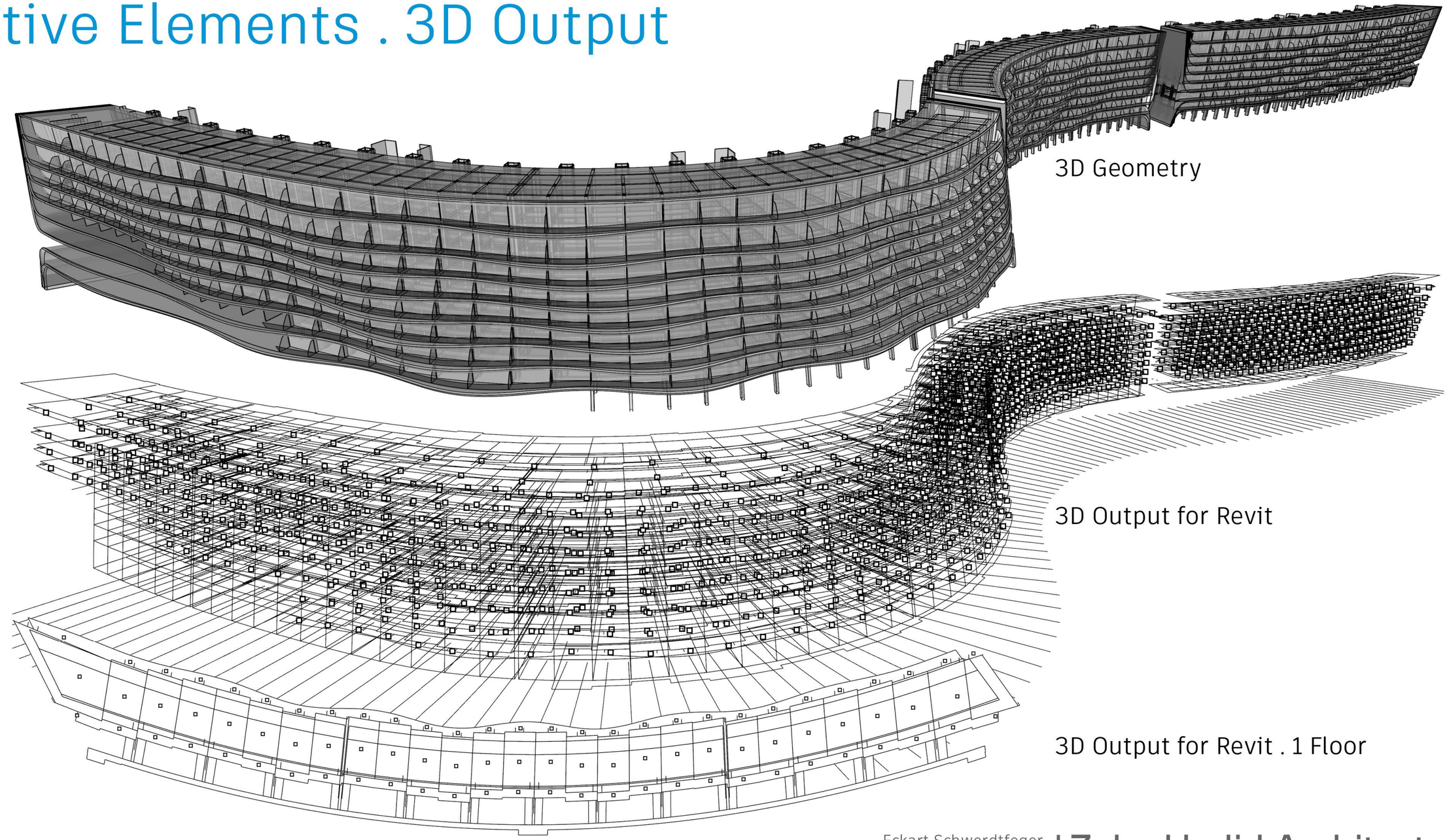
Grasshopper Script by Jose Pareja Gomez

Native Elements . 3D Model



3D Rhino Geometry

Native Elements . 3D Output



ZHA BIM

Development +
Programming

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ZHA BIM . Introduction

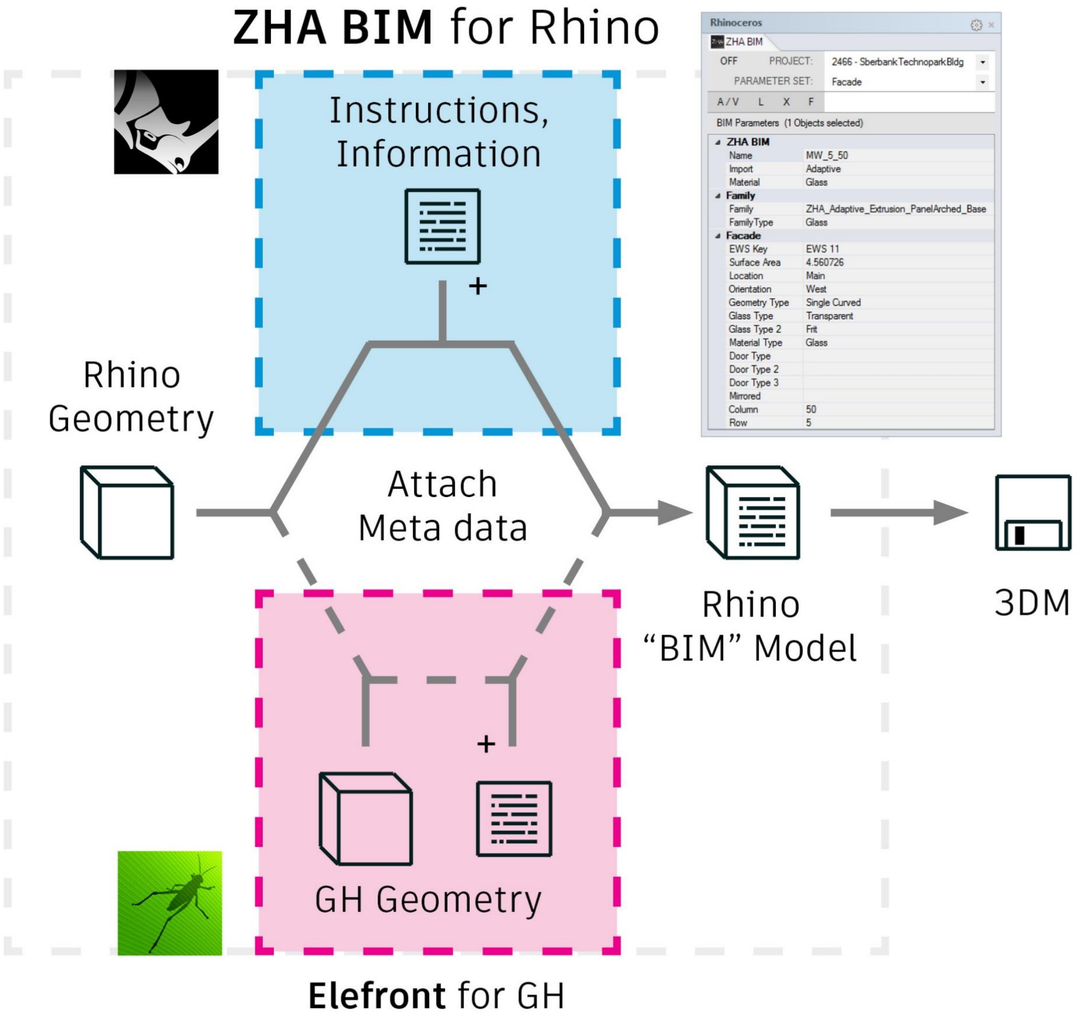
To Transfer an element cross-application we need

Geometry
of element or it's underlying geometry

Instructions
for transfer process and targeted software

Building element information
Parameters, meta data [optional]

ZHA BIM . Process



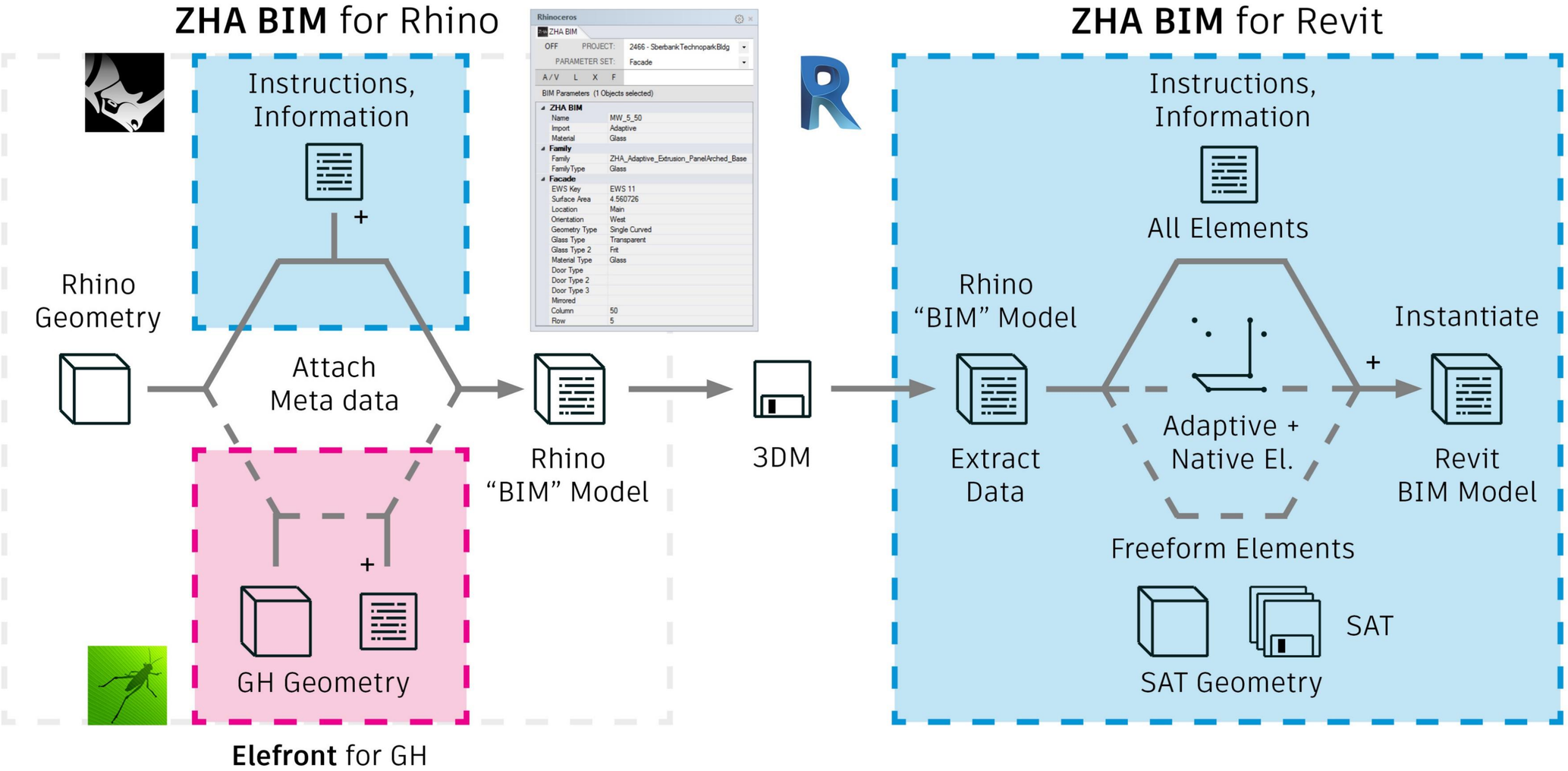
To Transfer an element
cross-application we need

Geometry
of element or it's
underlying geometry

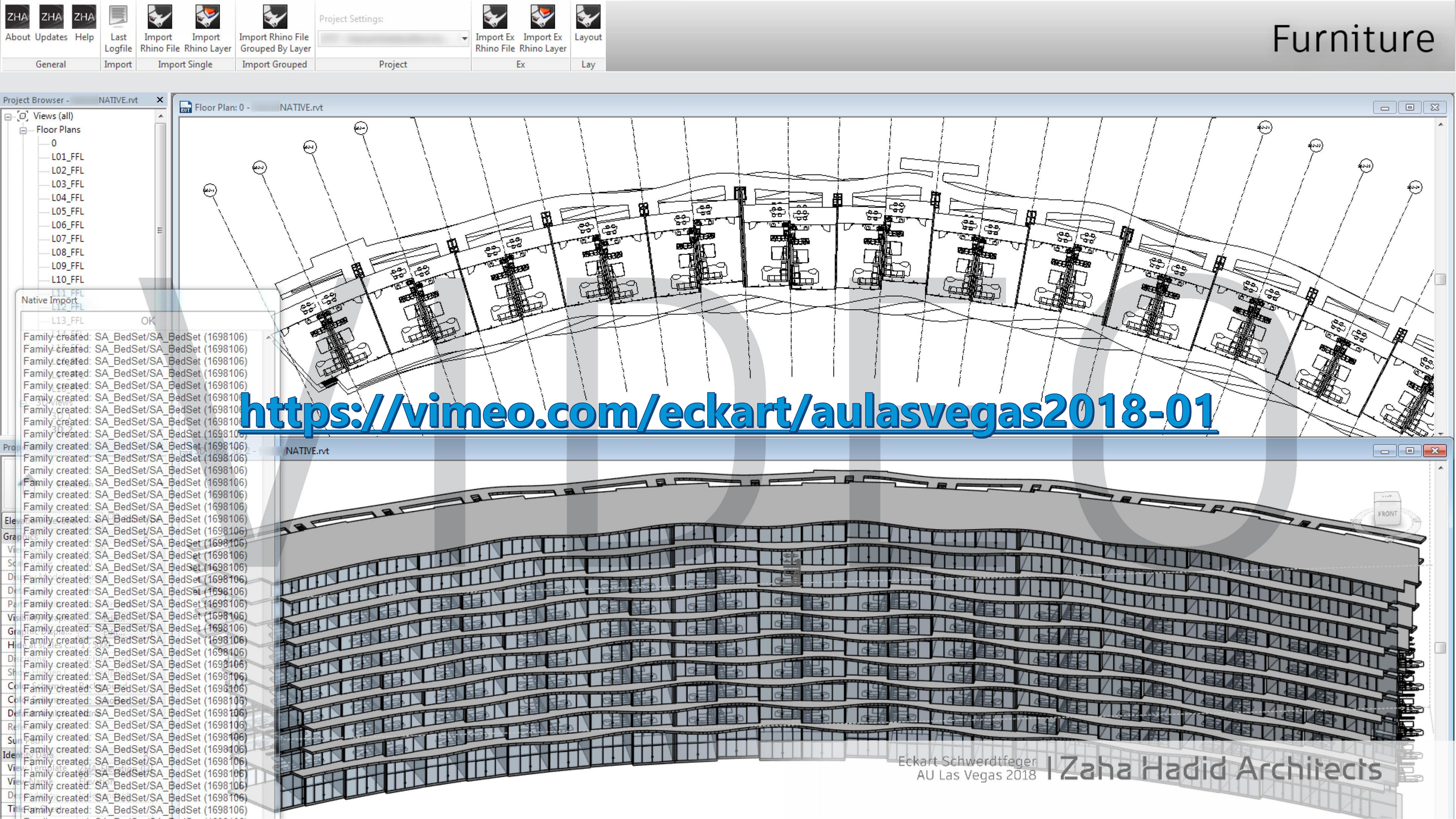
Instructions
for transfer process
and targeted software

Building element information
Parameters, meta data
[optional]

ZHA BIM . Process



Furniture


ZHA About Updates Help
Last Logfile
Import Rhino File
Import Rhino Layer
Import Rhino File Grouped By Layer
Project Settings:
Import Ex Rhino File
Import Ex Rhino Layer
Layout
General
Import
Import Single
Import Grouped
Project
Ex
Lay
Project Browser - NATIVE.rvt
Views (all)
Floor Plans
0
L01_FFL
L02_FFL
L03_FFL
L04_FFL
L05_FFL
L06_FFL
L07_FFL
L08_FFL
L09_FFL
L10_FFL
L11_FFL
L12_FFL
L13_FFL
Floor Plan: 0 - NATIVE.rvt
Native Import
OK
Family created: SA_BedSet/SA_BedSet (1698106)
https://vimeo.com/eckart/aulasvegas2018-01
NATIVE.rvt
FRONT
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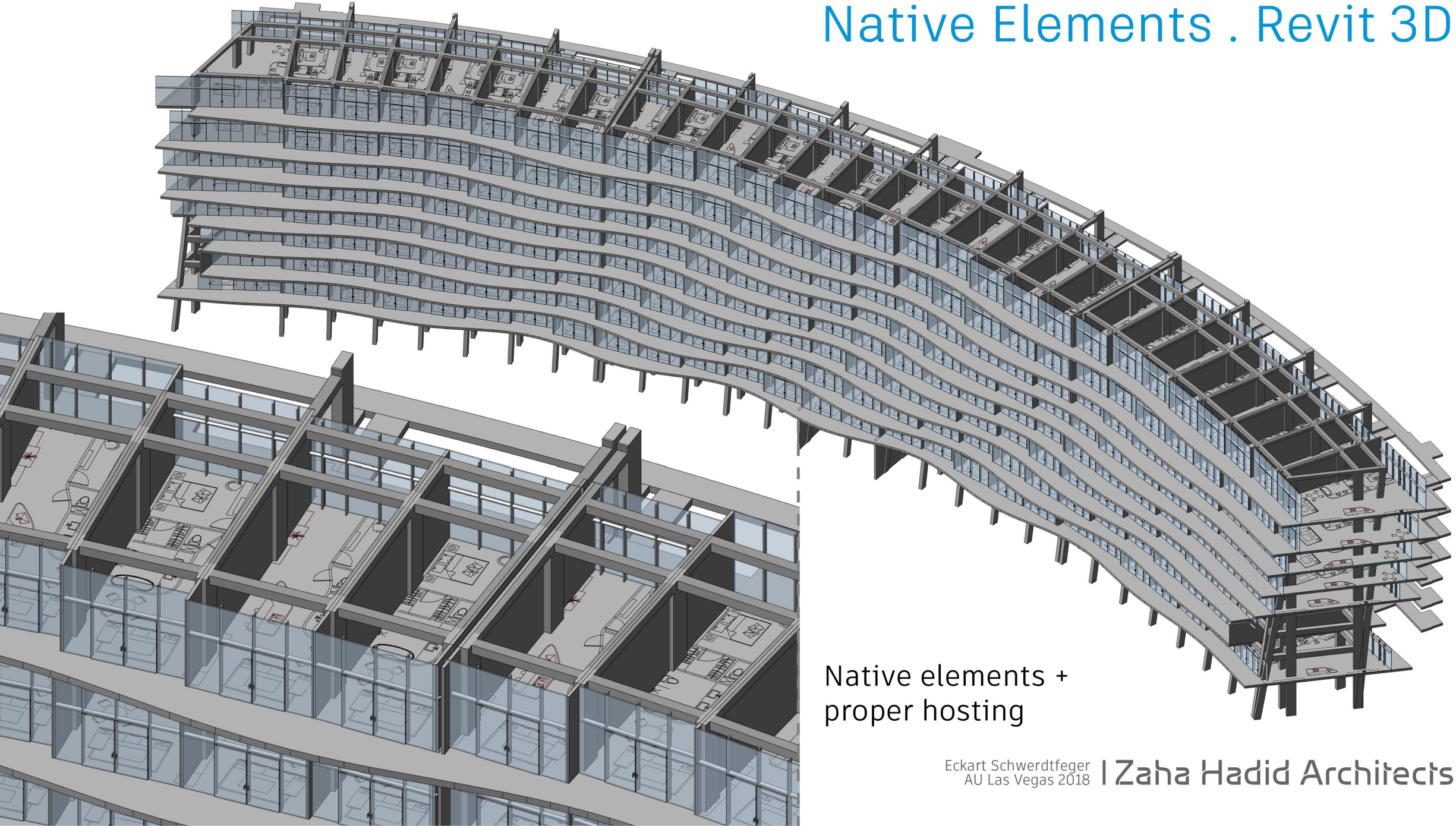
Native Elements . Revit 3D



Native elements +
proper hosting

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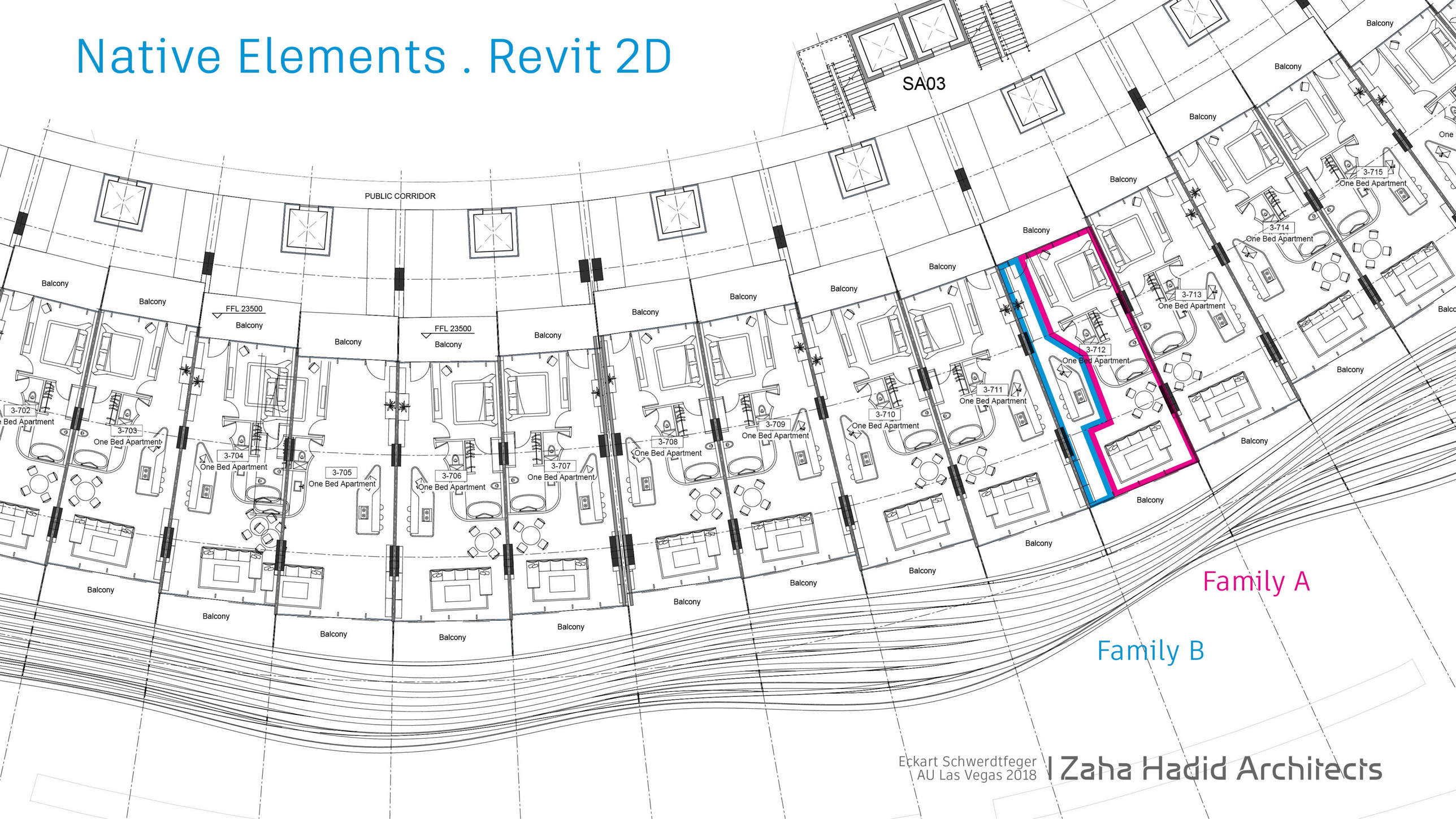
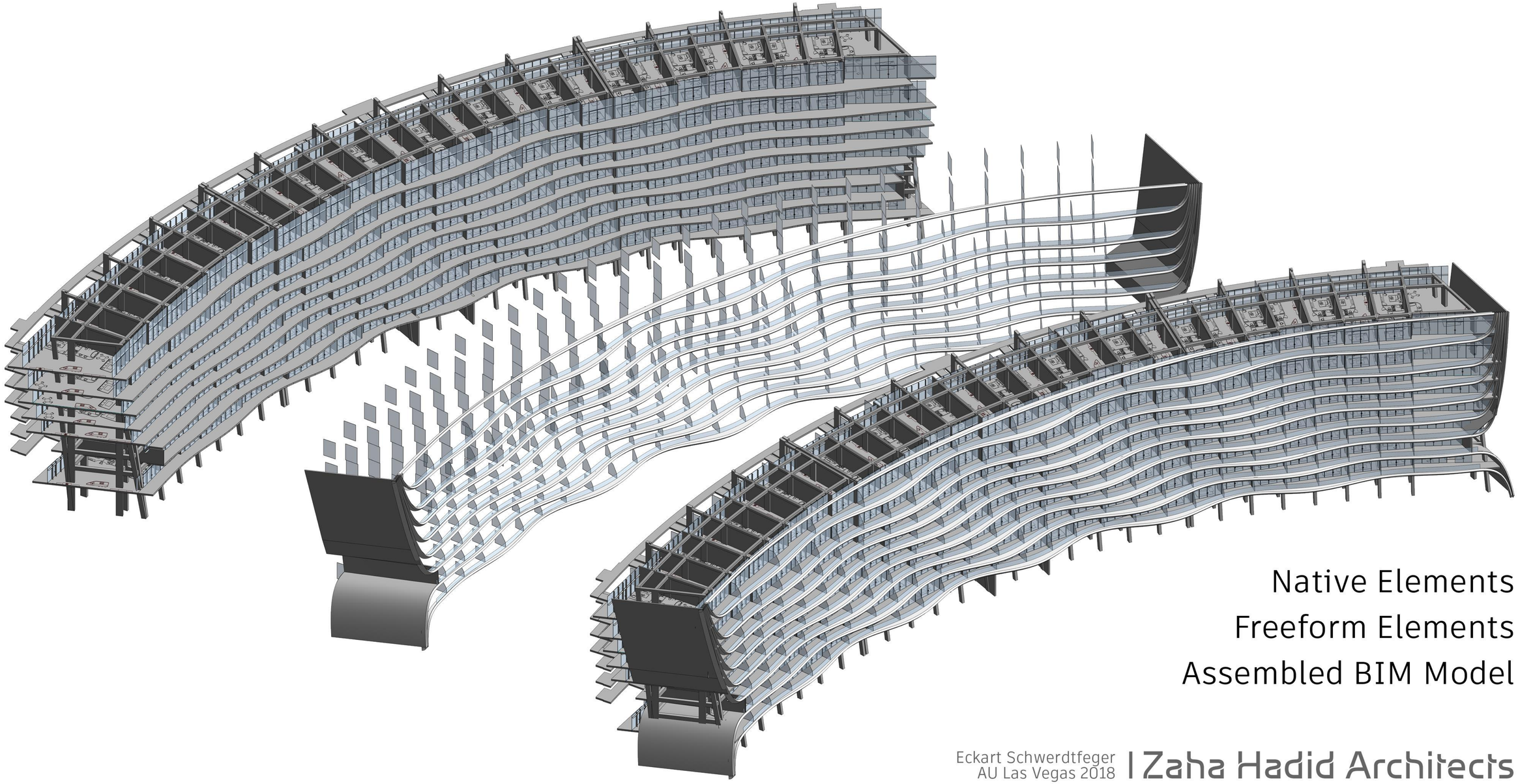
Native Elements . Revit 2D



Native Elements . Revit



Native Elements
Freeform Elements
Assembled BIM Model

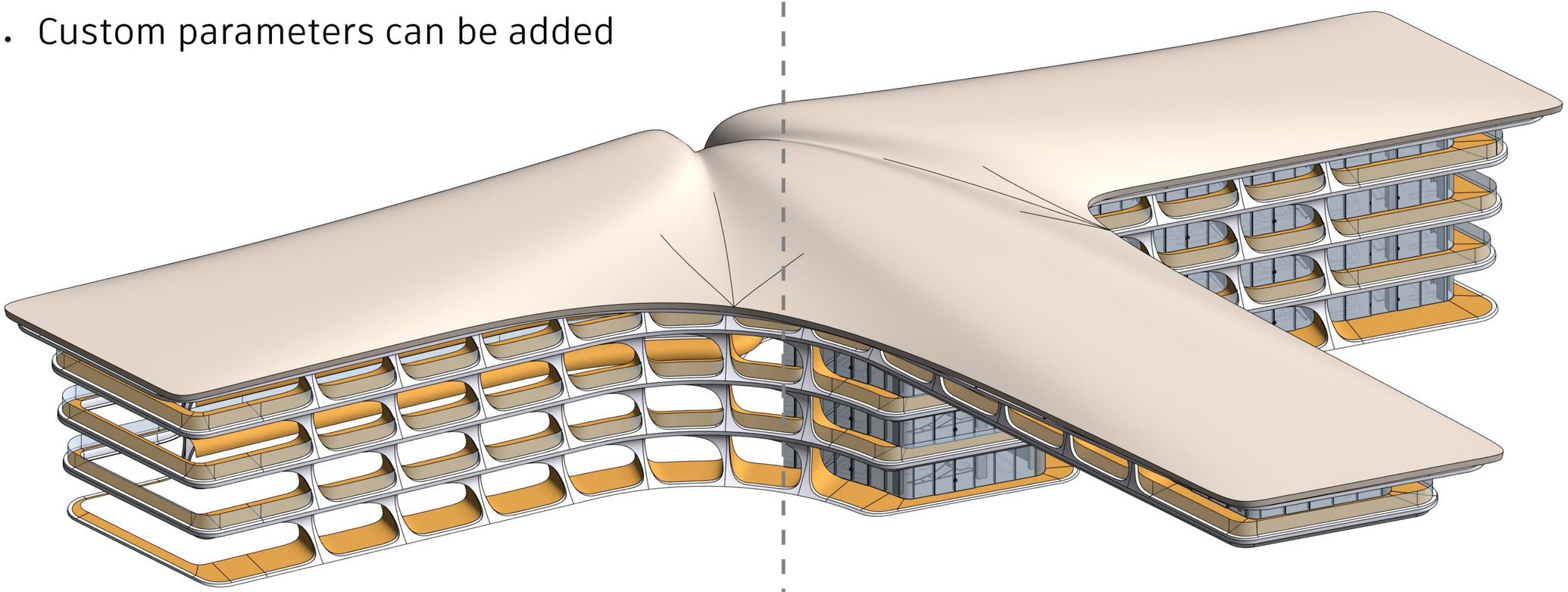
Freeform Elements

Freeform Elements

- E.g. sculpted roof, facade and balcony cladding, balustrades, etc.
- Freeform geometry not supported by preset building elements
- Custom parameters can be added

Creation

- Manual import [tedious process, slow, limitations]
- Automated custom workflow



Freeform Elements

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ZHA
About
Updates
Help
General
Last Logfile
Import
Import Rhino File
Import Rhino Layer
Import Single
Import Rhino File Grouped By Layer
Import Grouped
Project Settings:
Project
Import Ex Rhino File
Import Ex Rhino Layer
Ex
Layout
Lay
Project Browser -
Views (all)
Floor Plans
Ceiling Plans
3D Views
{3D}
Elevations (12mm Circle)
Legends
Schedules/Quantities
Sheets (all)
Families
Groups
Revit Links
Properties
3D View
Edit Type
FRONT
Burn
New folder
Documents library
Cache
Arrange by:
Folder
Name
ctjmbzuoidislcax#HT01__Wood.rfa
ctjmbzuoidislcax#HT01__Wood.sat
HT01__Wood#dwdguhbvxodlwrpn.0001.rfa
HT01__Wood#dwdguhbvxodlwrpn.rfa
VIDEO
https://vimeo.com/eckart/aulasvegas2018-02
ZHA BIM - Import Progress
RHINO
REVIT
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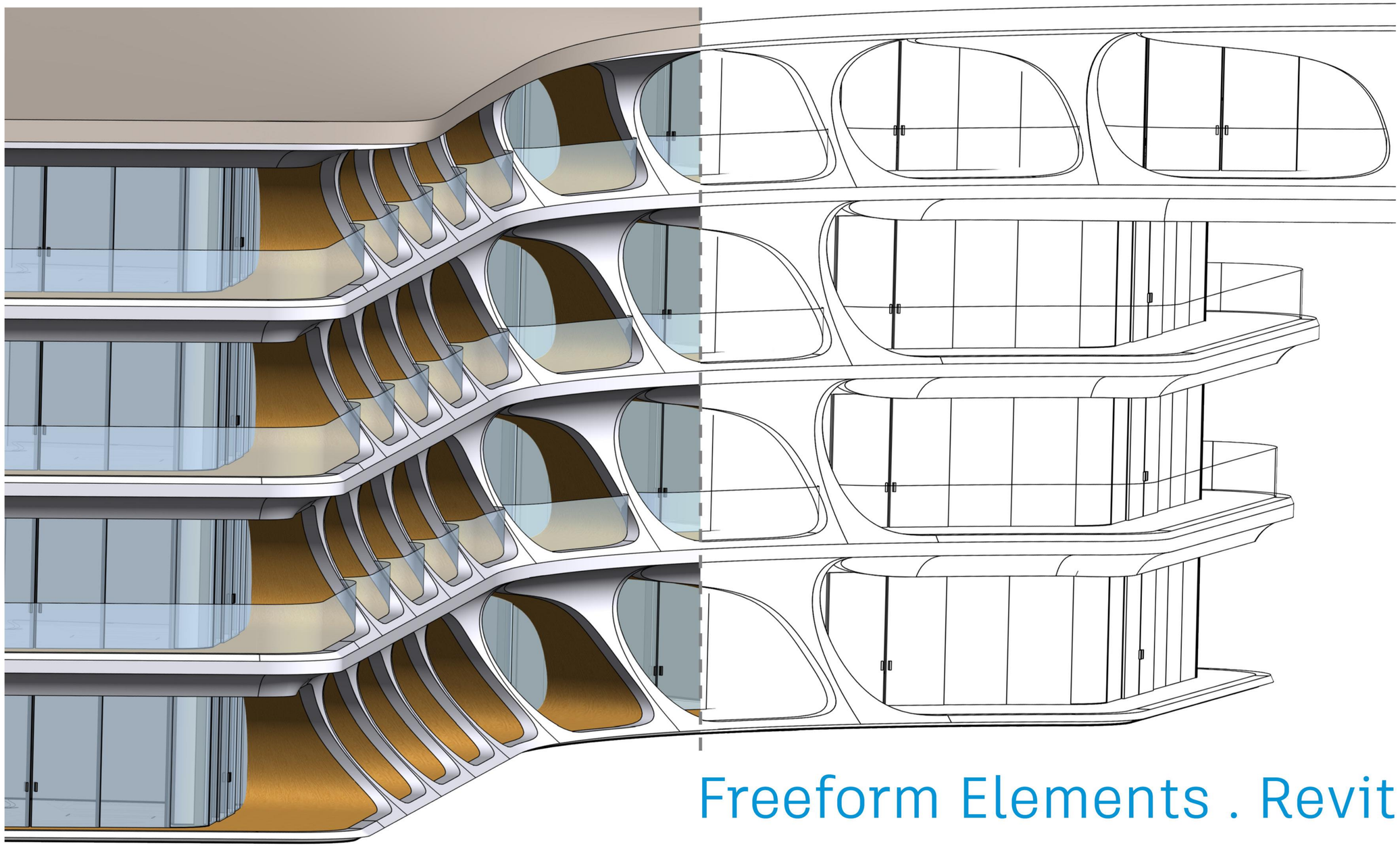

Freeform Elements . Revit 3D

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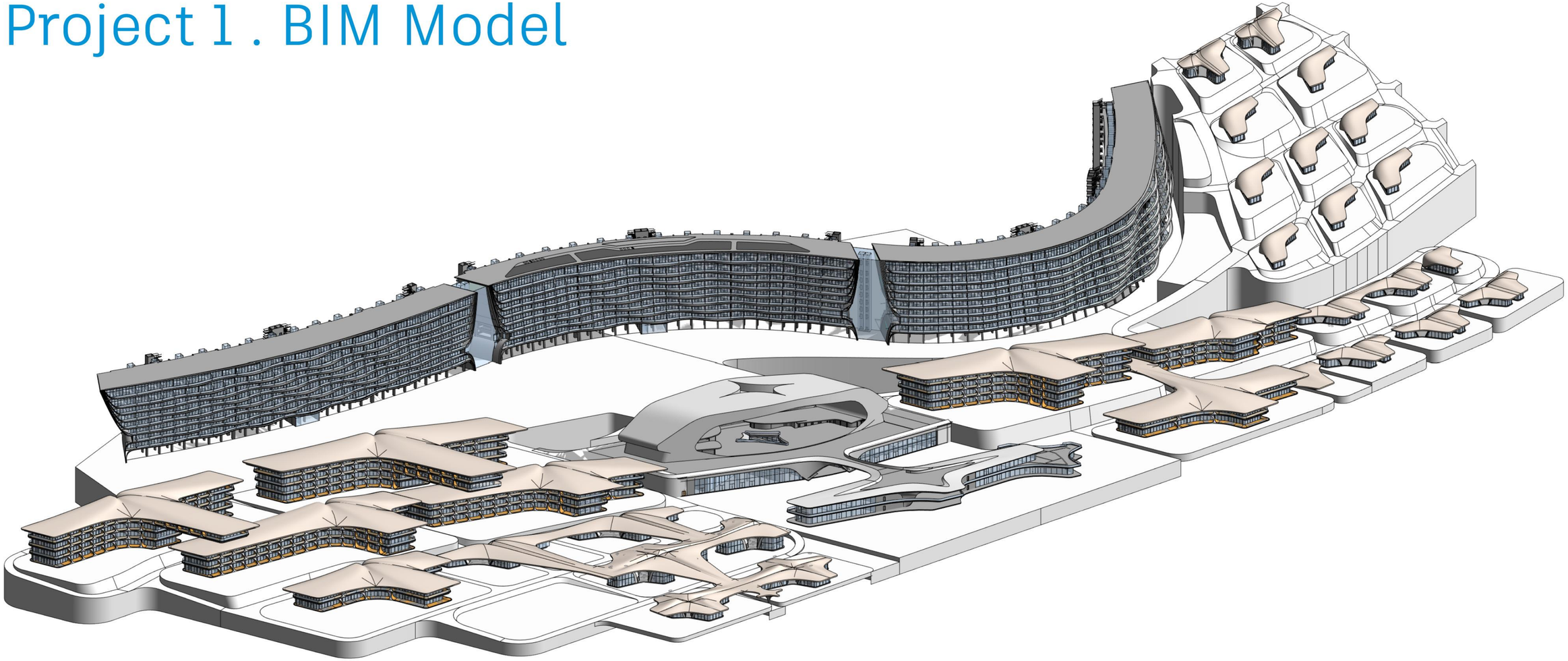
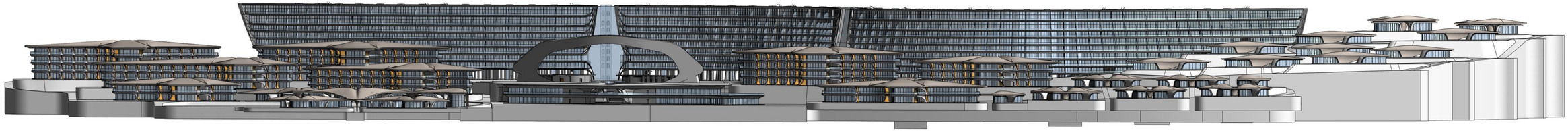
Project 1 . BIM Model



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Project 2

Project BIM Team

Eckart Schwerdtfeger
Valeria Perco
Maria Avrami
Mauro Sabiu


VIDEO
https://vimeo.com/eckart/aulasvegas2018-03
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Project 2

- Building complex of about 262.000 m^2
- Office building for up to 17.000 employees working in innovation + development

Project 2

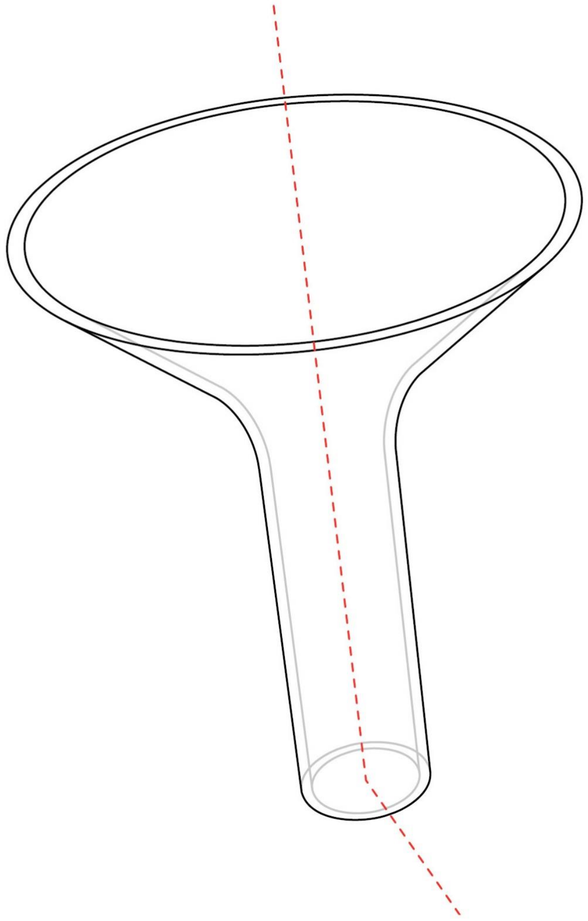
Aims

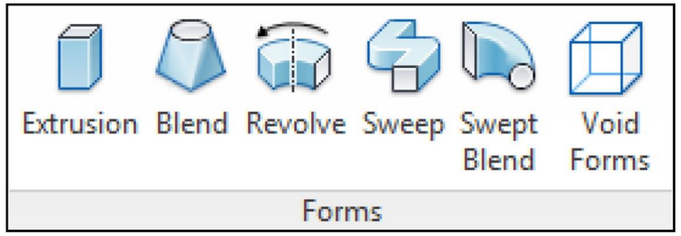
- Parametric Revit elements instead of importing “dead” geometry
- Intensified use of visual scripting / Dynamo

Freeform Elements In Revit

Freeform Elements . Forms

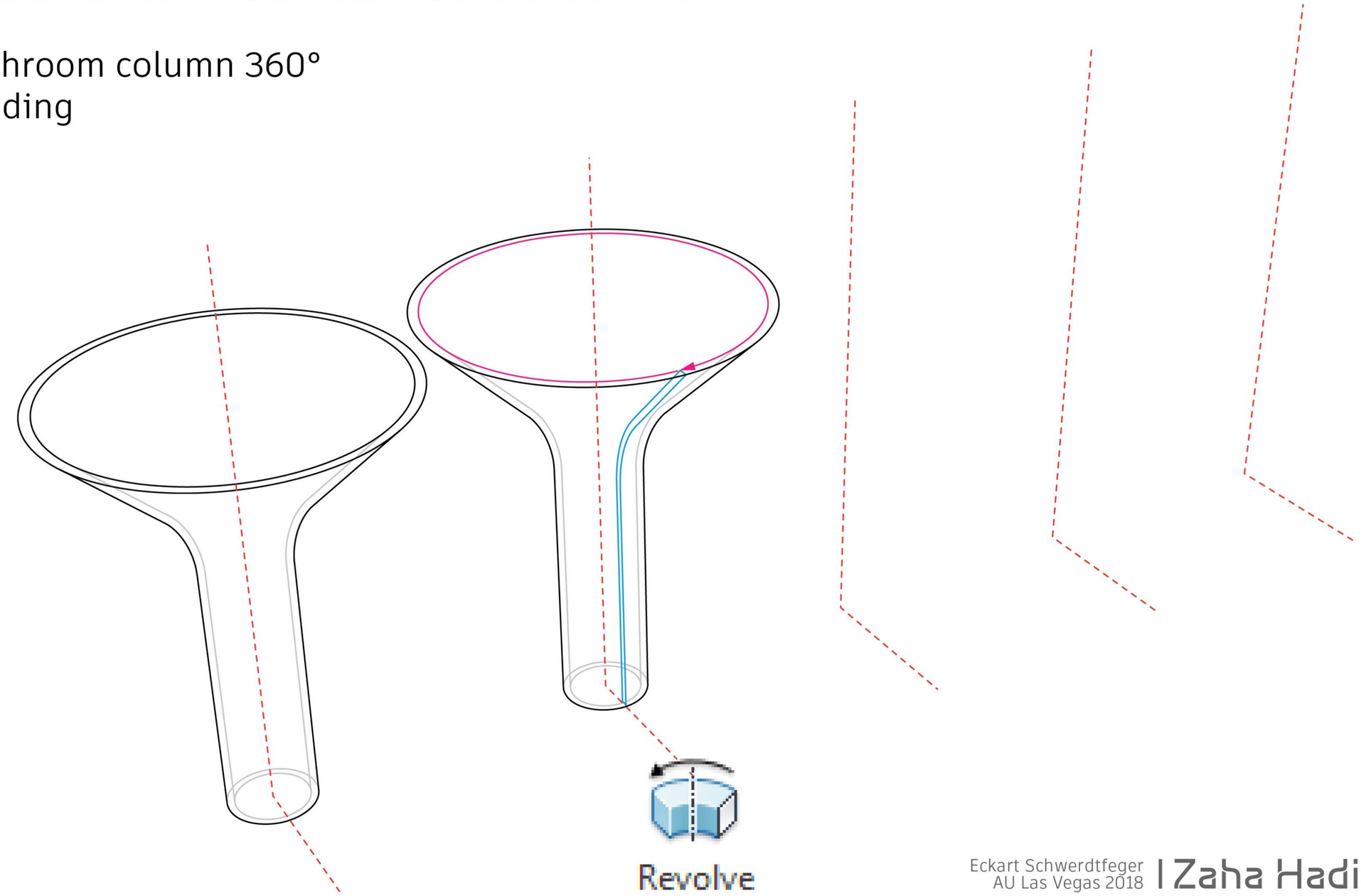
Mushroom column 360°
Cladding





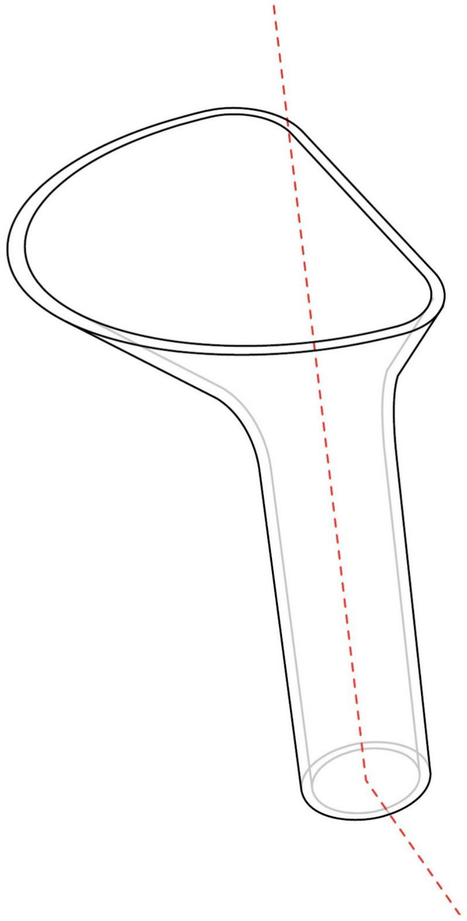
Freeform Elements . Forms

Mushroom column 360°
Cladding



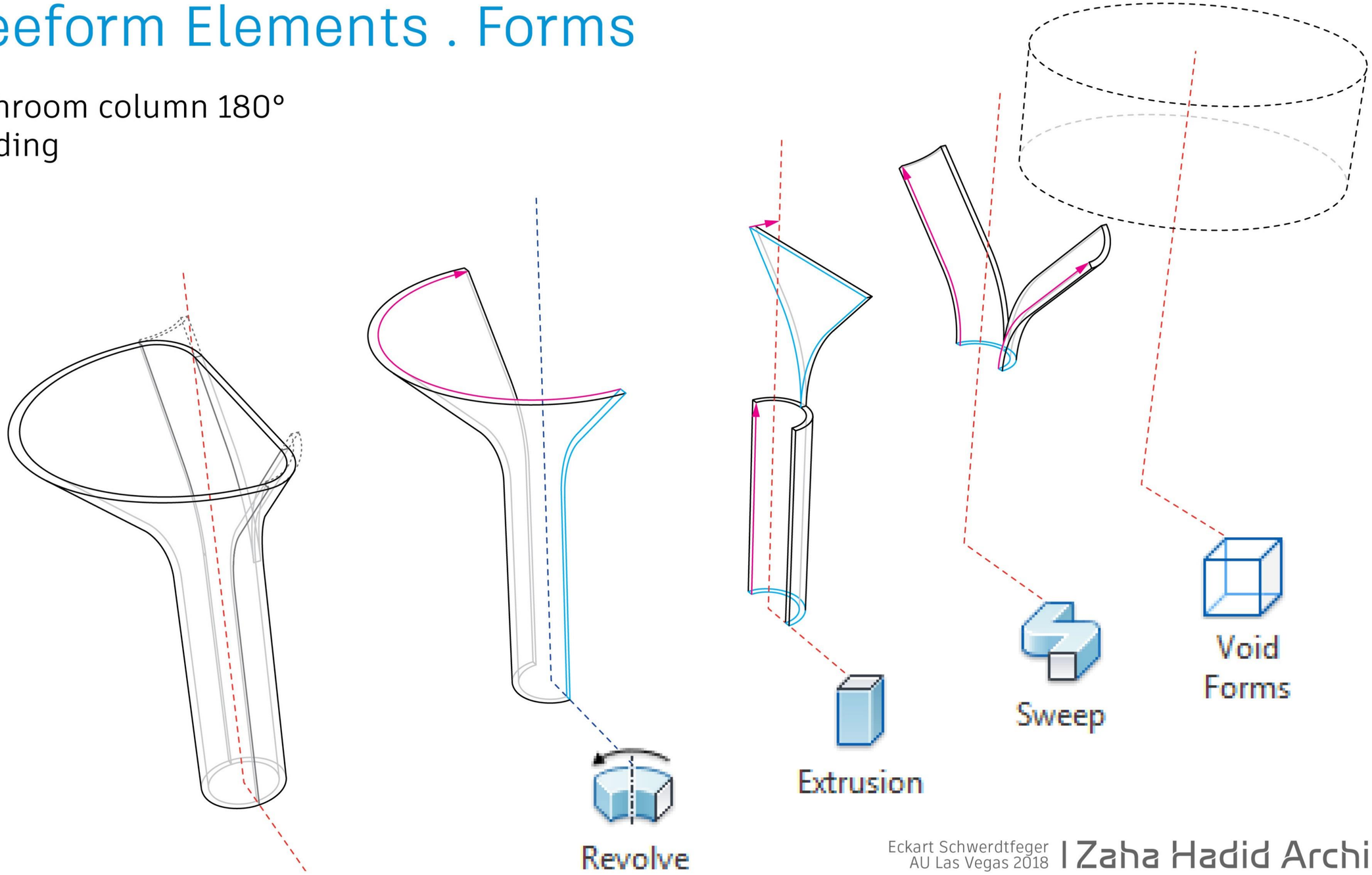
Freeform Elements . Forms

Mushroom column 180°
Cladding



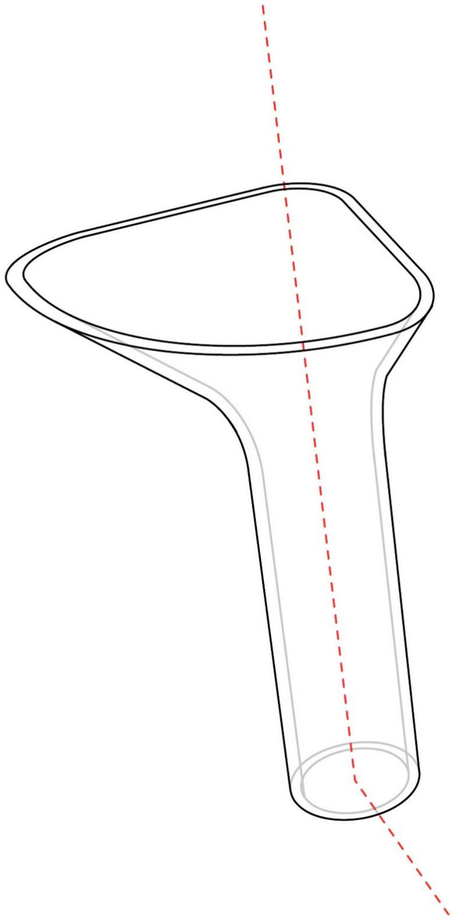
Freeform Elements . Forms

Mushroom column 180°
Cladding



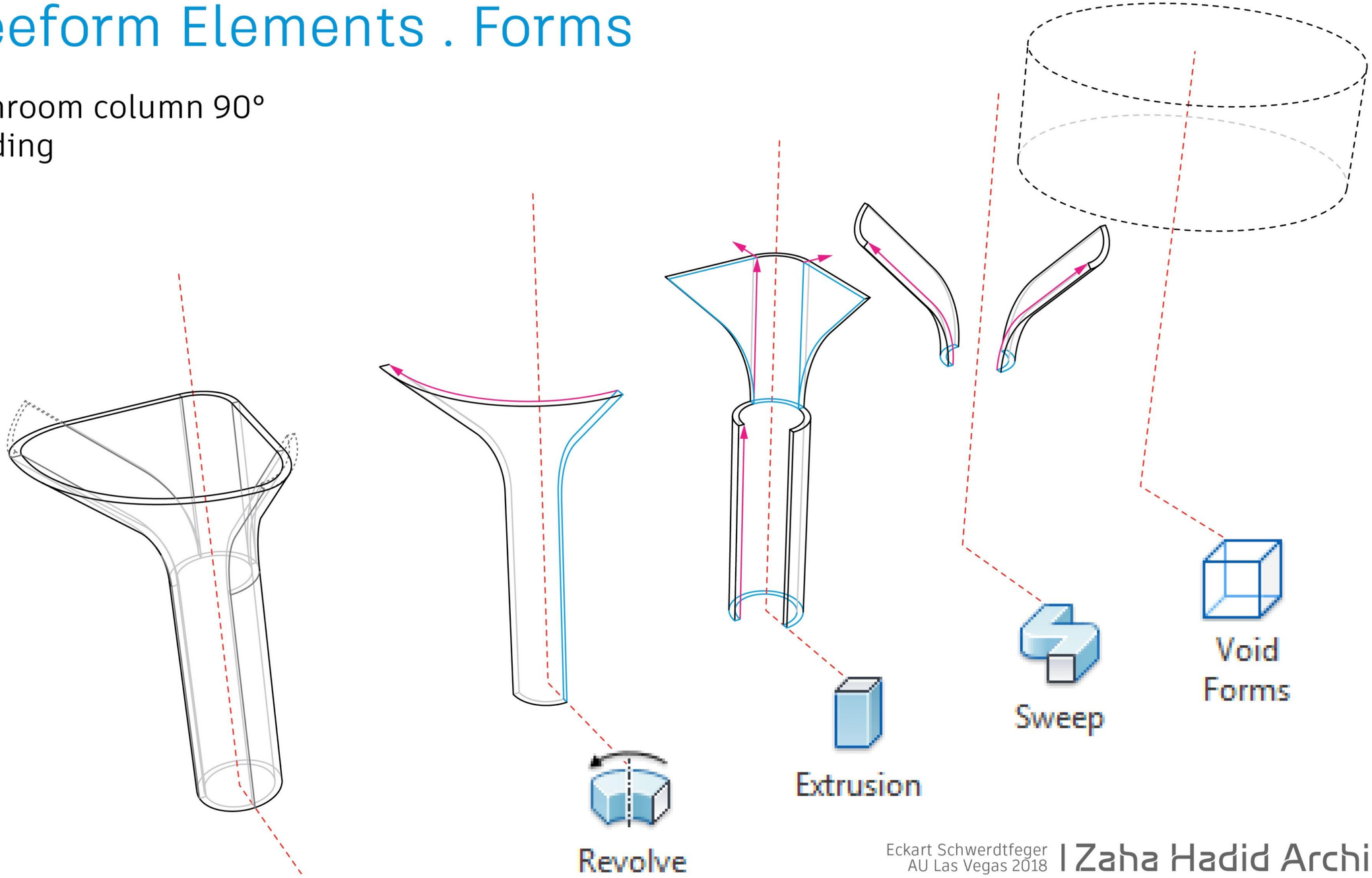
Freeform Elements . Forms

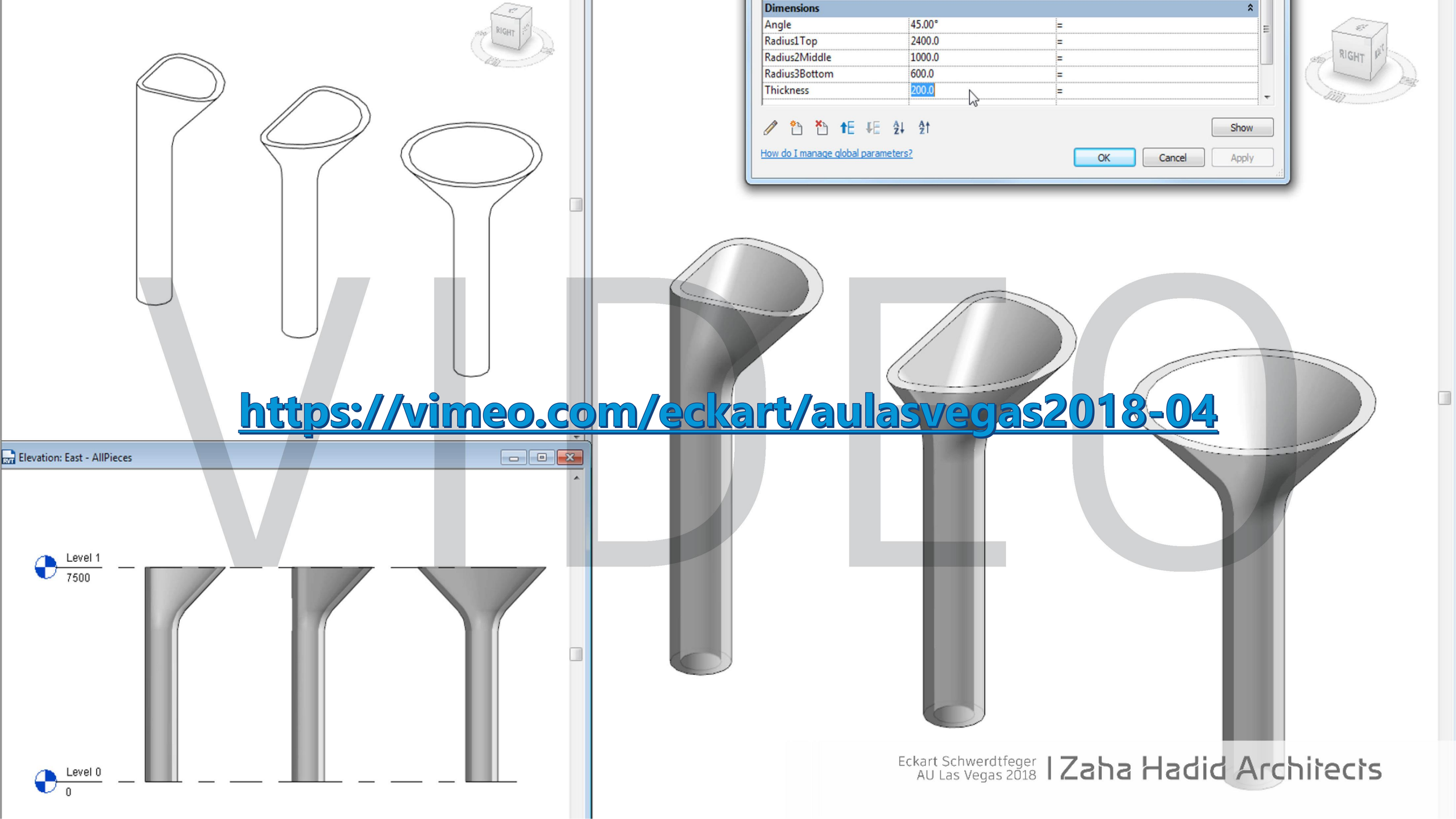
Mushroom column 90°
Cladding



Freeform Elements . Forms

Mushroom column 90°
Cladding

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Radius2Middle 1000.0
Radius3Bottom 600.0
Thickness 200.0
Show
How do I manage global parameters?
OK
Cancel
Apply
RIGHT
Elevation: East - AllPieces
Level 1
7500
Level 0
0
VIDEO
https://vimeo.com/eckart/aulasvegas2018-04
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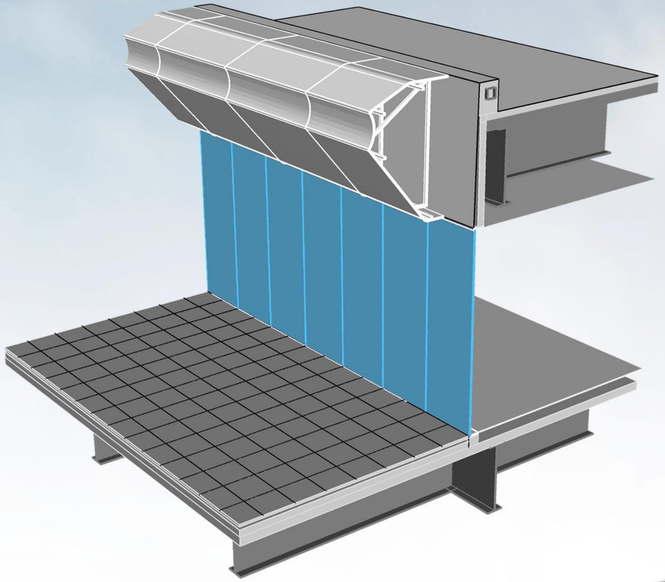
Freeform Elements . Adaptive

Facade cladding



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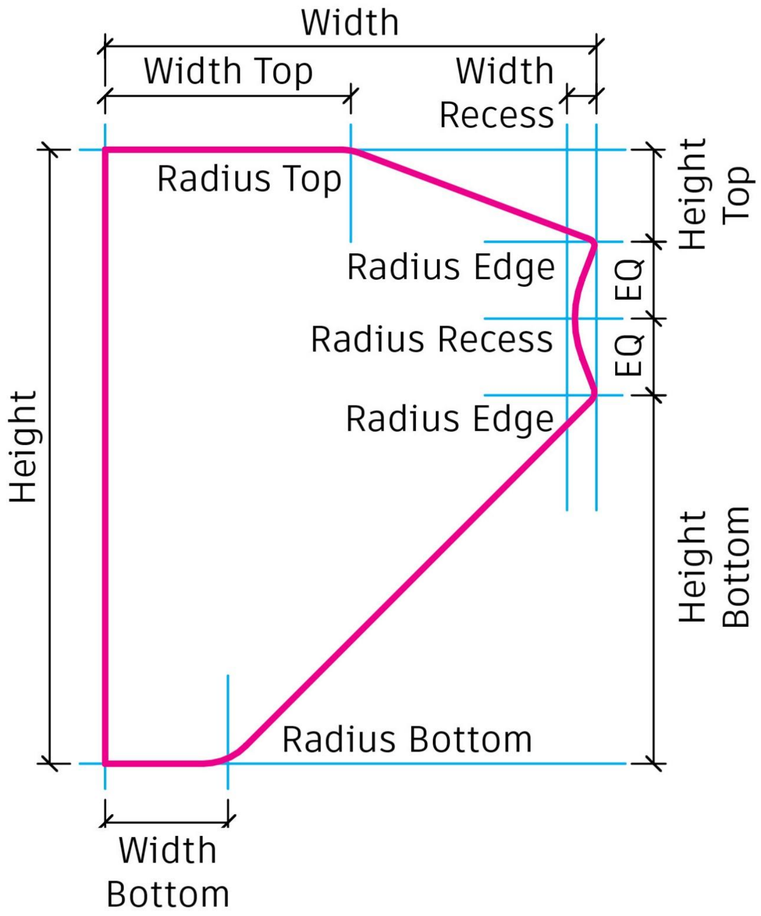
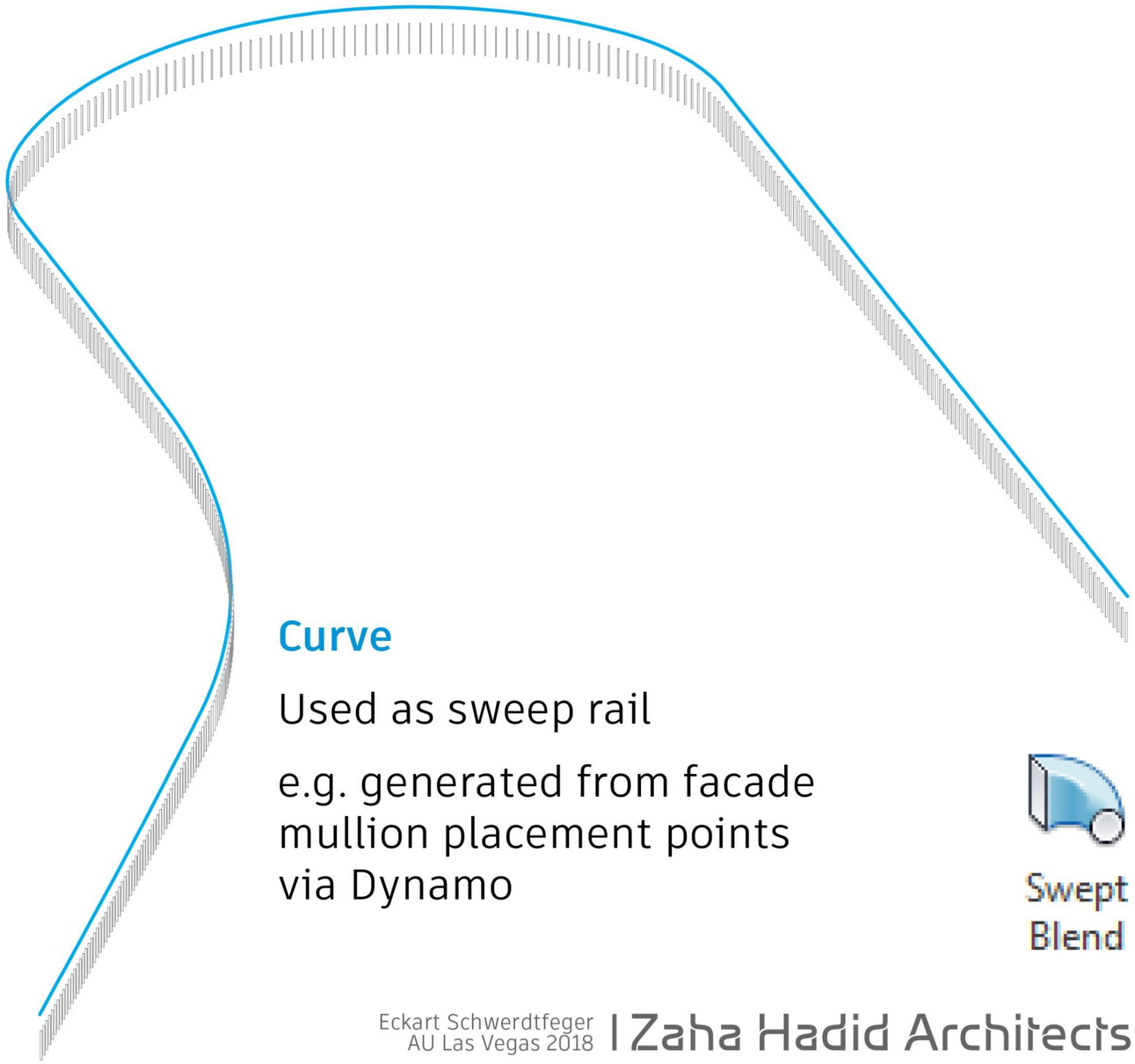
Freeform Elements . Adaptive

Facade cladding

Curve
+ Parameter-based profile



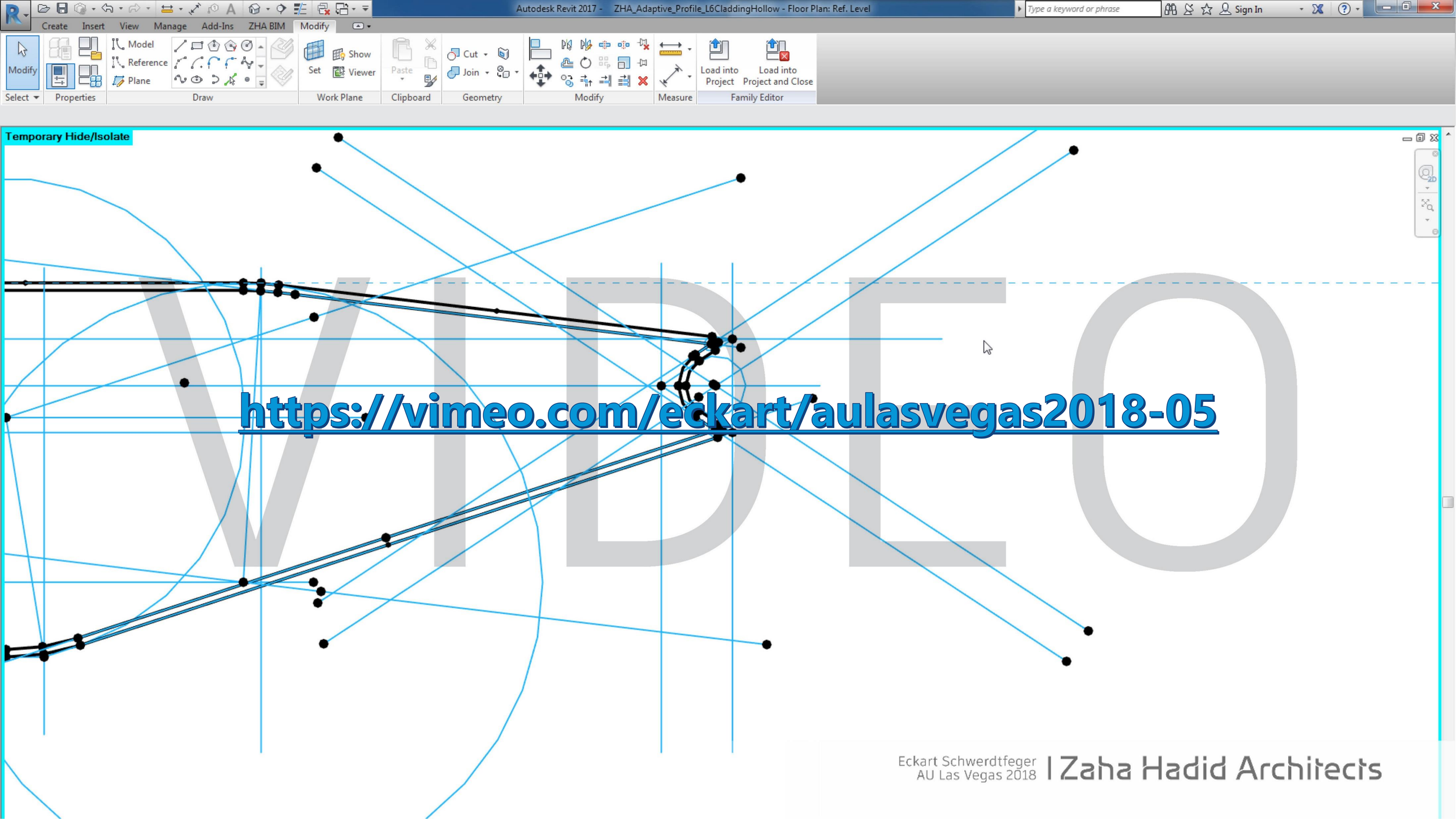


Curve

Used as sweep rail

e.g. generated from facade mullion placement points via Dynamo

Swept Blend


Autodesk Revit 2017 - ZHA_Adaptive_Profile_L6CladdingHollow - Floor Plan: Ref. Level
Create
Insert
View
Manage
Add-Ins
ZHA BIM
Modify
Modify
Select
Properties
Model
Reference
Plane
Draw
Set
Show
Viewer
Work Plane
Paste
Clipboard
Cut
Join
Geometry
Modify
Measure
Load into Project
Load into Project and Close
Family Editor
Temporary Hide/Isolate
VIDEO
https://vimeo.com/eckart/aulasvegas2018-05
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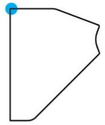
Freeform Elements . Adaptive

Facade cladding

Curve
+ Parameter-based profile
+ Profile family instances

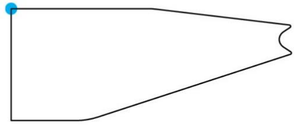
Type	R	H	W
Width	2000	2000	6300
Width Top	1000	1000	3150
Width Bottom	500	500	1700
Width Recess	120	475	475
Height	2500	7000	2500
Height Top	375	1900	375
Height Bottom	1500	3250	1500
Radius Top	250	250	2000
Radius Bottom	250	250	1600
Radius Edge	30	100	30
Radius Recess	450	1150	200

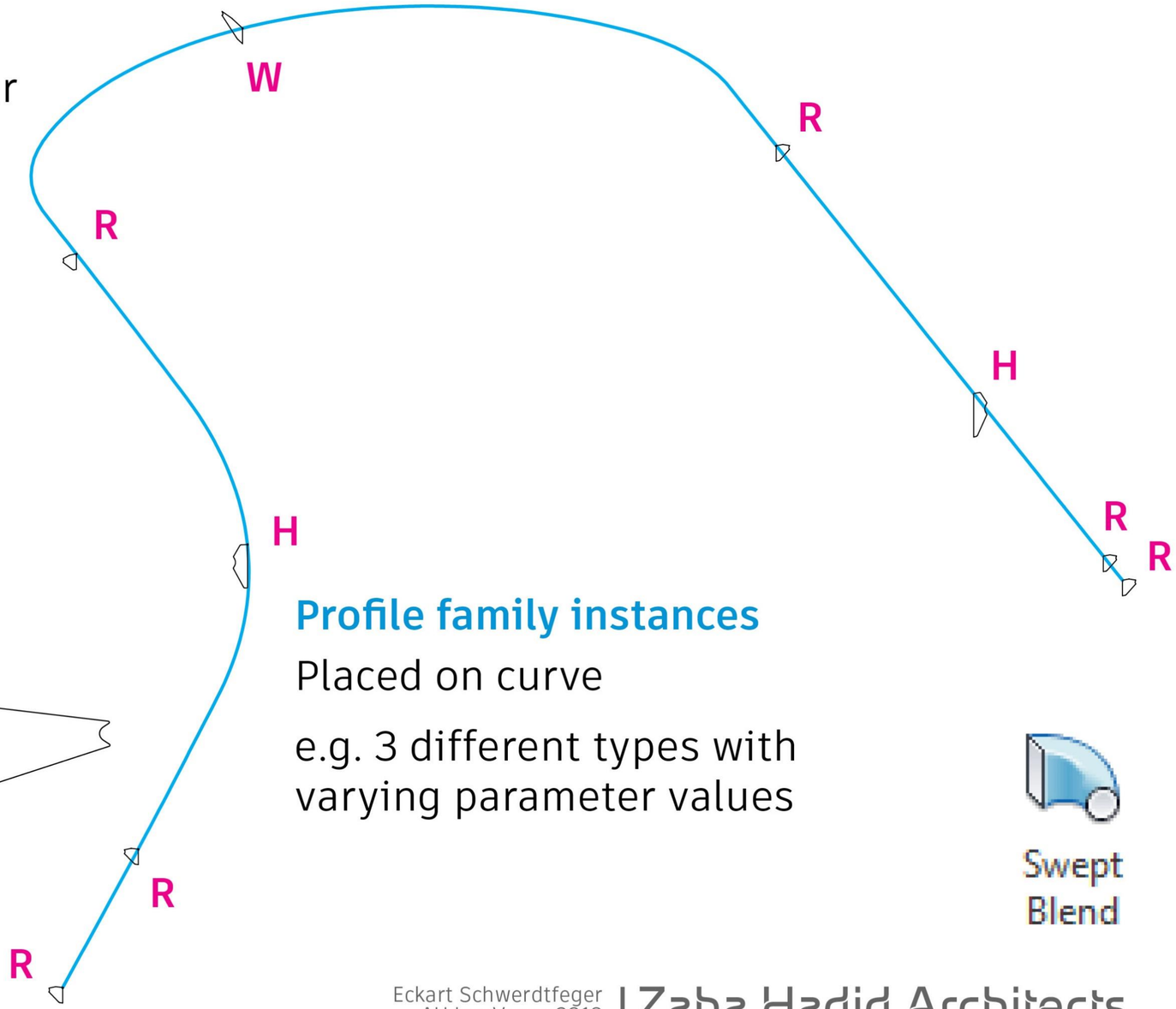
Regular



High

Wide



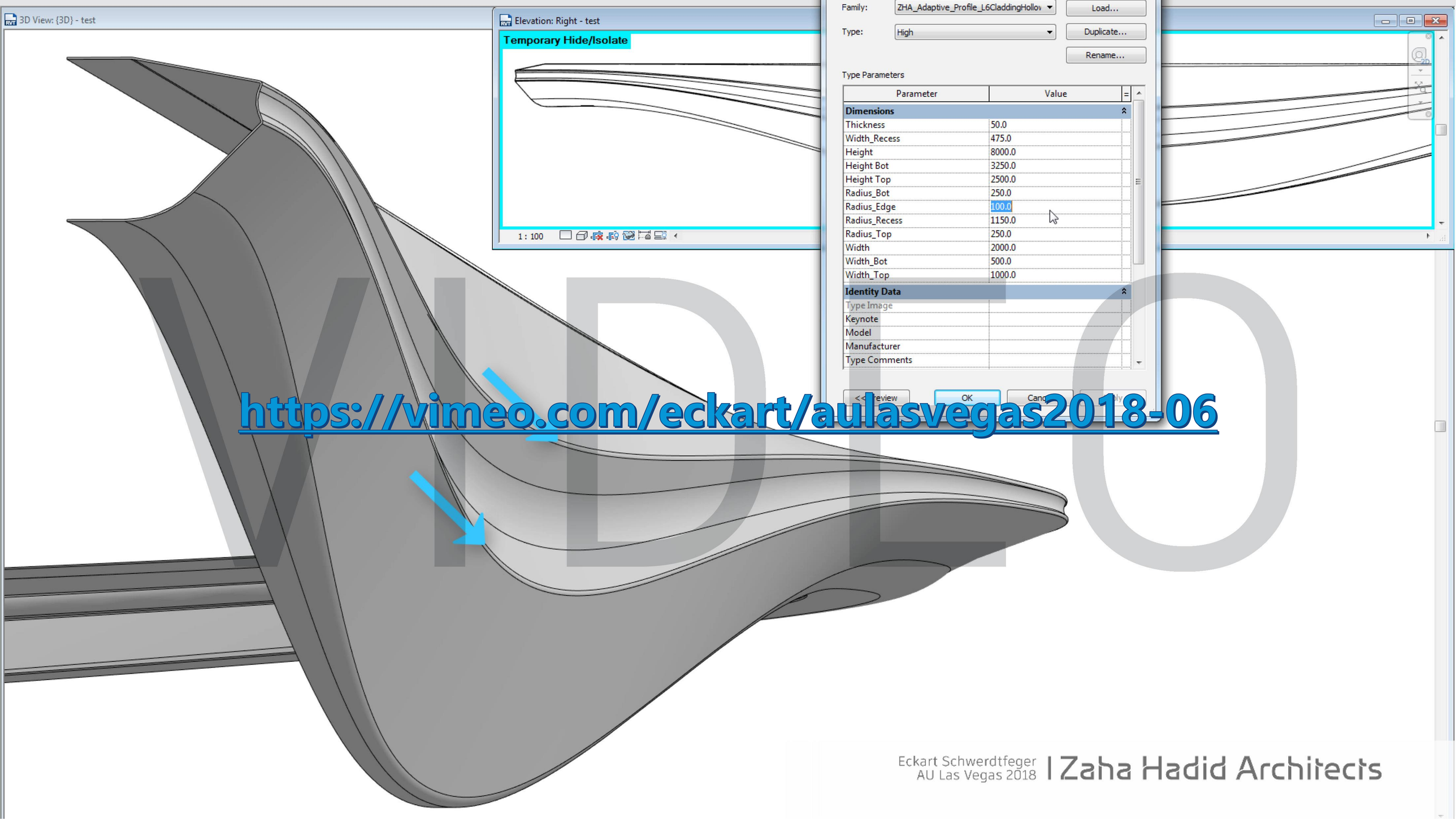


Profile family instances

Placed on curve

e.g. 3 different types with varying parameter values

Swept Blend


3D View: {3D} - test
Elevation: Right - test
Temporary Hide/Isolate
1 : 100
Family: ZHA_Adaptive_Profile_L6CladdingHollov
Load...
Type: High
Duplicate...
Rename...
Type Parameters
Parameter
Value
Dimensions
Thickness 50.0
Width_Recess 475.0
Height 8000.0
Height Bot 3250.0
Height Top 2500.0
Radius_Bot 250.0
Radius_Edge 100.0
Radius_Recess 1150.0
Radius_Top 250.0
Width 2000.0
Width_Bot 500.0
Width_Top 1000.0
Identity Data
Type Image
Keynote
Model
Manufacturer
Type Comments
OK
VIDEO
https://vimeo.com/eckart/aulasvegas2018-06
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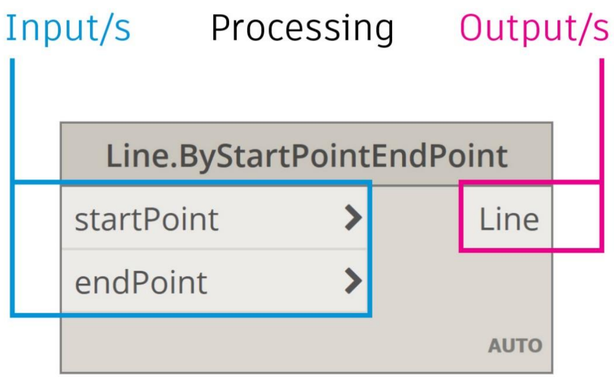
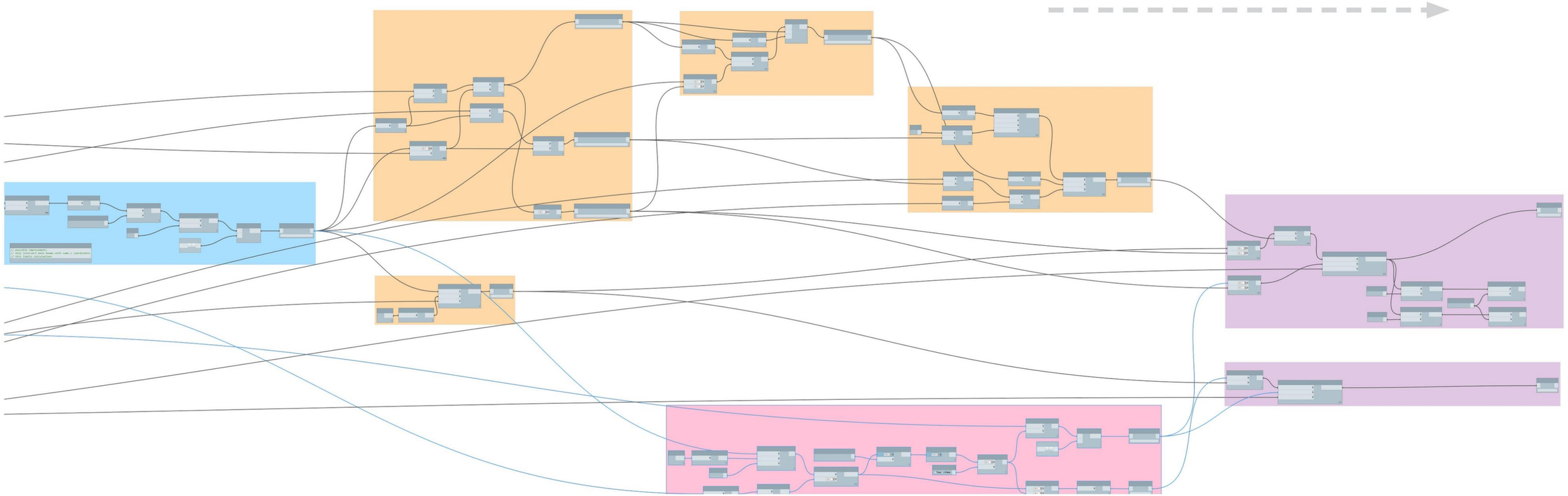
Dynamo
Visual Scripting

Dynamo . Introduction

Visual Scripting

- Graphical user interface for Dynamo + Revit application programming interface [API]
- Linear sequence of instructions [**Nodes**]





Dynamo . Visual Scripting

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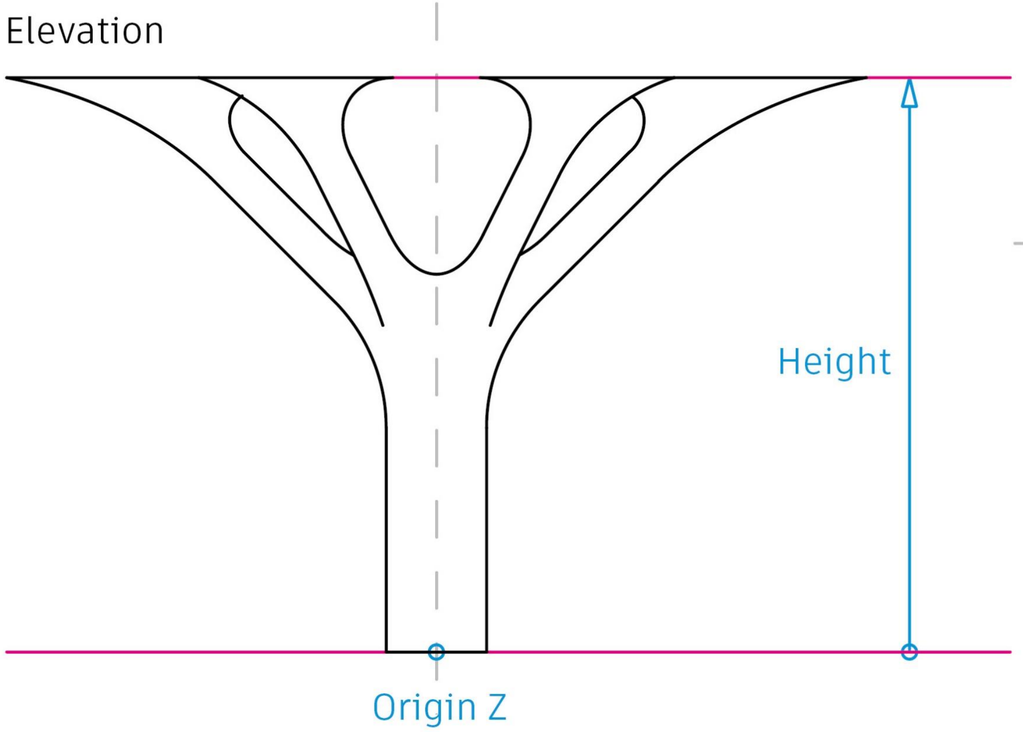
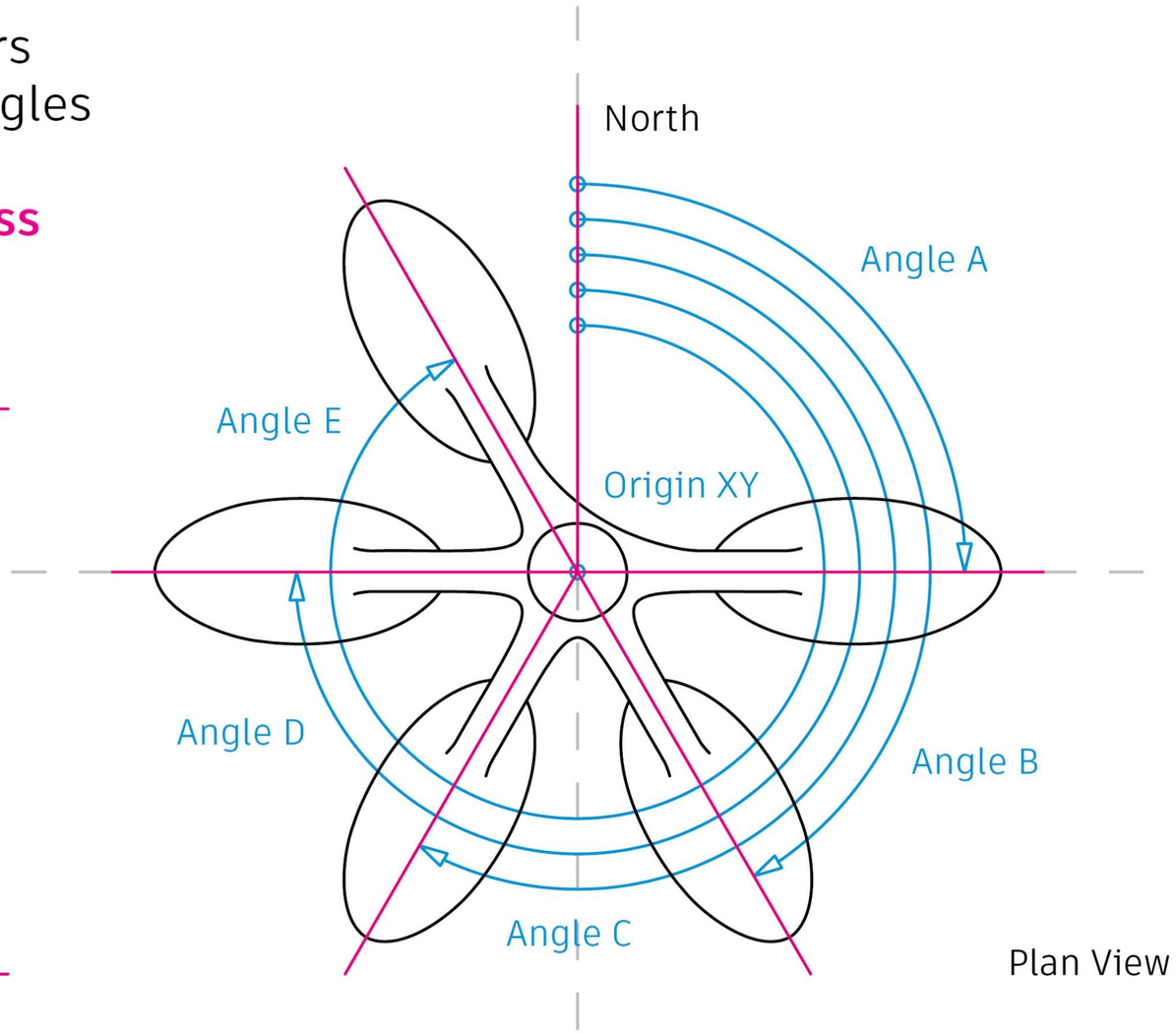
Dynamo . Tree Columns

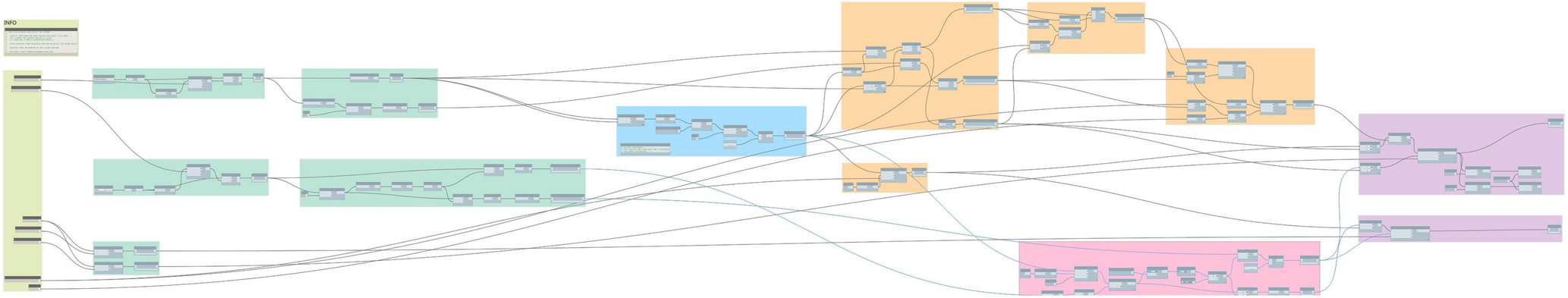
Process

- Analyse **live** building model - main beams, floors
- Collect + sort meta data - origin XYZ, height, angles
- Store meta data - csv spreadsheet file
- **Generate structure - automated Dynamo process**
- **...**





Dynamo . Tree Column Structure



1 Define parameters

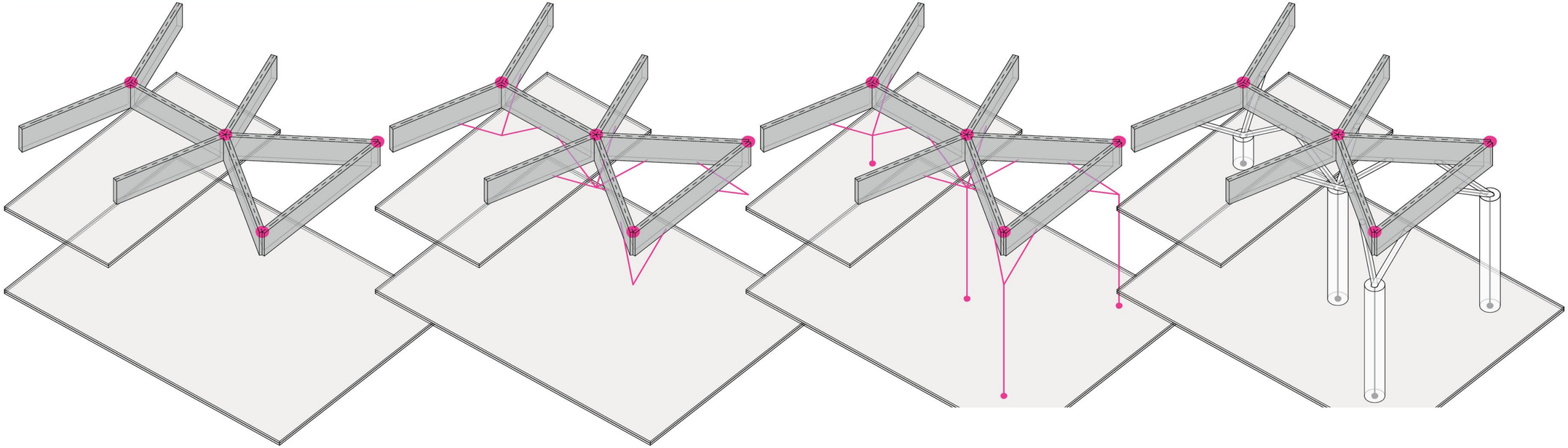
2 Read building elements and their properties from current Revit file, e.g. beams, floors

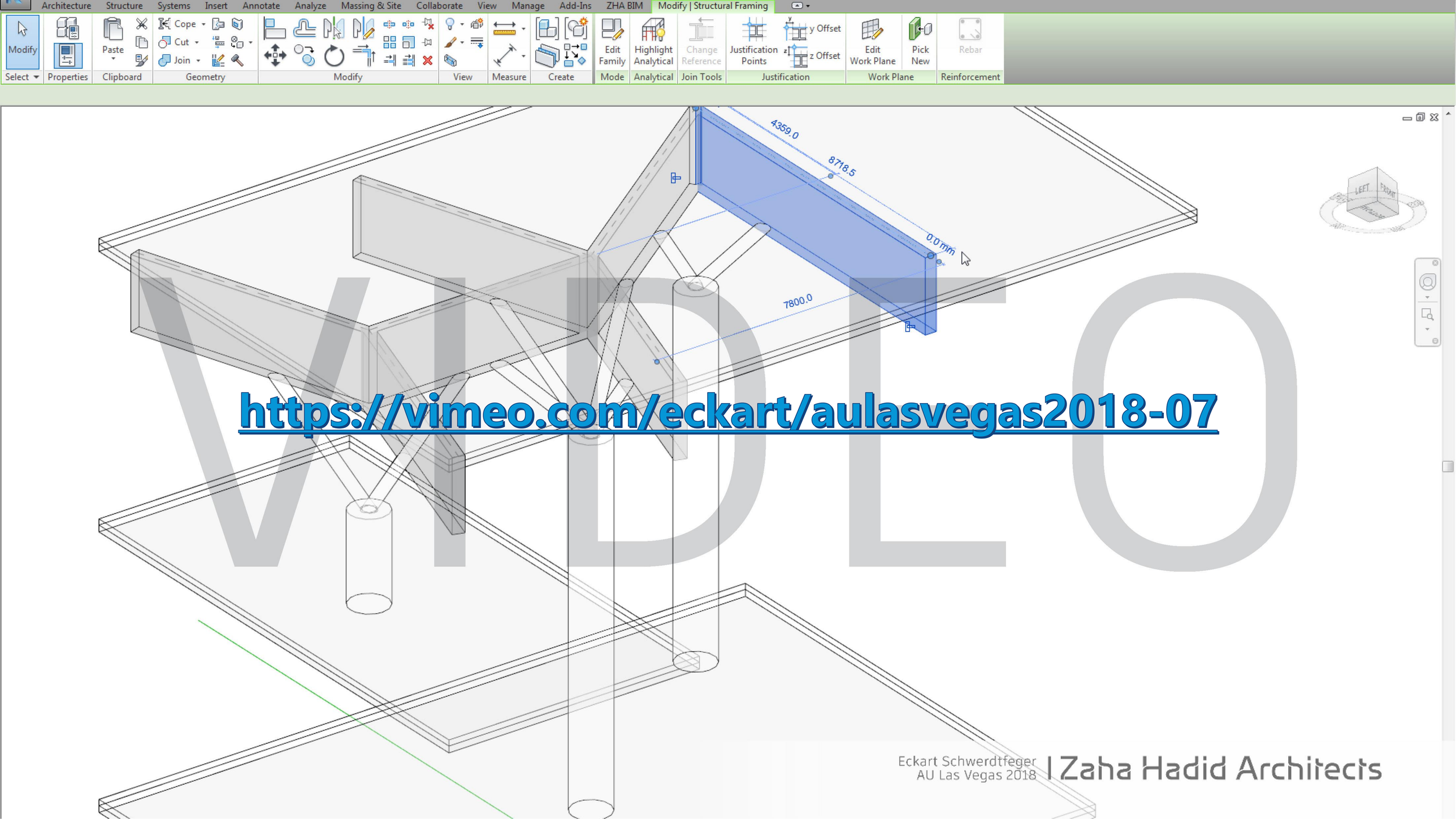
3 Find main beam intersections for tree column placement

4 Generate axis lines for tree column branches

5 Find floor slab below to create tree column trunks

6 Create building elements for branches and trunks

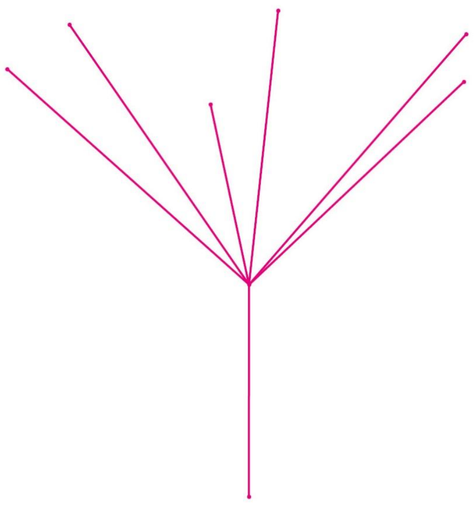



Architecture
Structure
Systems
Insert
Annotate
Analyze
Massing & Site
Collaborate
View
Manage
Add-Ins
ZHA BIM
Modify | Structural Framing
Modify
Select
Properties
Paste
Clipboard
Cope
Cut
Join
Geometry
Modify
View
Measure
Create
Edit Family
Mode
Highlight Analytical
Analytical
Change Reference
Join Tools
Justification Points
y Offset
z Offset
Justification
Edit Work Plane
Pick New
Work Plane
Rebar
Reinforcement
4359.0
8718.5
0.0 mm
7800.0
VIDEO
https://vimeo.com/eckart/aulasvegas2018-07
Eckart Schwerdtfeger
AU Las Vegas 2018
Zaha Hadid Architects

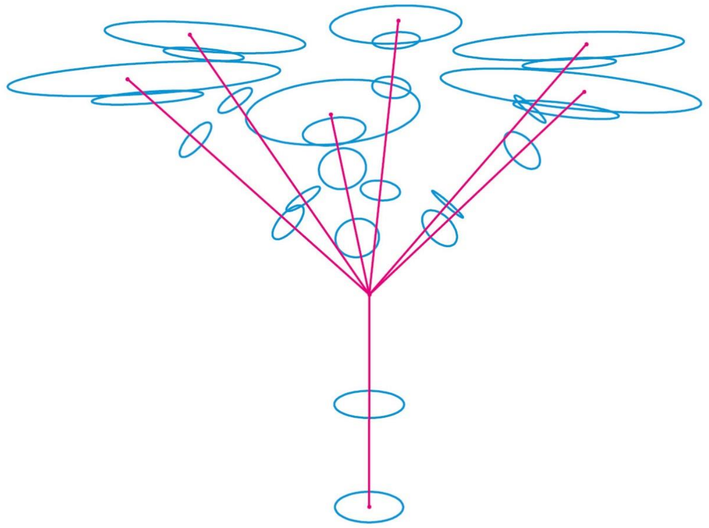
Dynamo . Tree Column Cladding

Process

- Analyse live building model - main beams, floors
- Collect + sort meta data - origin XYZ, height, angles
- Store meta data - csv spreadsheet file
- Generate structure - automated Dynamo process
- **Generate freeform cladding**
- **Automated Dynamo + T-Splines process**



Axis lines

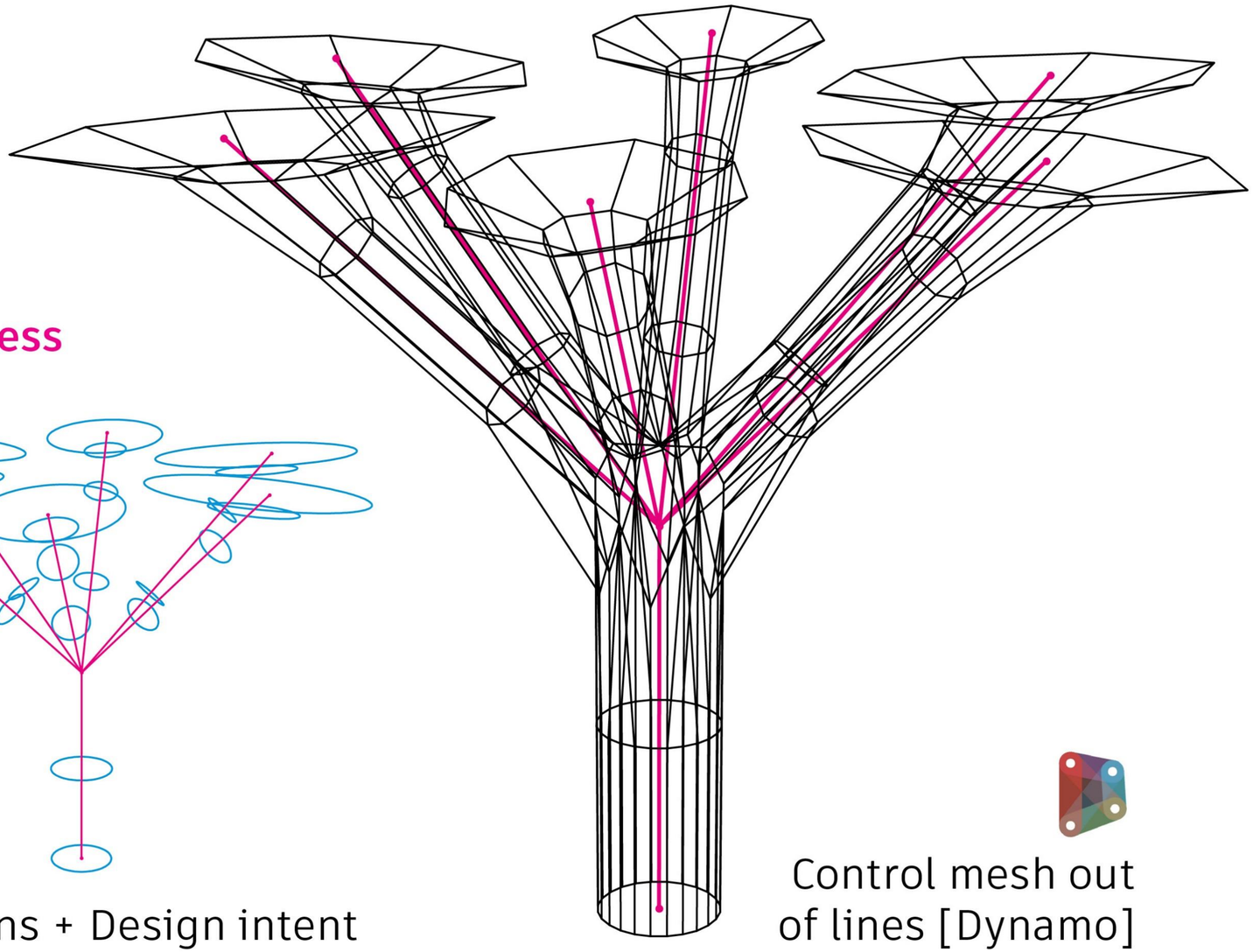


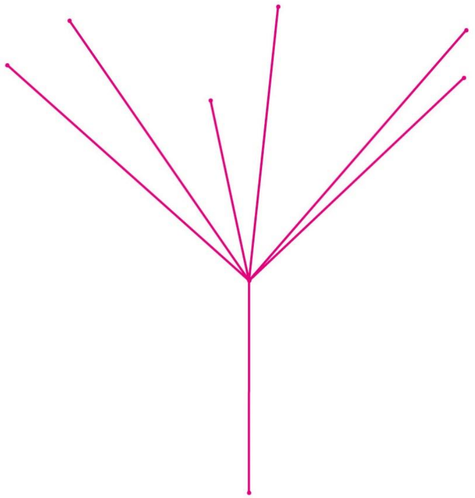
Dimensions + Design intent

Dynamo . Tree Column Cladding

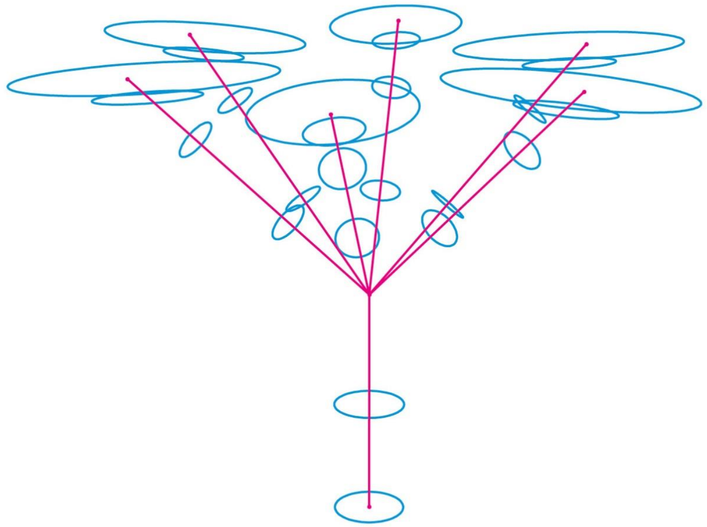
Process

- Analyse live building model
- Collect + sort meta data
- Store meta data
- Generate structure
- **Generate freeform cladding**
- **Automated Dynamo + T-Splines process**





Axis lines



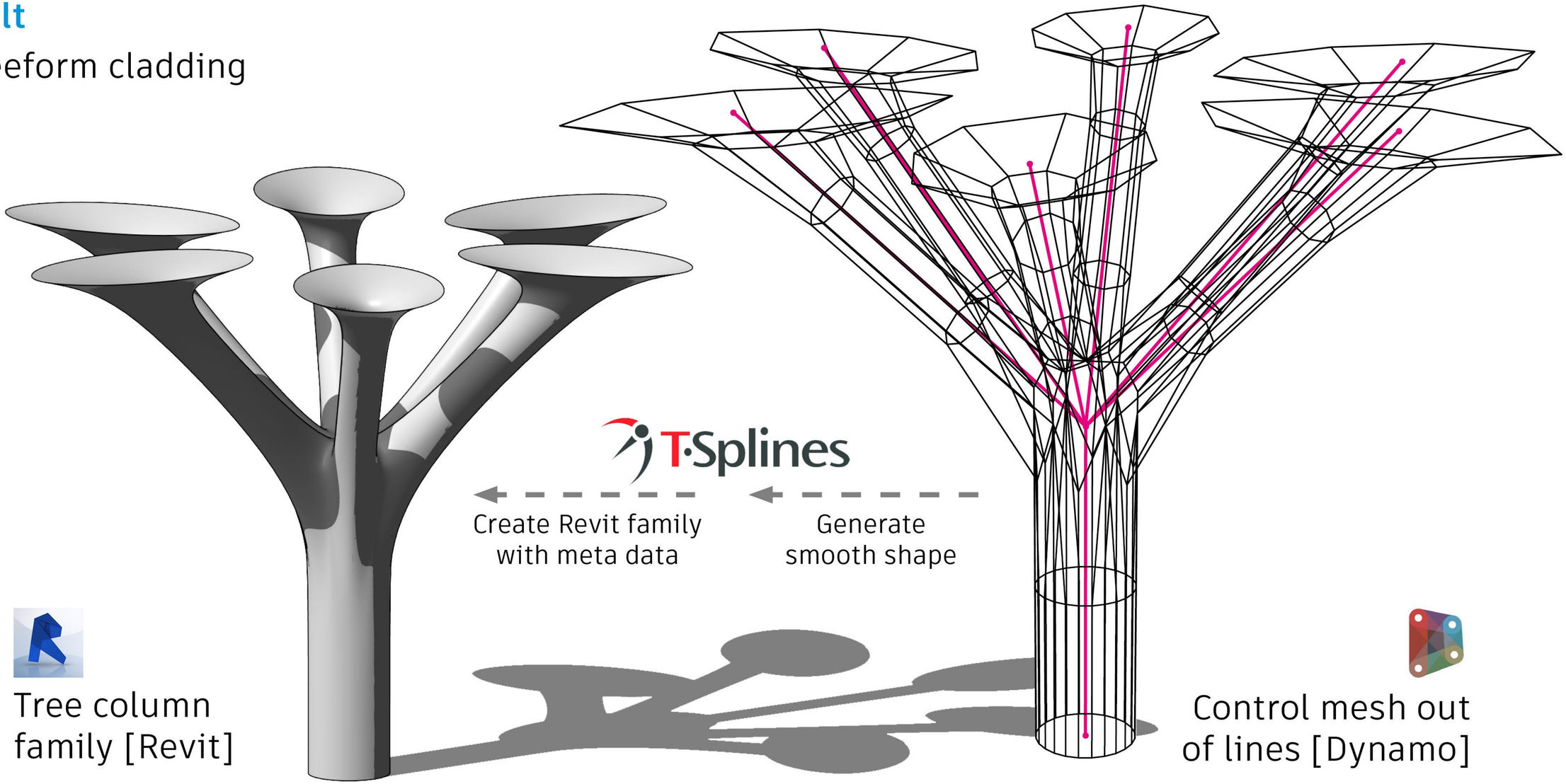
Dimensions + Design intent

Control mesh out of lines [Dynamo]

Dynamo . Tree Column Cladding

Result

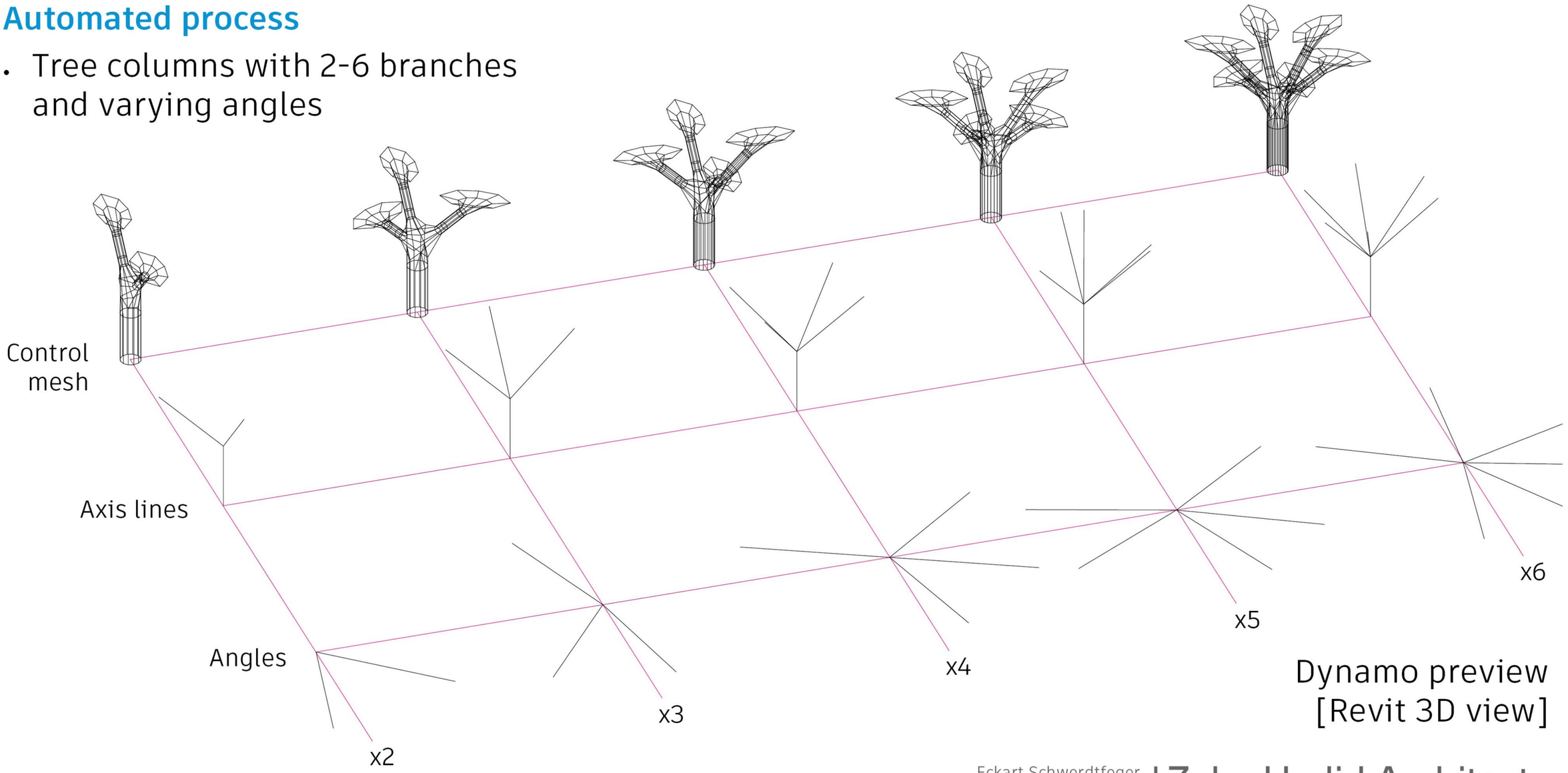
- Freeform cladding



Dynamo . Tree Column Cladding

Automated process

- Tree columns with 2-6 branches and varying angles



Dynamo preview
[Revit 3D view]

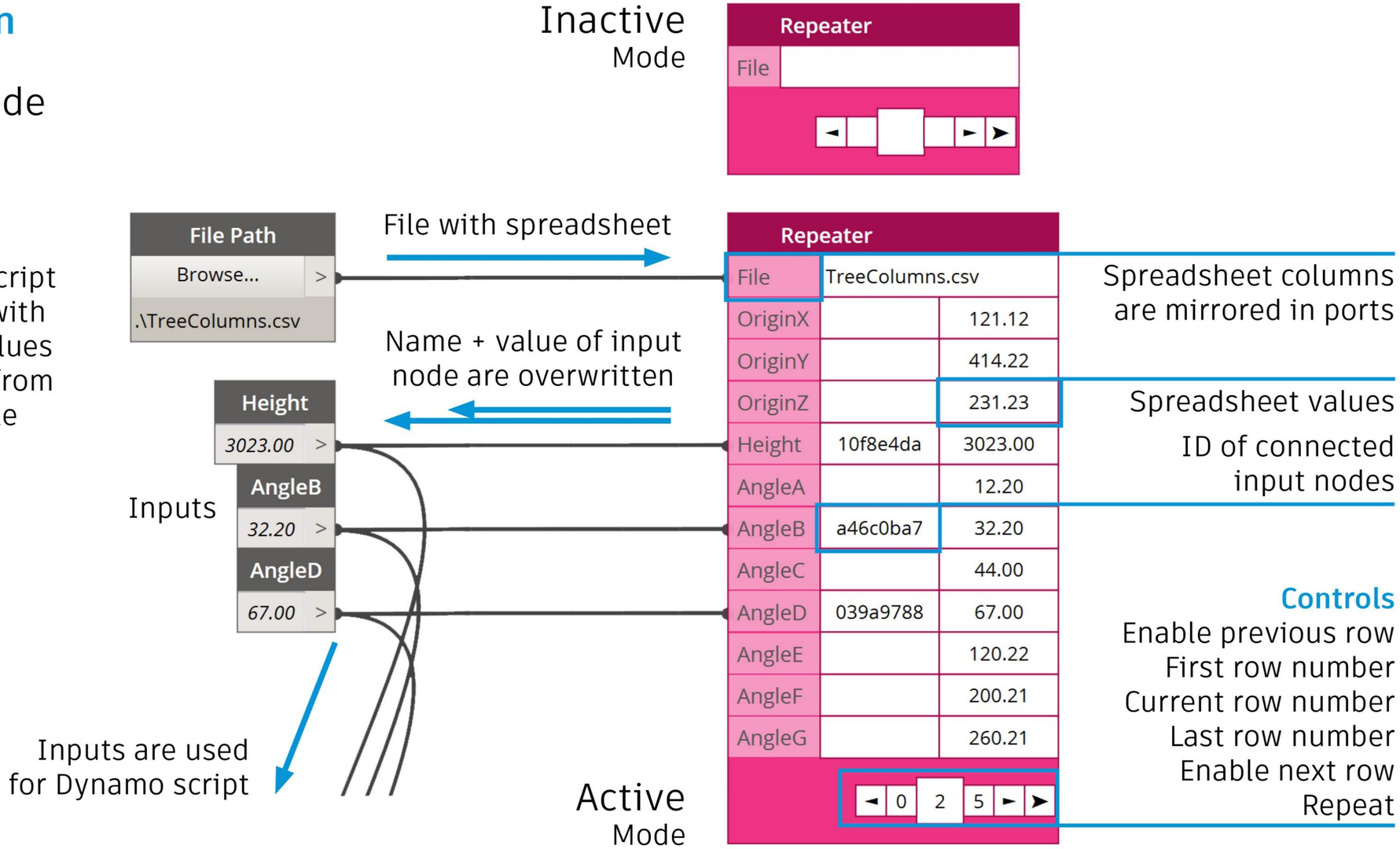
Dynamo . Custom Nodes

Automation Plugin

Repeater Node

Custom user interface node

Run a Dynamo script repeatedly and with varying input values that are loaded from a spreadsheet file



Dynamo

File Edit View Packages Settings Help

TreeColumnRepeater.dyn*

Library

String
C:\TreeColumns\TreeColumns.csv

OriginX 40.000
OriginZ 0.000
AngleA 60.000
AngleC 211.469
AngleE 289.533
Index 14.000

OriginY -20.000
Height 4.600
AngleB 170.125
AngleD 250.498
AngleF 354.875

Repeater

File	TreeColumns.csv	
OriginX	3f5d88a6	40.0
OriginY	0282b840	-20.0
OriginZ	637f796b	0.0
Height	902e17c1	4.6
AngleA	91ccc959	60.000
AngleB	23960d4c	170.125
AngleD	14d88925	250.498
AngleE	bb4d8348	289.533
AngleF	284de04d	354.875
Index	b63df52e	14

0 13 14

Empty Dictionary

List Create
item0 + - list

https://vimeo.com/eckart/aulasvegas2018-08

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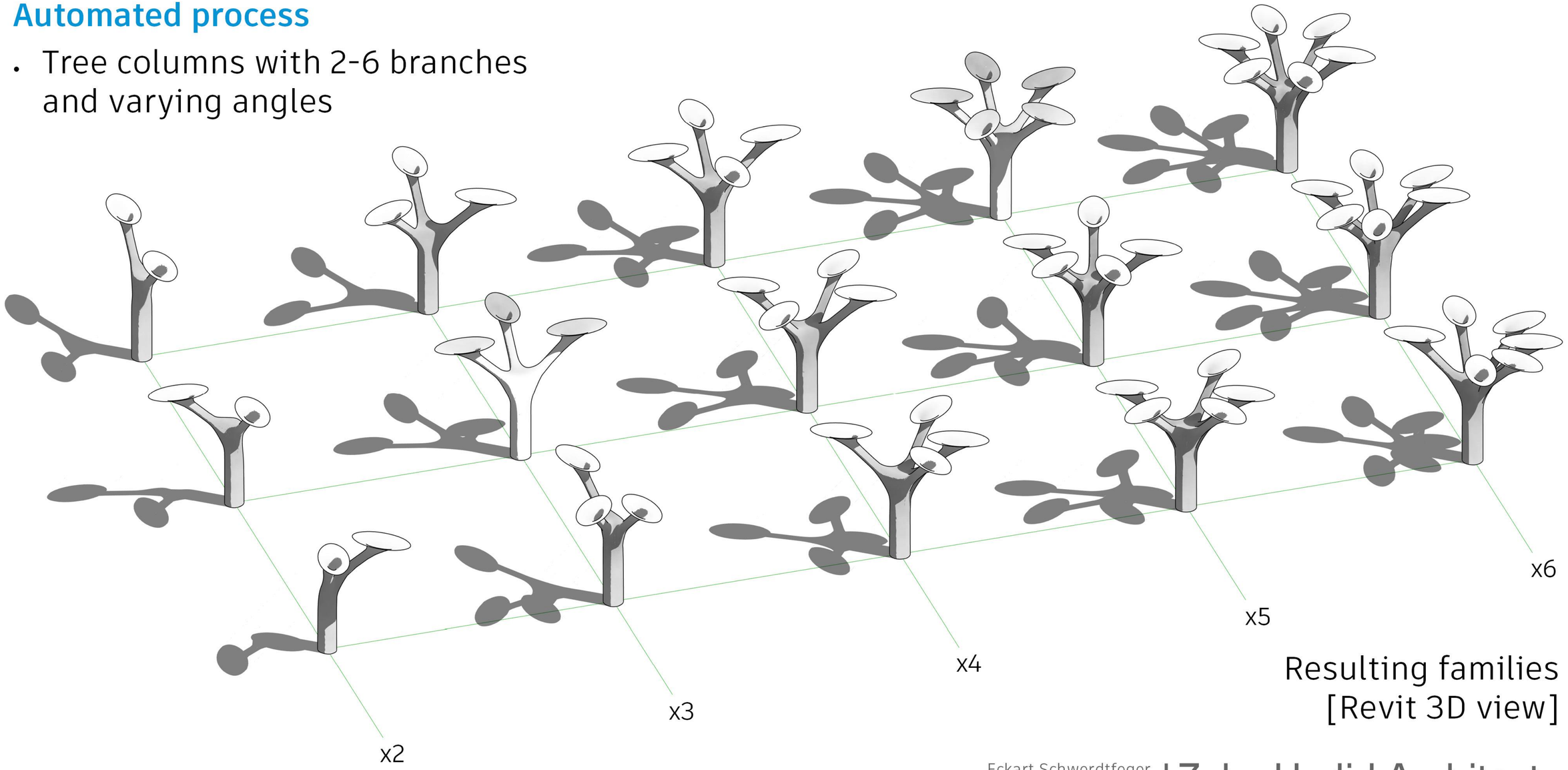
Automatic

Run completed.

Dynamo . Tree Column Cladding

Automated process

- Tree columns with 2-6 branches and varying angles



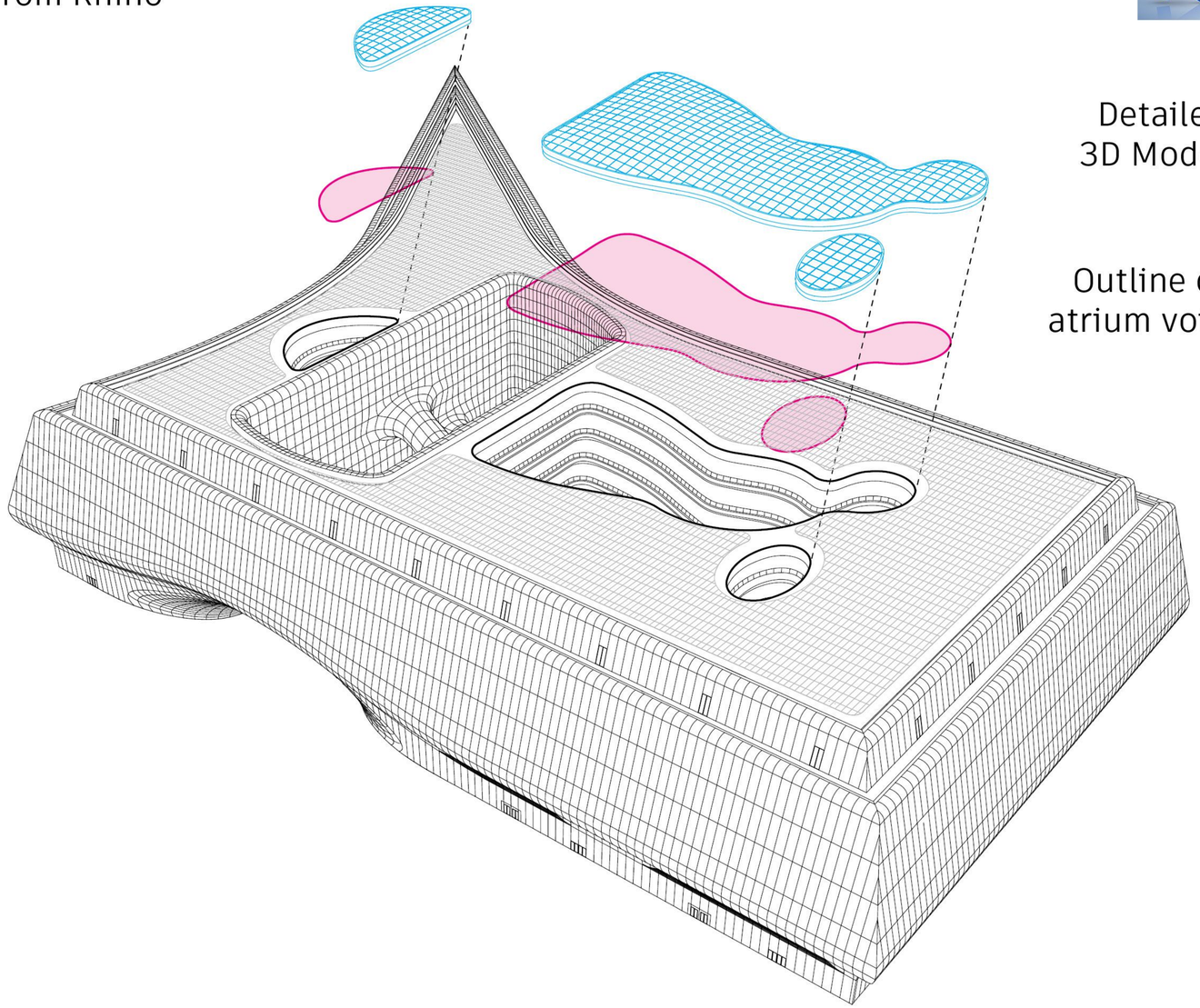
Resulting families
[Revit 3D view]

Dynamo . Skylight

Base geometry
from Rhino

?

BIM 3D model with
meta data + schedules

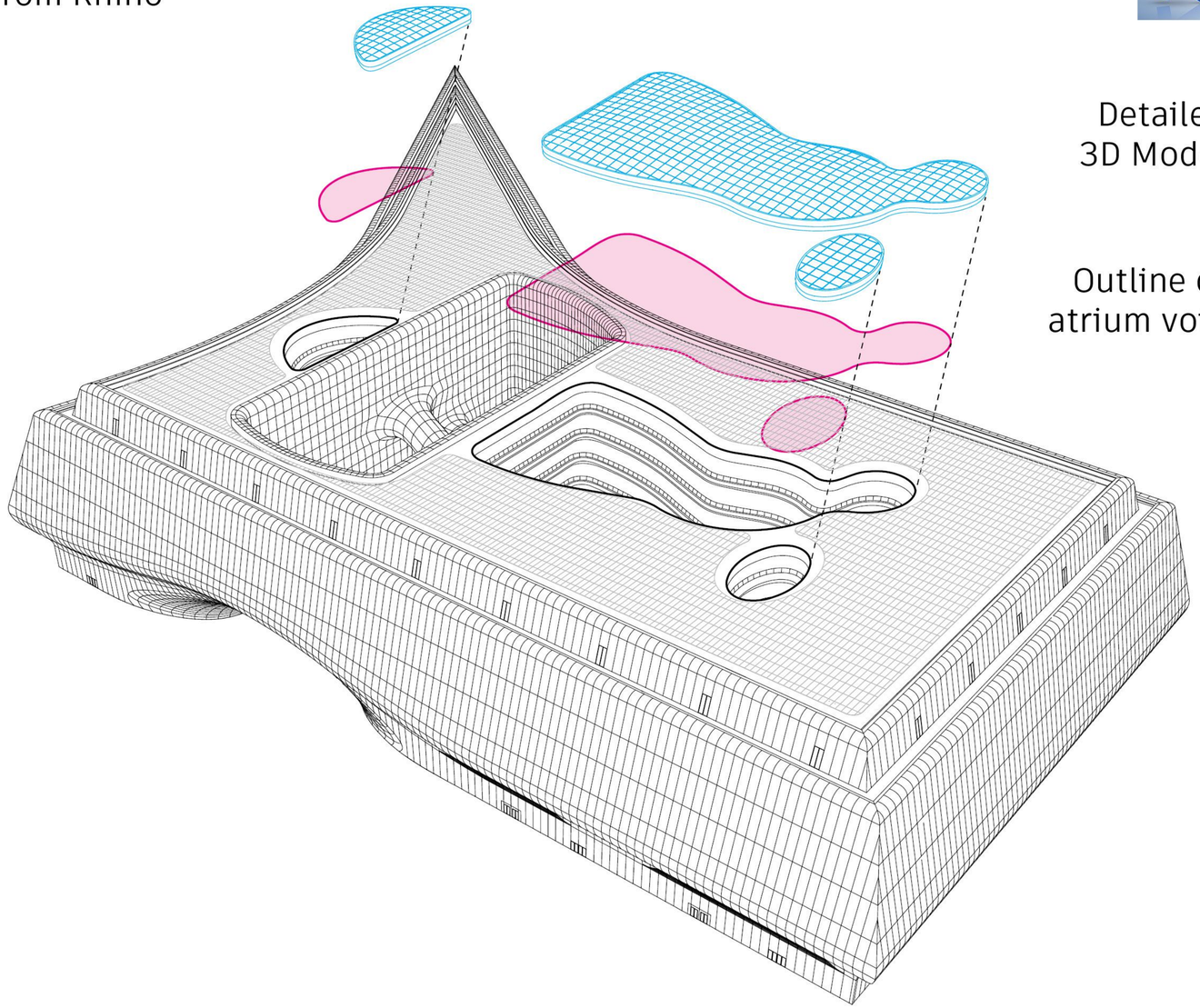


Dynamo . Skylight

Base geometry from Rhino

?

BIM 3D model with meta data + schedules



Detailed 3D Model

Outline of atrium void

Aims

- Exchange geometry via cloud server
- Visual scripting in Revit
- Structurally sound design via physics simulation
- Detailled model generated by Dynamo + Revit

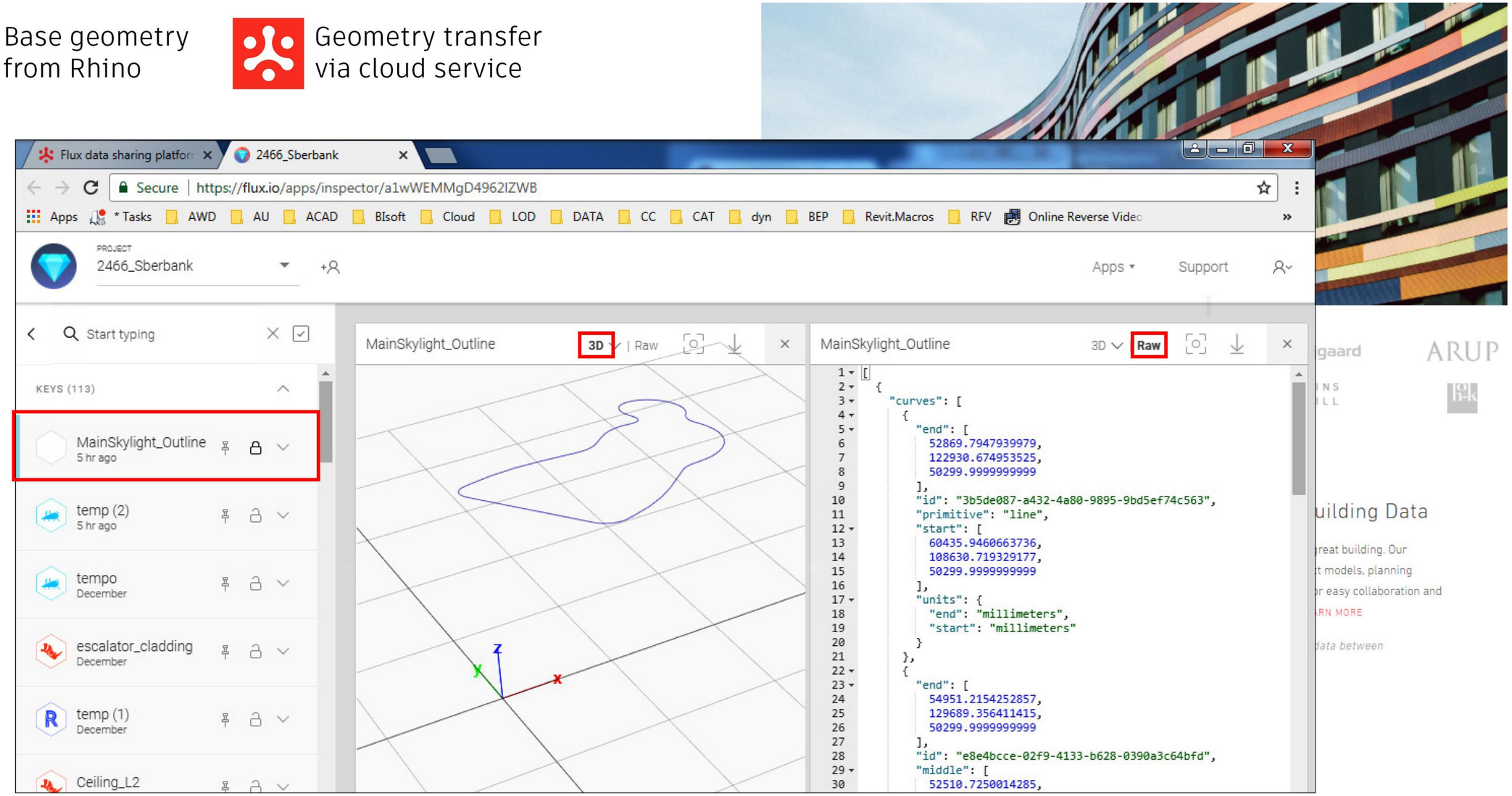
Dynamo . Skylight

FLUX

Predictably Great Building™
Connecting Architects, Engineers, and Contractors
to the information they need, when they need it.

Base geometry
from Rhino

Geometry transfer
via cloud service

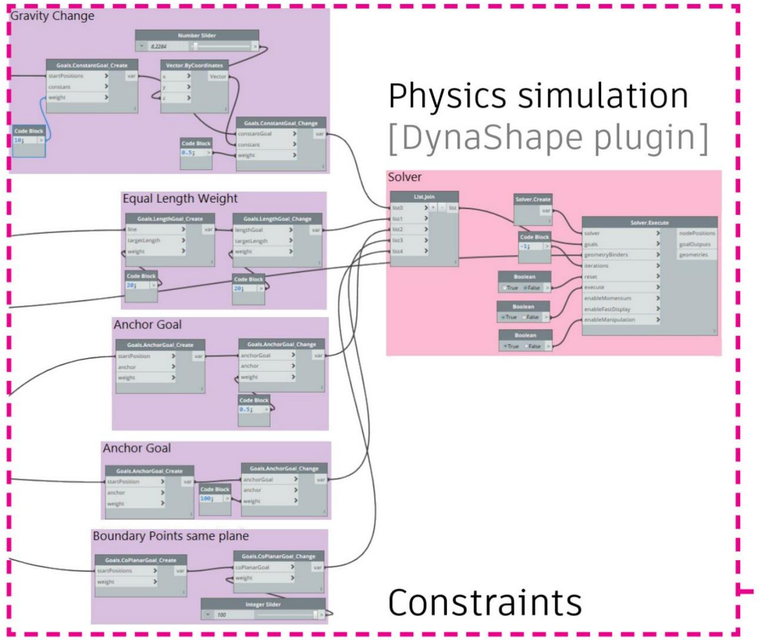


Dynamo . Skylight

Base geometry from Rhino

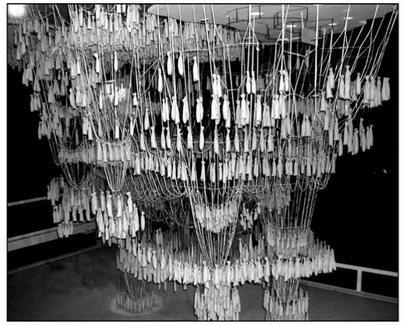
Geometry transfer via cloud service

Visual scripting
Physics simulation

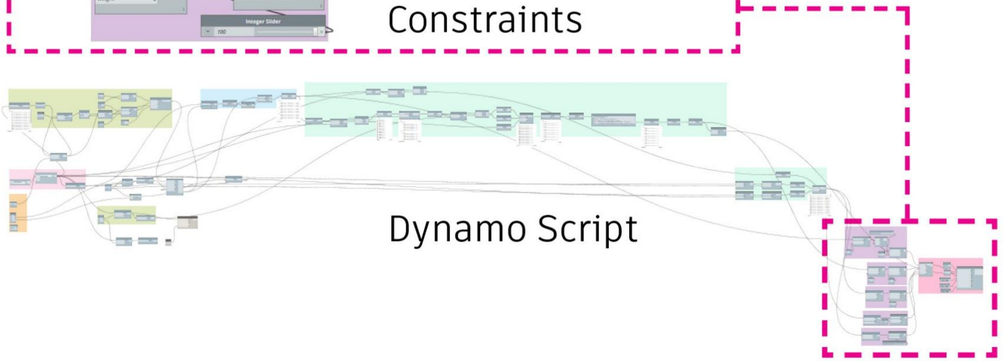


Physics simulation
[DynaShape plugin]

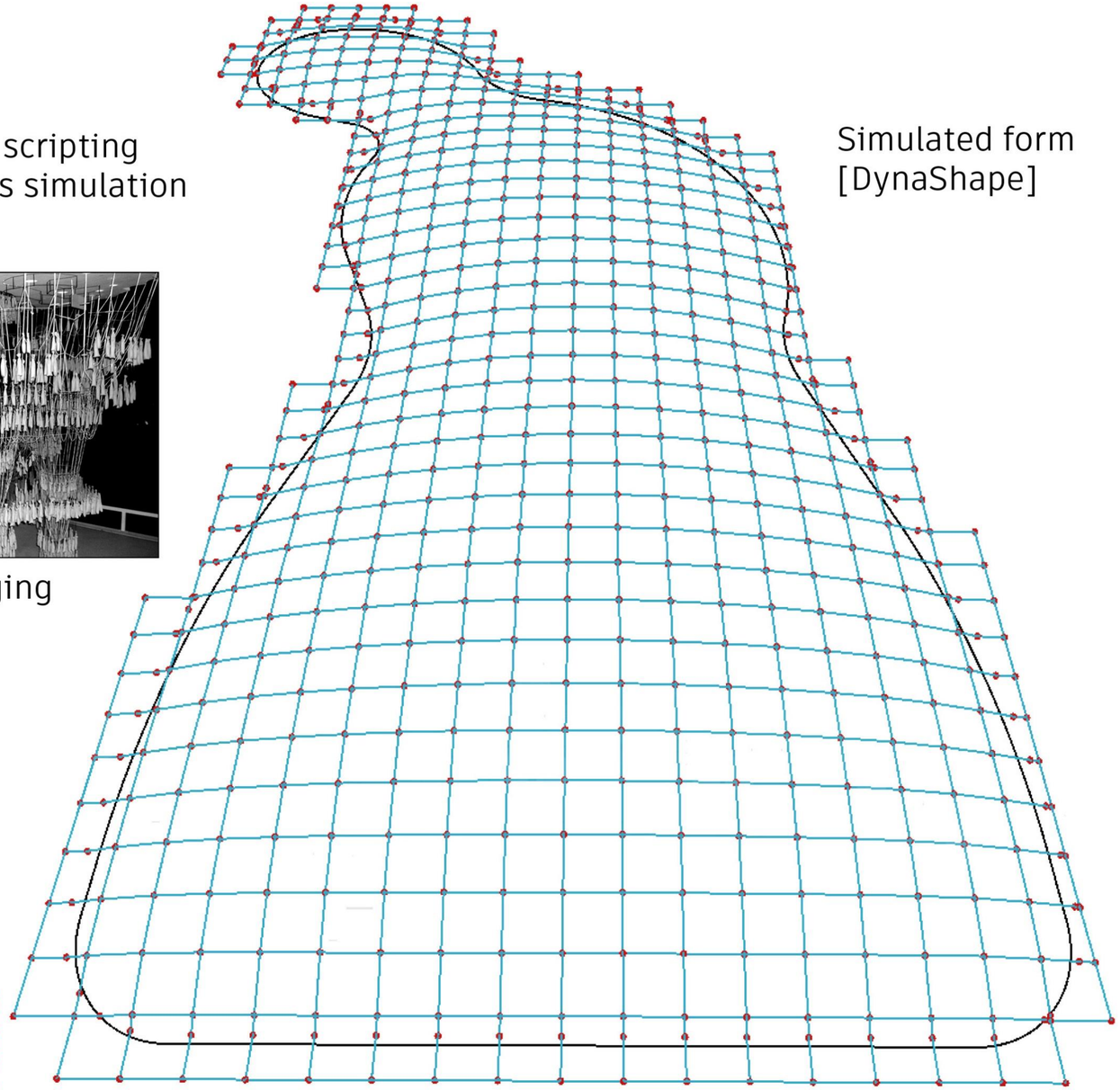
Constraints



Gaudi . Hanging chain model

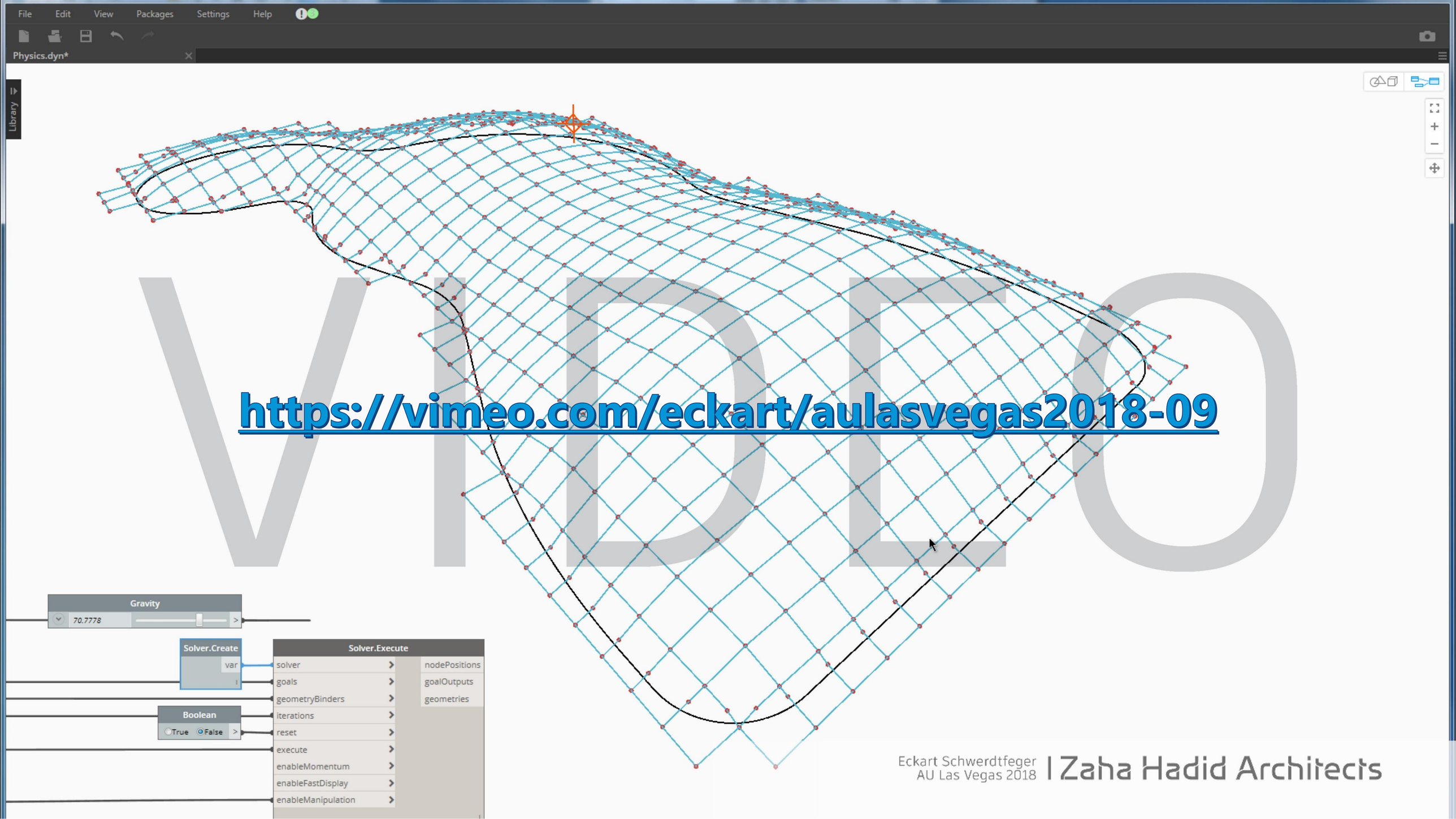


Dynamo Script



Simulated form
[DynaShape]

Dynamo script by Mauro Sabiu
DynaShape plugin by Long Nguyen


File
Edit
View
Packages
Settings
Help
Physics.dyn*
Library
VIDEO
https://vimeo.com/eckart/aulasvegas2018-09
Gravity
70.7778
Solver.Create
var
Solver.Execute
solver
goals
geometryBinders
iterations
reset
execute
enableMomentum
enableFastDisplay
enableManipulation
nodePositions
goalOutputs
geometries
Boolean
True
False
Eckart Schwerdtfeger
AU Las Vegas 2018
Zaha Hadid Architects

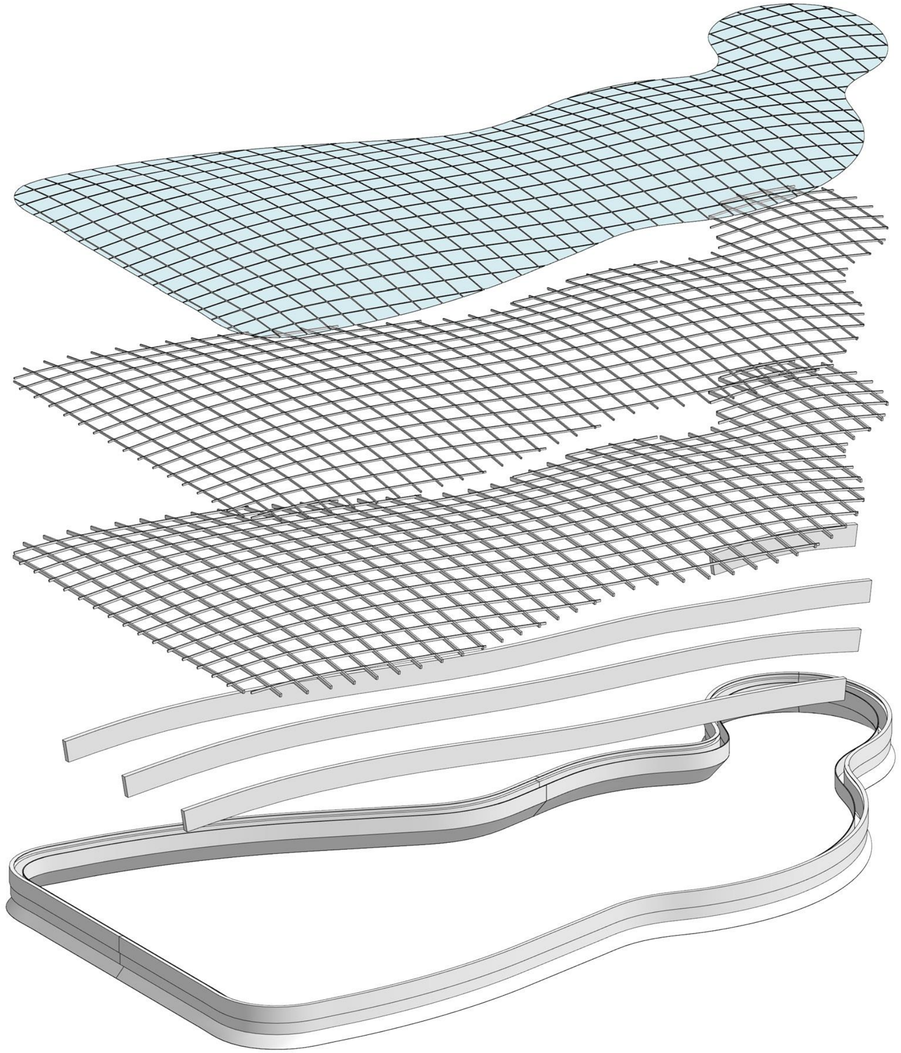
Dynamo . Skylight

Base geometry
from Rhino

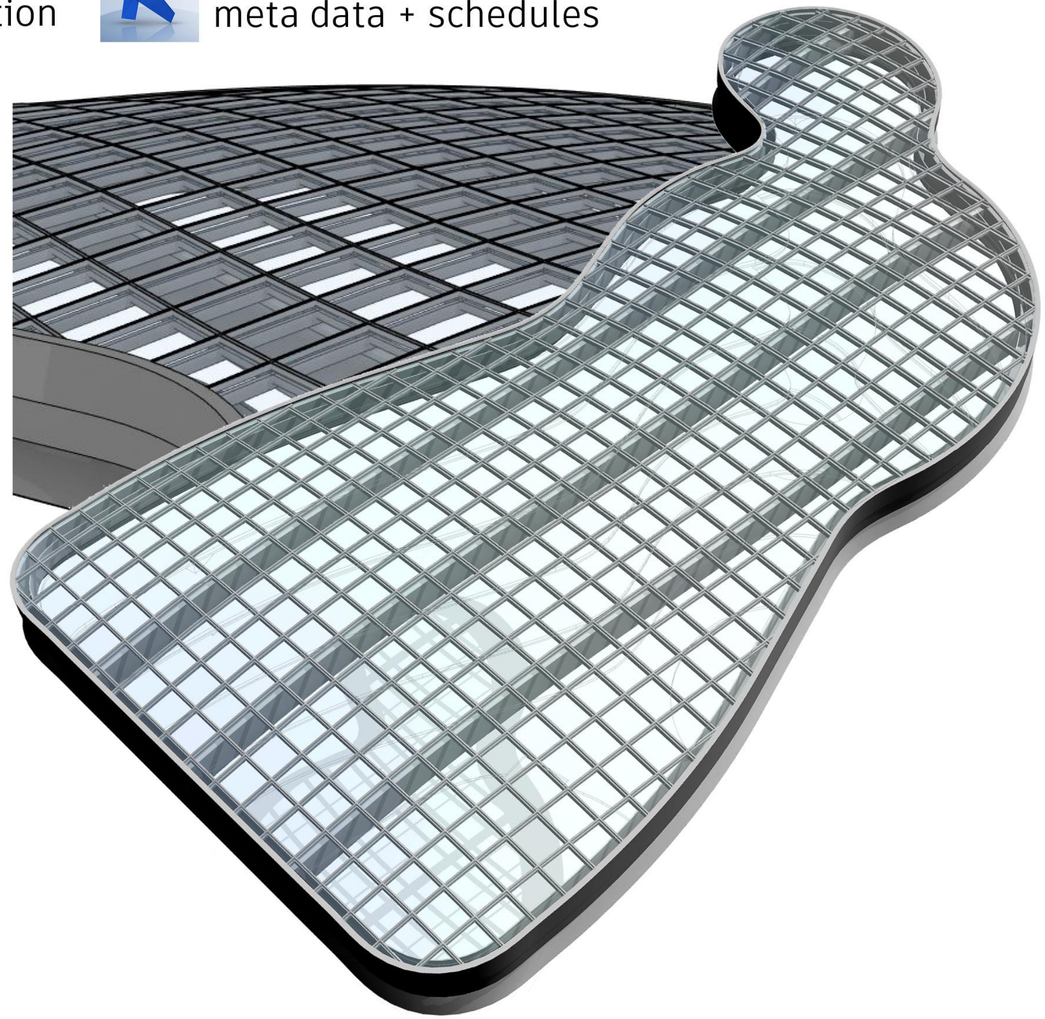
Geometry transfer
via cloud service

Visual scripting
Physics simulation

BIM 3D model with
meta data + schedules



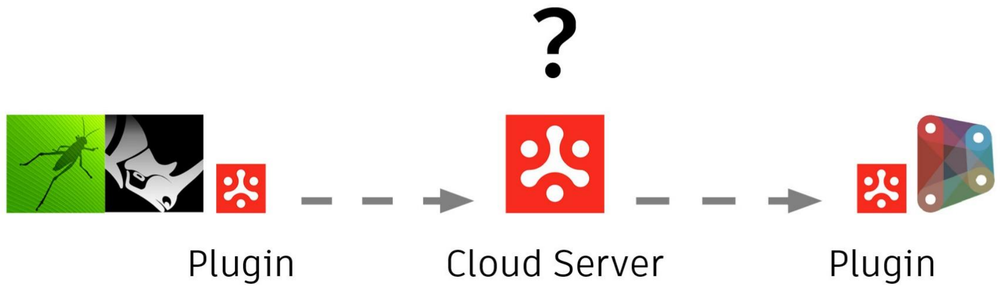
Panels
Profiles
Structure
Beams
Cladding

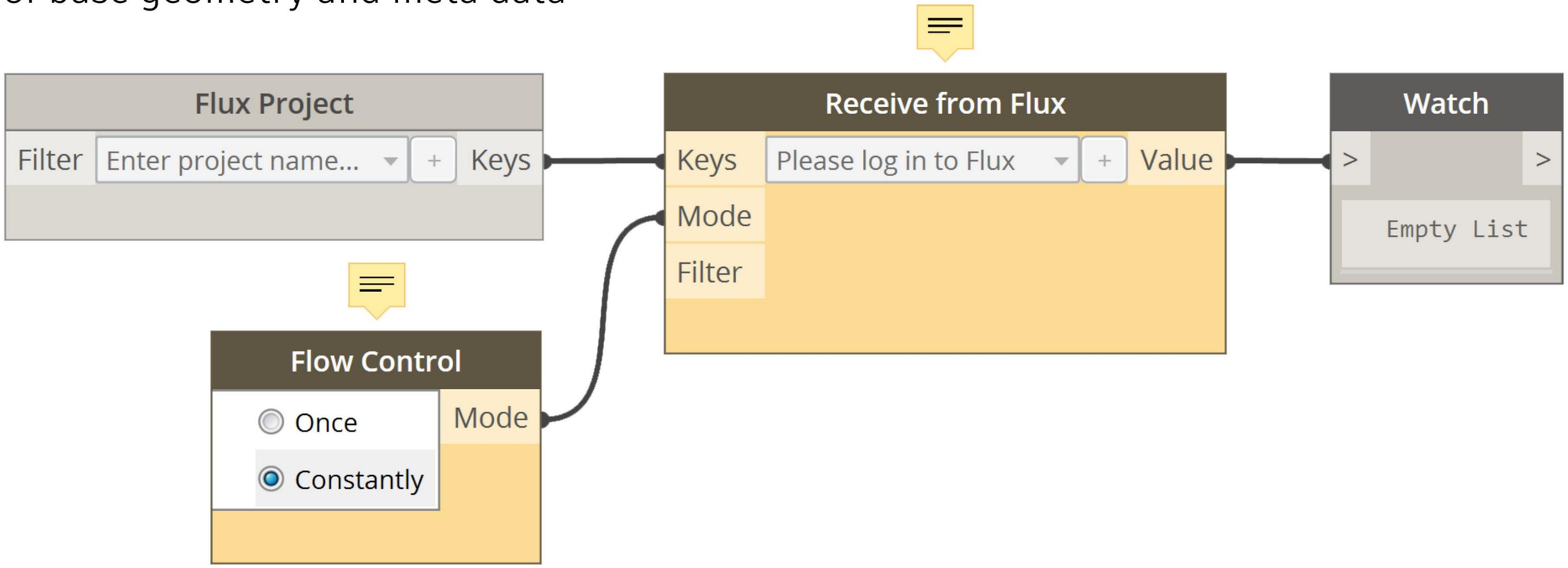


Dynamo . Custom Nodes

Cloud Plugin

for cross-application transfer
of base geometry and meta data

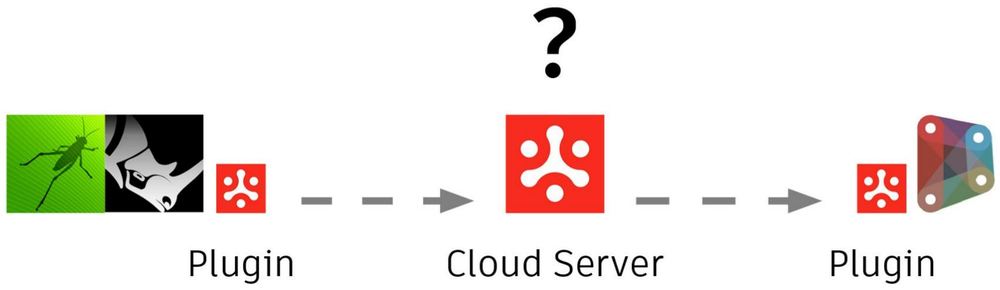


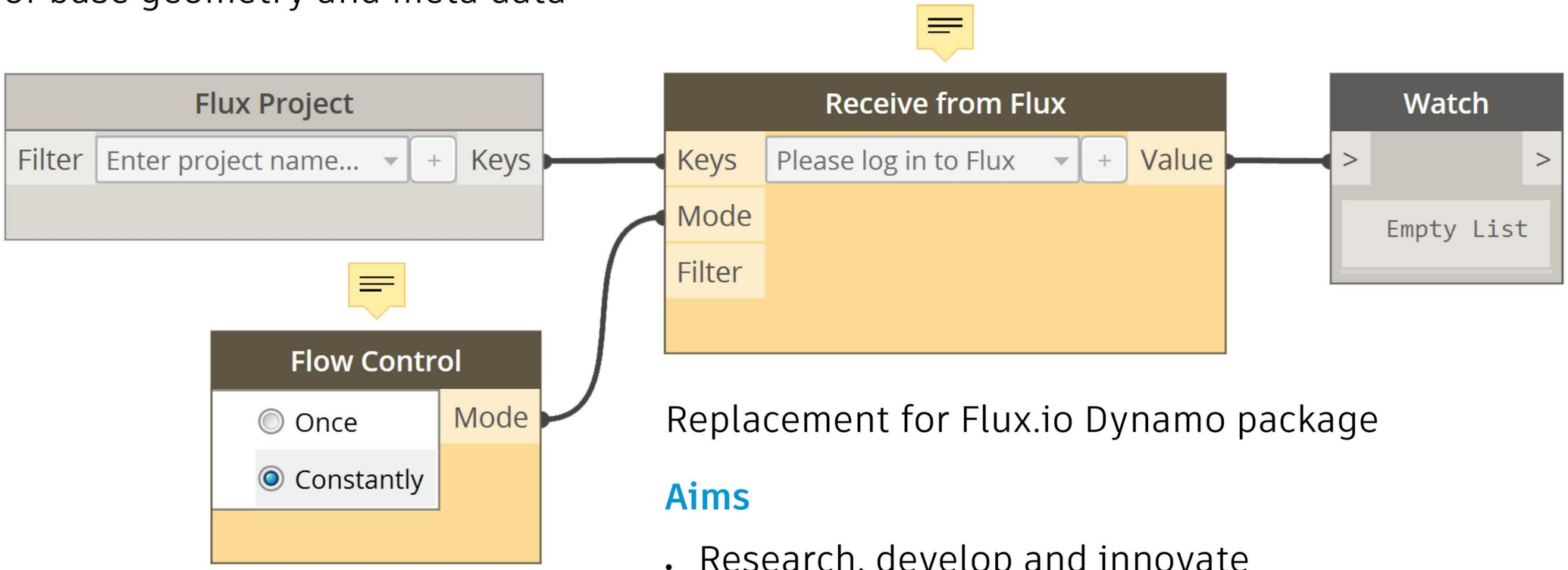


Dynamo . Custom Nodes

Cloud Plugin

for cross-application transfer
of base geometry and meta data





Replacement for Flux.io Dynamo package

Aims

- Research, develop and innovate
- Efficient, intelligent and adaptable nodes
- Better user interaction and user friendlyness

Dynamo . Custom Nodes

Cloud Plugin

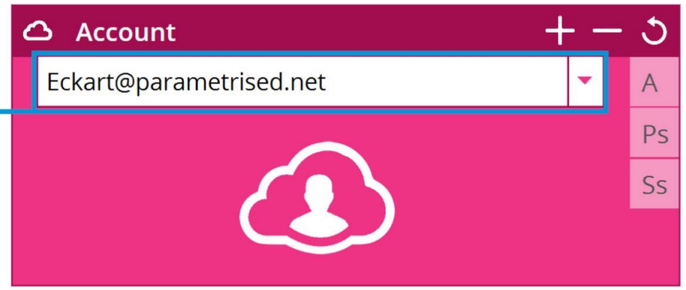
Account Node

Custom user interface node

Select an existing account or login + register a new account

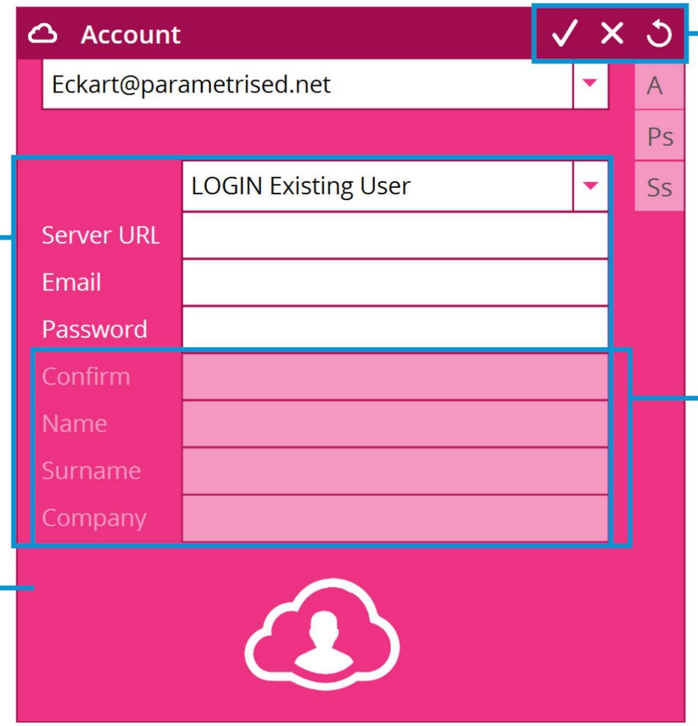
Account selection

Account Selection Mode



Account
Projects
Streams

Account Login + Registration Mode



Adaptive windows-like control buttons for additional functions

e.g.
Add, delete account, submit, cancel, reload

All necessary functionality is embedded inside node

Node layout adapts on the fly

User interface adapts to user interaction for guidance

Custom colour scheme

Dynamo

File Edit View Packages Settings Help

Account2.dyn*

Library

Account

Test@parametrised.net

LOGIN Existing User

Server URL https://cloudserver

Email

Password

Confirm

Name

Surname

Company

A

Ps

Ss

Account

Account: Test@parametrised.net

Projects

List

2 Project: Indian project

@L2 @L1 {3}

Streams

List

0 Stream: SJkT7UGjf // GeoTest

1 Stream: SknlIzhsG // Anonymous

2 Stream: ryghlhnif // MeshTree

3 Stream: ry4_Sb0oG // Anonymous

4 Stream: [illegible] // Anonymous

5 Stream: B1p2dwvaz // Nurbs Test

6 Stream: Bk_bd0vaz // Anonymous

Dynamo . Custom Nodes

Cloud Plugin

Stream Node

Custom user interface node

Select a data stream and receive the associated geometry + meta data

Stream selection

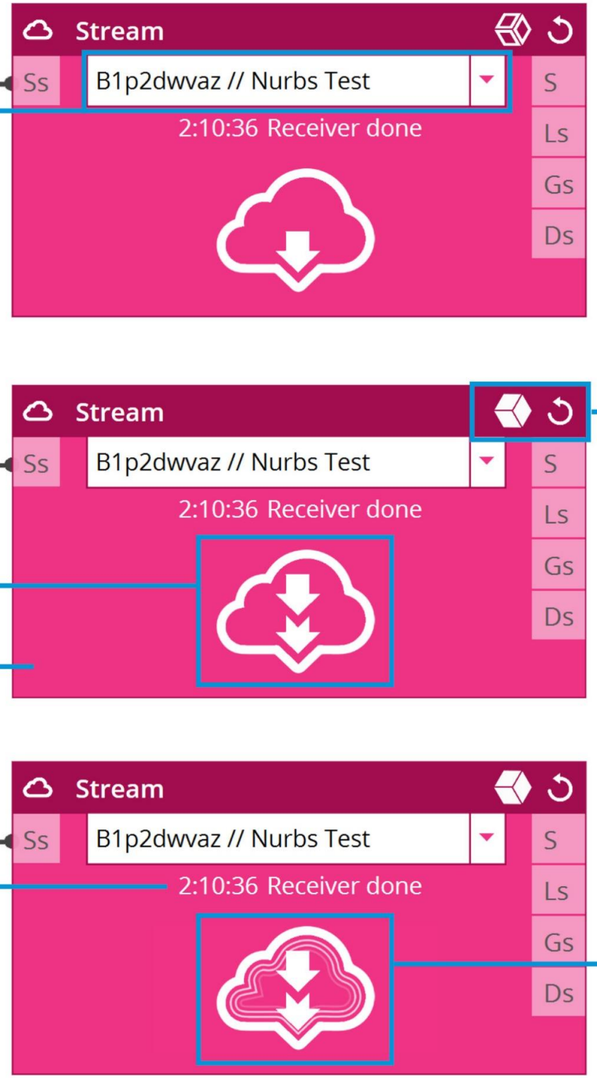
Manual Updates Mode

Automatic Updates Mode

Click icon to switch mode

Custom colour scheme

Live messages from executing code



Stream
Layers
Geometries
Dictionaries

Adaptive windows-like control buttons for additional functions

e.g.
Load geometry, reload

Animation triggered on server interaction


Dynamo
File
Edit
View
Packages
Settings
Help
Simple.dyn*
Library
Account
Eckart@parametrised.net
A
Ps
Ss
Stream
Ss
rJQFhJoyX // Geometry B
17:37:32 Receiver done
S
Ls
Gs
Ds
Stream
Stream: rJQFhJoyX // Geometry B
Geometry
List
0 EllipseArc(Normal = Vector(X =
1 EllipseArc(Normal = Vector(X =
2 EllipseArc(Normal = Vector(X =
3 EllipseArc(Normal = Vector(X =
4 EllipseArc(Normal = Vector(X =
5 EllipseArc(Normal = Vector(X =
6 EllipseArc(Normal = Vector(X =
7 EllipseArc(Normal = Vector(X =
8 NurbsCurve(Degree = 3)
9 NurbsCurve(Degree = 3)
10 NurbsCurve(Degree = 3)
11 NurbsCurve(Degree = 3)
12 NurbsCurve(Degree = 3)
13 NurbsCurve(Degree = 3)
14 NurbsCurve(Degree = 3)
MetaData
List
0 Dictionary
number 435.324
string TestString
integer 352
1 Dictionary
number 435.324
string TestString
integer 352
2 Dictionary
number 435.324
string TestString
integer 352
3 Dictionary
number 435.324
string TestString
integer 352
4 Dictionary
@L2 @L1
{26}
Layers
List
0 Layer: arcs // 8 Objects
1 Layer: nurbs // 8 Objects
2 Layer: polycurves // 1 Objects
3 Layer: planes // 8 Objects
https://vimeo.com/eckart/aulasvegas2018-11
VIDEO
Eckart Schwerdtfeger
AU Las Vegas 2018
Zaha Hadid Architects

Dynamo . Custom Nodes

Cloud Plugin

Stream Node

Custom user interface node

Responsive colour schemes

Visualise node status and events

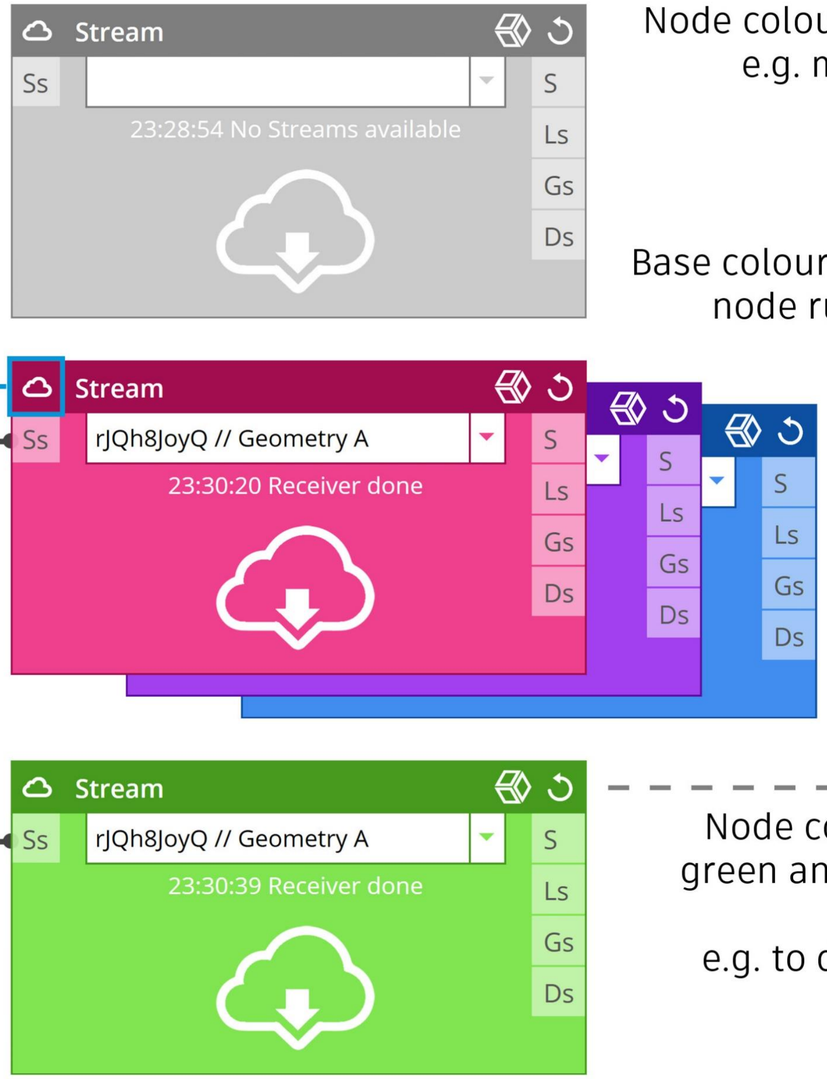
Enable user customisation

Inactive Mode

Colour scheme can be individualised and is stored in Dynamo file

Active Mode

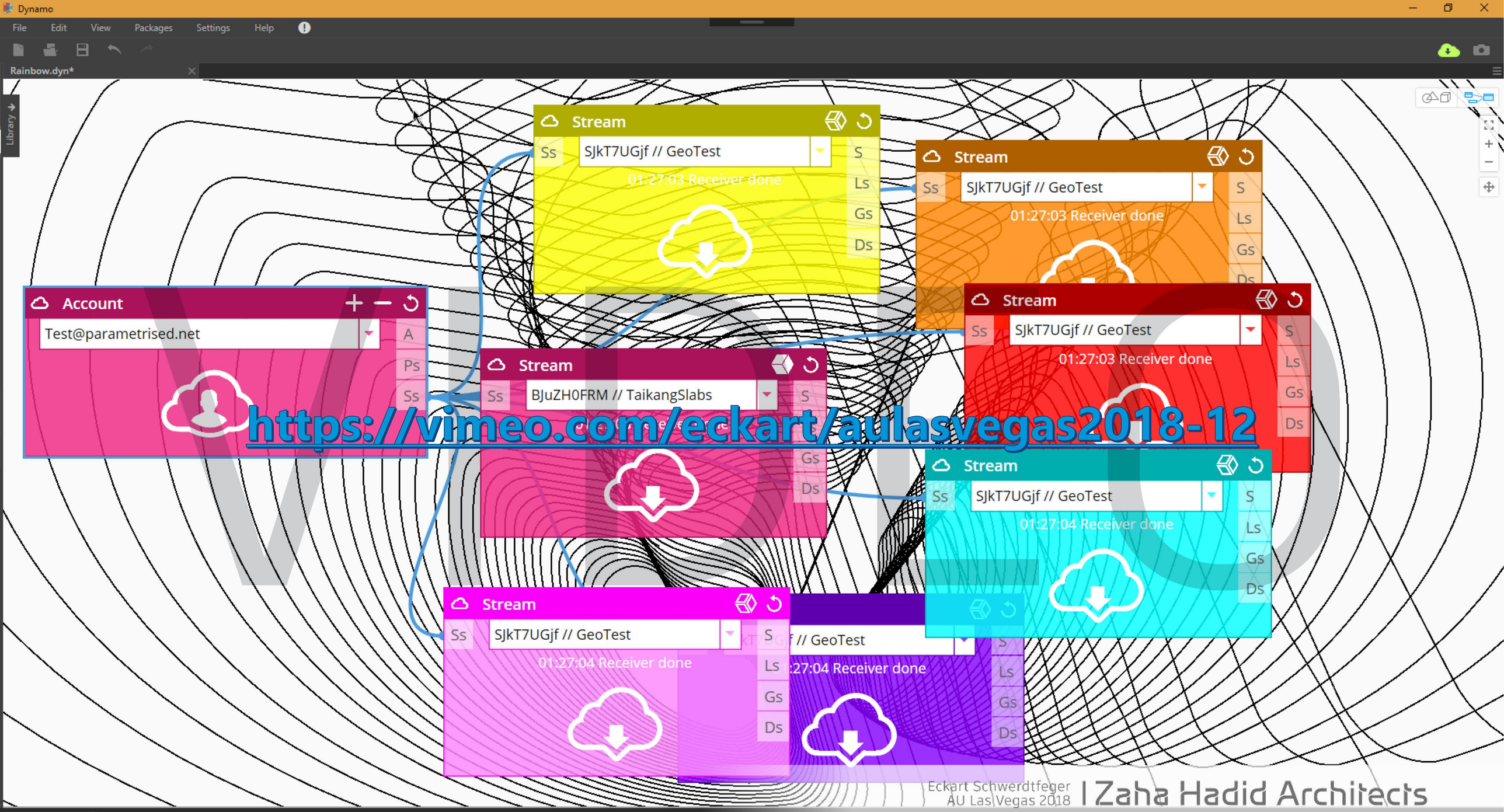
Elevated Mode



Node colour greyed out e.g. missing input

Base colour active when node runs normally

Node colour flashes green and fades back to normal e.g. to display event


Dynamo
File
Edit
View
Packages
Settings
Help
Rainbow.dyn*
Library
Stream
Ss
SJkT7UGjf // GeoTest
01:27:03 Receiver done
S
Ls
Gs
Ds
Account
Test@parametrised.net
A
Ps
BJuZH0FRM // TaikangSlabs
01:27:04 Receiver done
https://vimeo.com/eckart/aulasvegas2018-12
Eckart Schwerdtfeger
AU Las Vegas 2018
Zaha Hadid Architects
Automatic
Run completed.

Dynamo . Extensions

ViewExtension Plugin

Custom Nodes

can integrate new user interfaces + functionality within Dynamo nodes

Access is restricted to the current node

Extensions

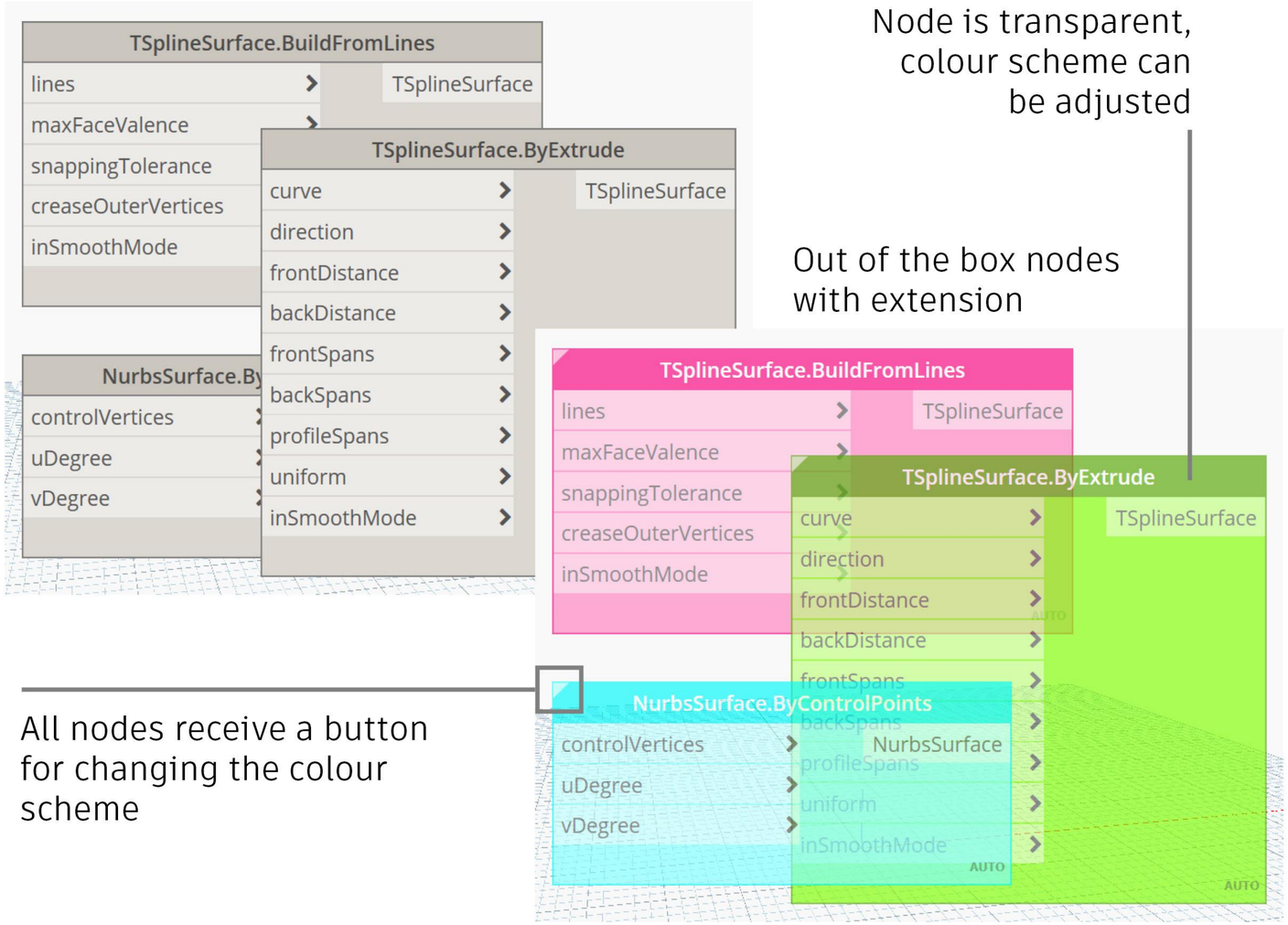
have access to Dynamo + the open script and enable global functionalities and adaptations

e.g.
Individualisation of standard nodes

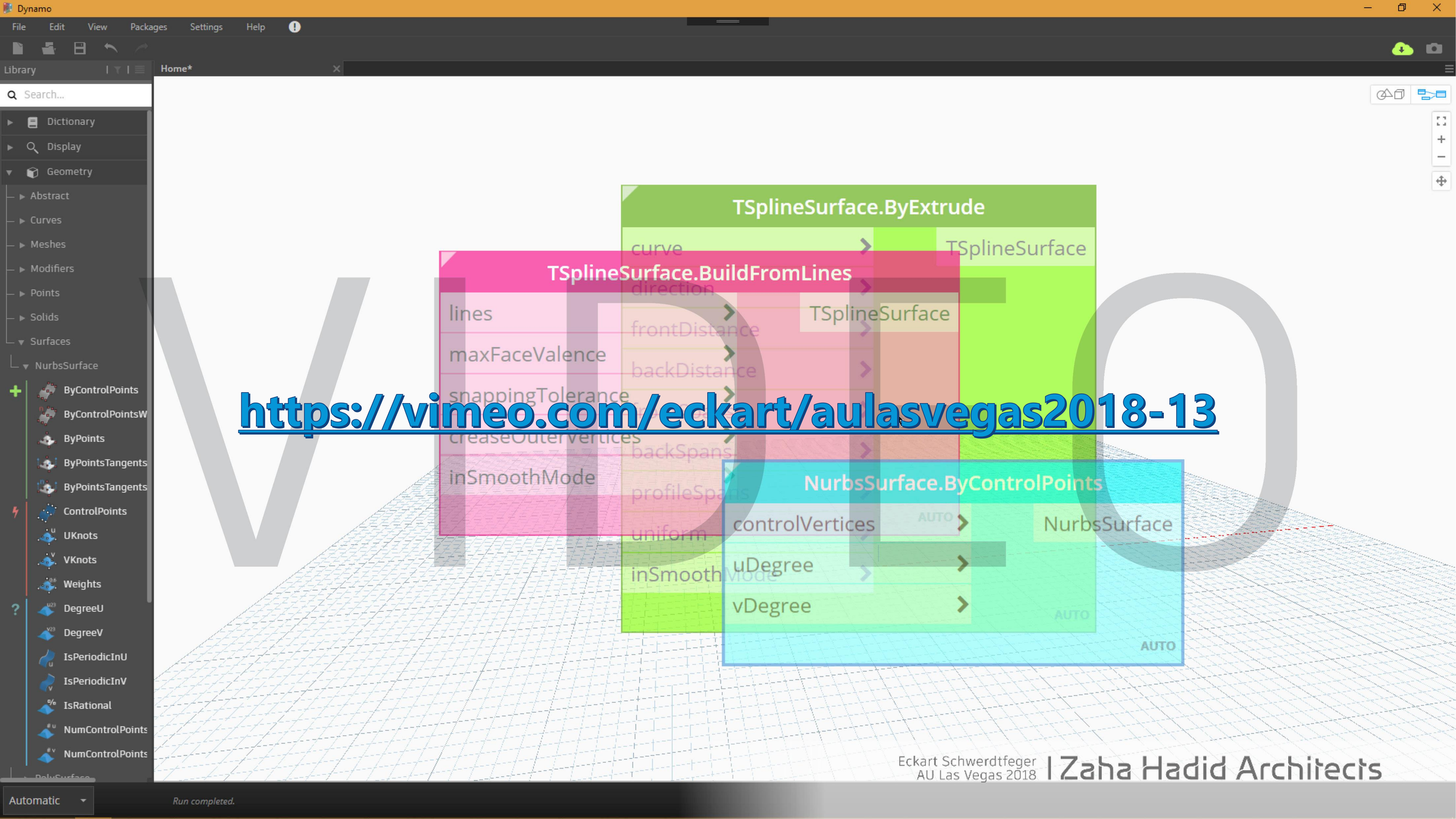
Out of the box nodes without extension

Node is transparent, colour scheme can be adjusted

Out of the box nodes with extension



All nodes receive a button for changing the colour scheme


Dynamo
File
Edit
View
Packages
Settings
Help
Library
Home*
Search...
Dictionary
Display
Geometry
Abstract
Curves
Meshes
Modifiers
Points
Solids
Surfaces
NurbsSurface
ByControlPoints
ByControlPointsW
ByPoints
ByPointsTangents
ByPointsTangents
ControlPoints
UKnots
VKnots
Weights
DegreeU
DegreeV
IsPeriodicInU
IsPeriodicInV
IsRational
NumControlPoints
NumControlPoints
TSplineSurface.ByExtrude
curve
direction
frontDistance
backDistance
backSpans
profileSpans
uniform
inSmoothMode
TSplineSurface
TSplineSurface.BuildFromLines
lines
maxFaceValence
snappingTolerance
creaseOuterVertices
inSmoothMode
TSplineSurface
NurbsSurface.ByControlPoints
controlVertices
uDegree
vDegree
AUTO
NurbsSurface
AUTO
AUTO
https://vimeo.com/eckart/aulasvegas2018-13
VIDEO
Eckart Schwerdtfeger
AU Las Vegas 2018
Zaha Hadid Architects
Automatic
Run completed.

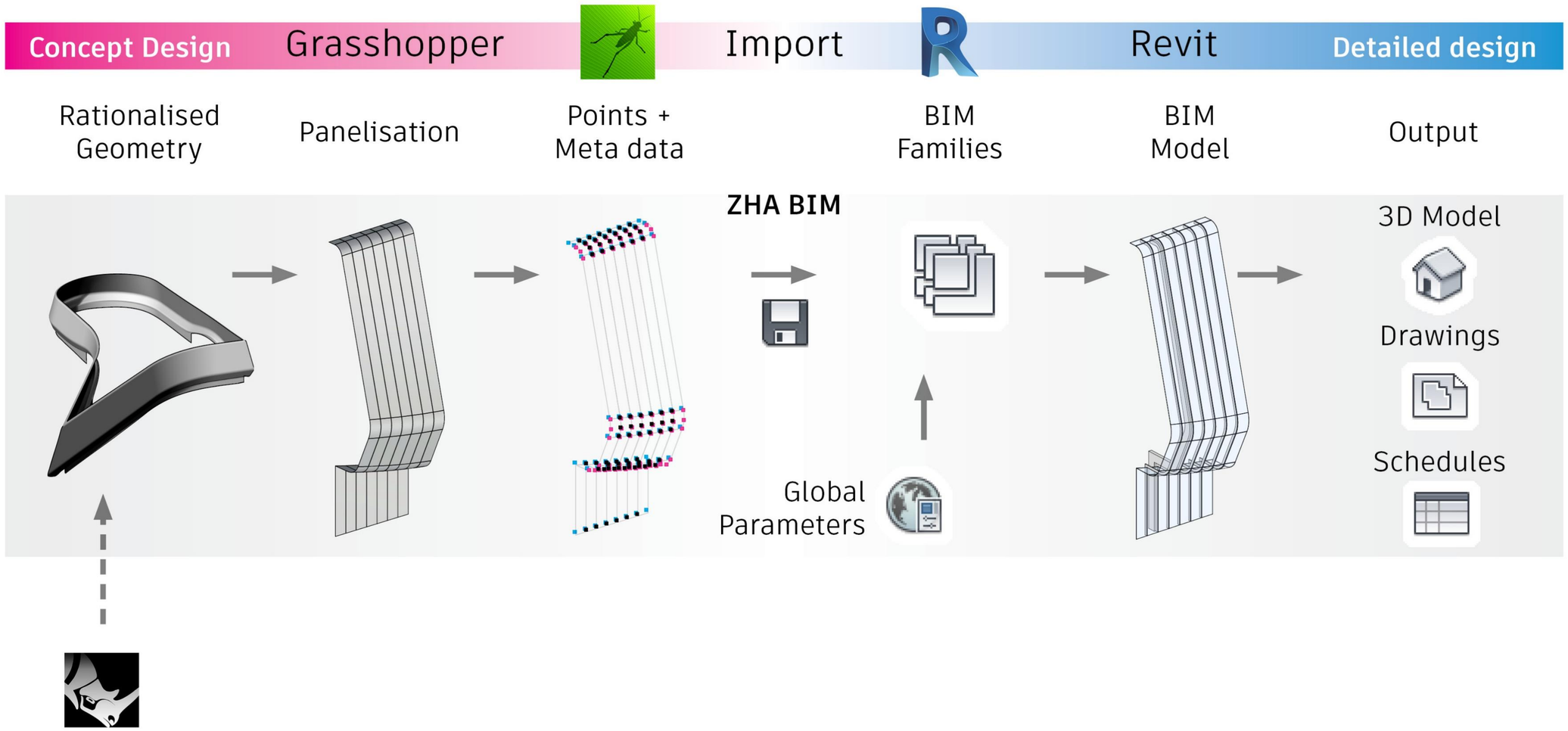
Adaptive Elements

Adaptive Elements

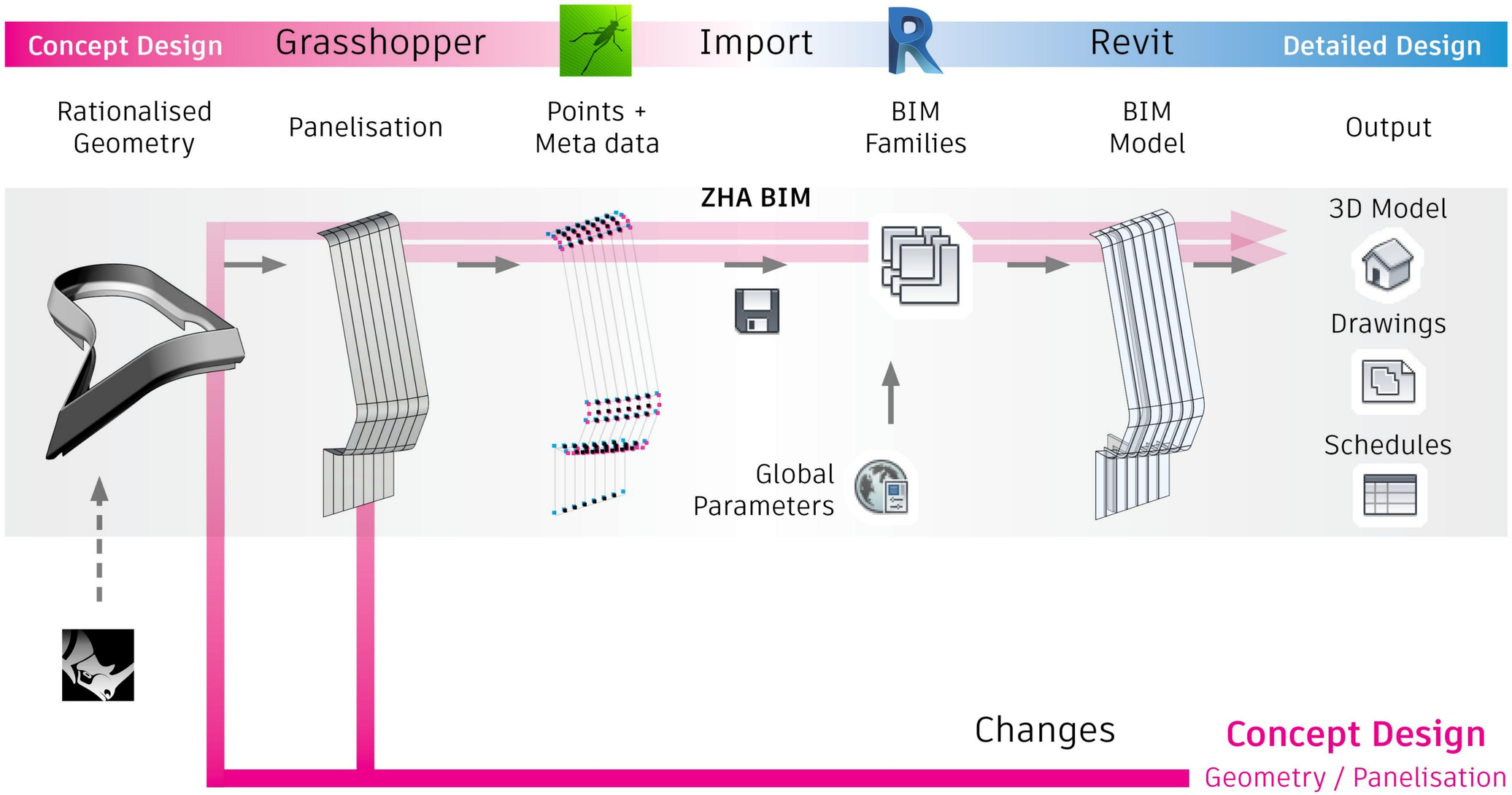
Eckart Schwerdtfeger
AU Las Vegas 2018

Zaha Hadid Architects

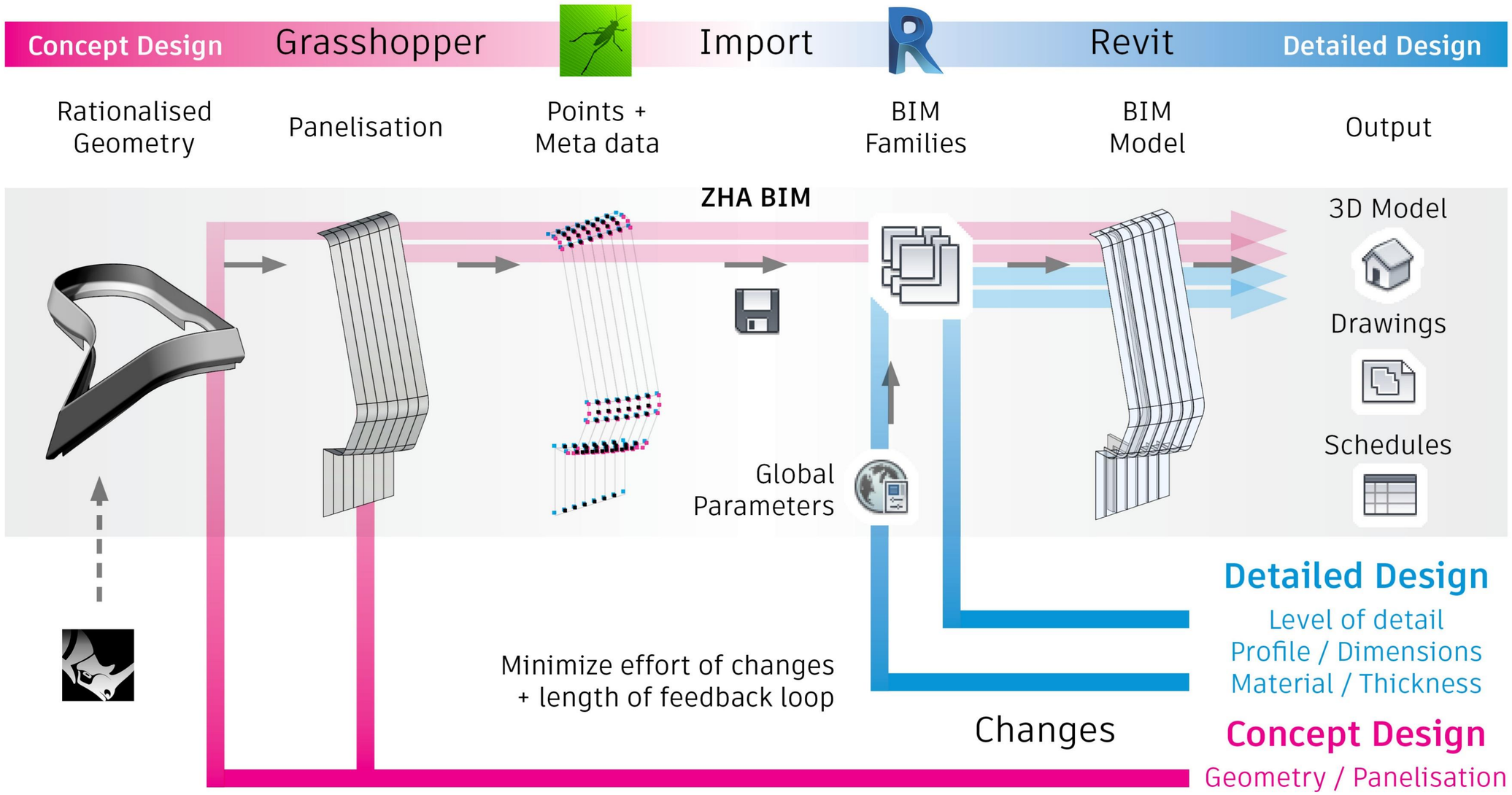
Adaptive Elements . Process



Adaptive Elements . Process



Adaptive Elements . Process



Adaptive Elements

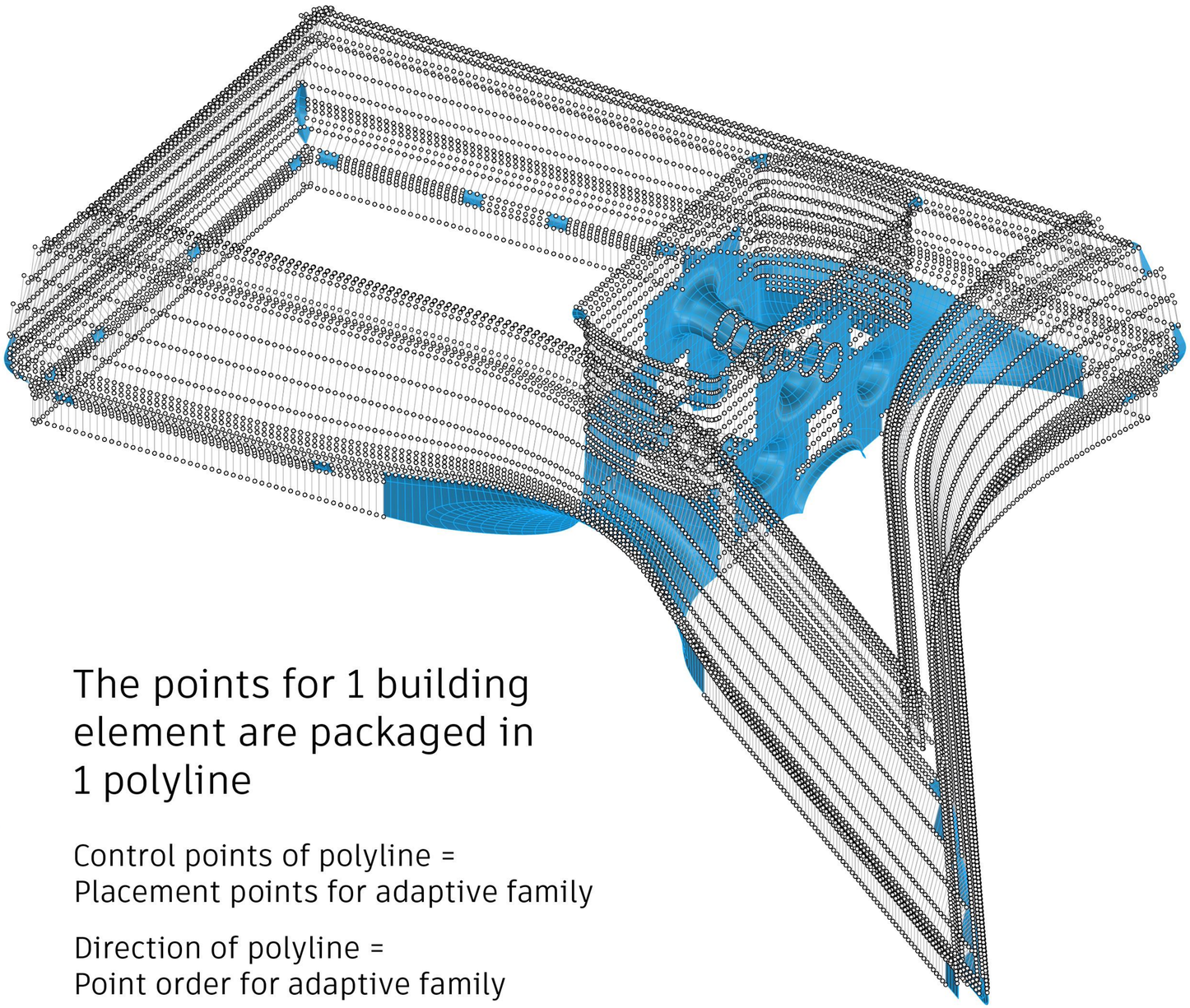
Geometry for Revit

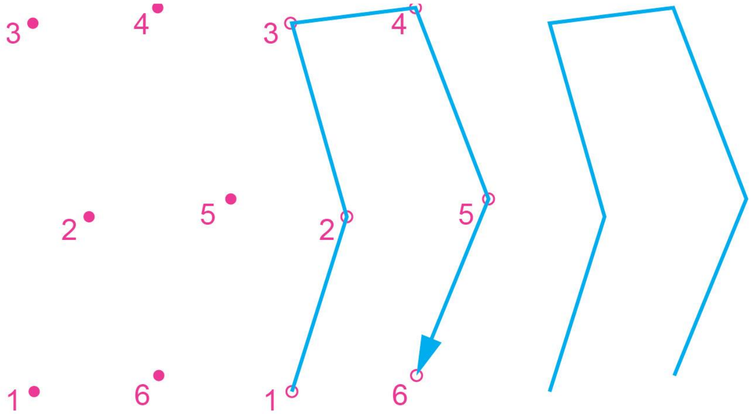
3D Surfaces + Solids
for form-based families

Freeform / double curved

Point cloud
for adaptive families

Rational / rule-based





The points for 1 building element are packaged in 1 polyline

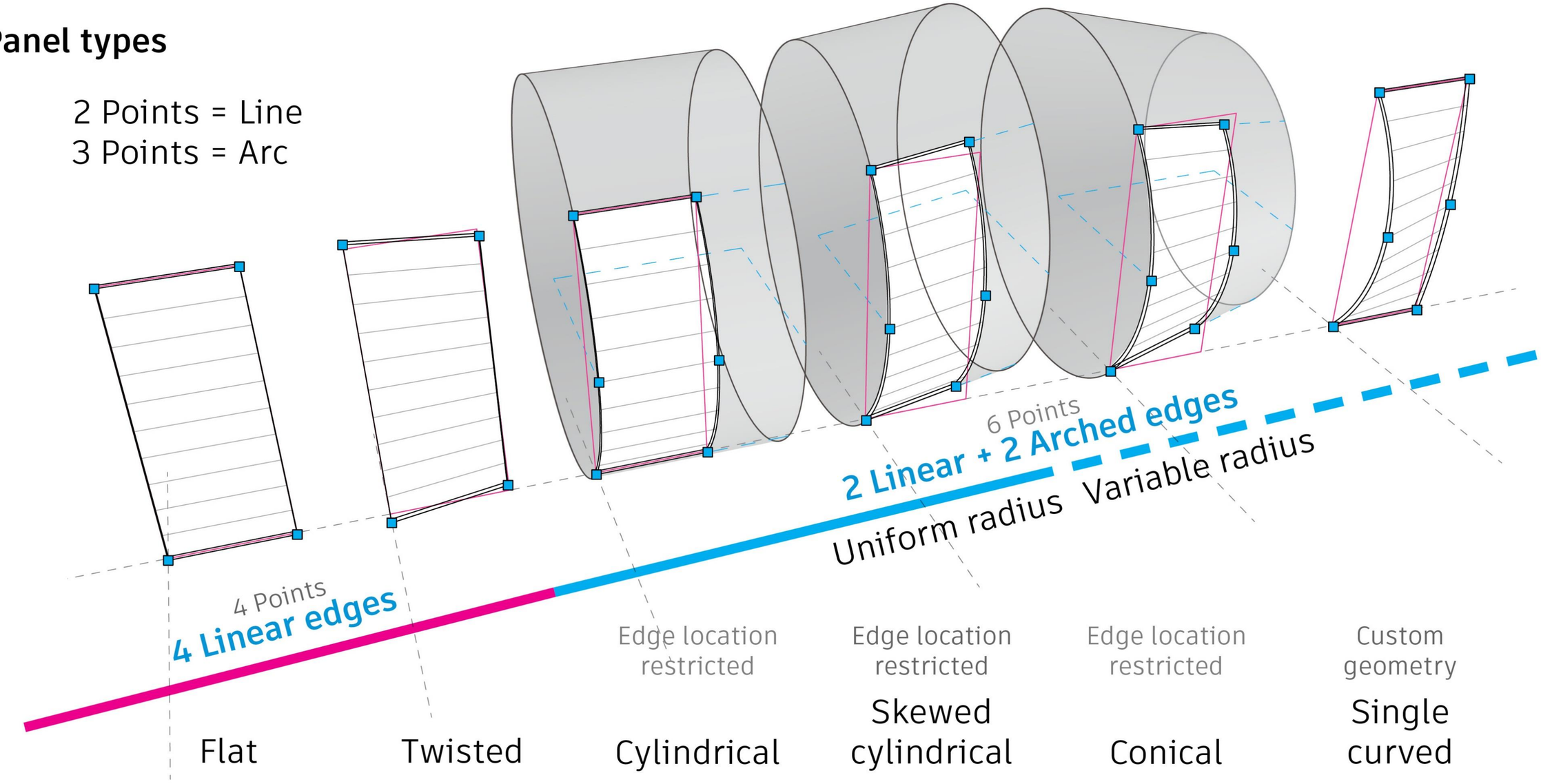
Control points of polyline =
Placement points for adaptive family

Direction of polyline =
Point order for adaptive family

Adaptive Elements . Facade Panels

Panel types

2 Points = Line
3 Points = Arc



Adaptive Elements . Facade Panels

Adaptive Family

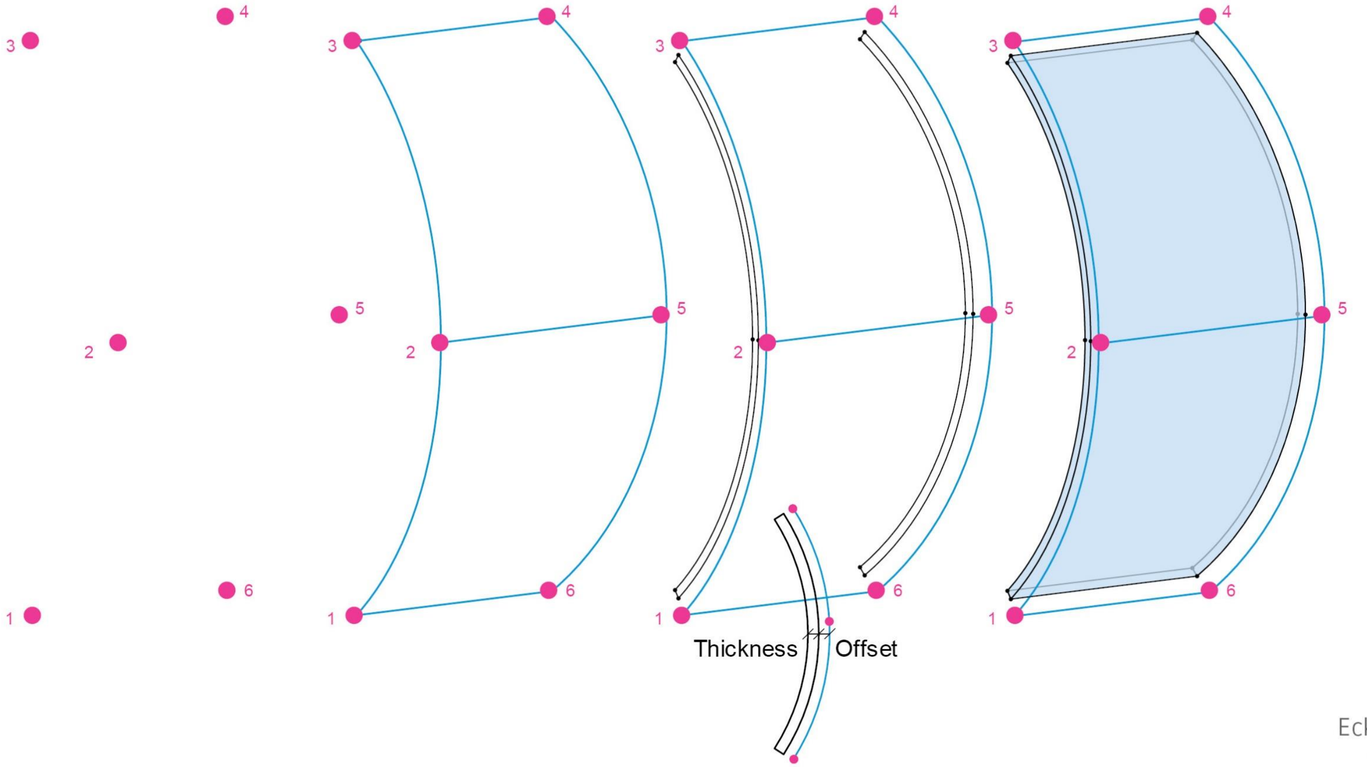
1
Set up adaptive points, order and placement

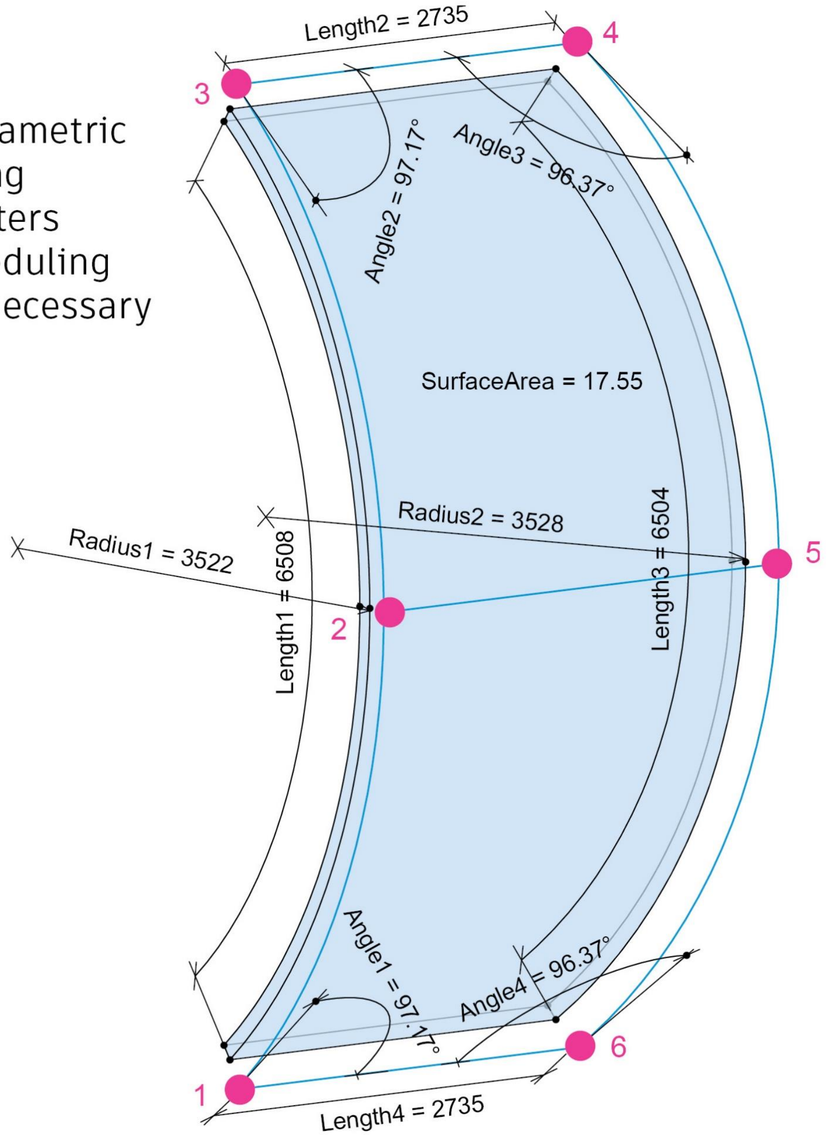
2
Create frame out of lines [2 points] and arcs [3 points] that allows for panel edge offsets

3
Place edge profiles using nested family that deals with panel offset and thickness

4
Blend both edge profiles into a solid object

5
Add parametric reporting parameters for scheduling where necessary





Adaptive Elements

Adaptive Elements . Facade Columns

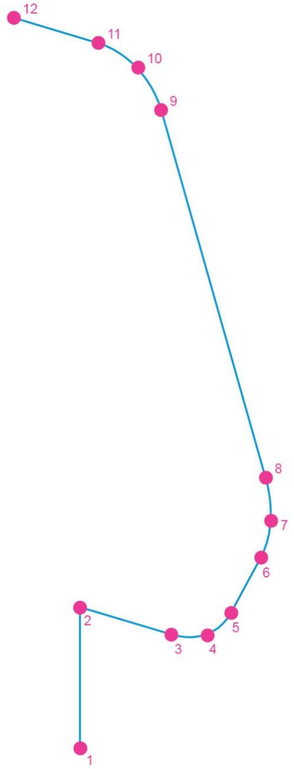
Adaptive Family

1

Set up adaptive points, order and placement

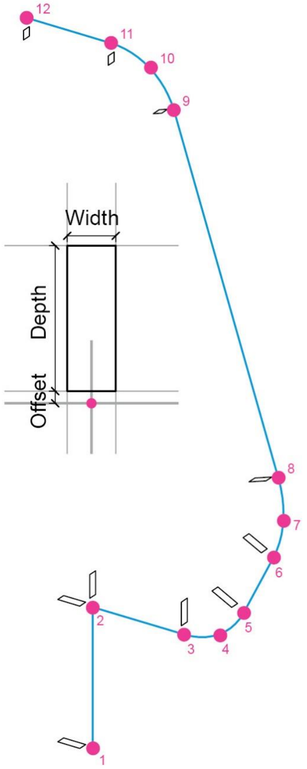
2

Create column axis out of lines [2 points] and arcs [3 points]



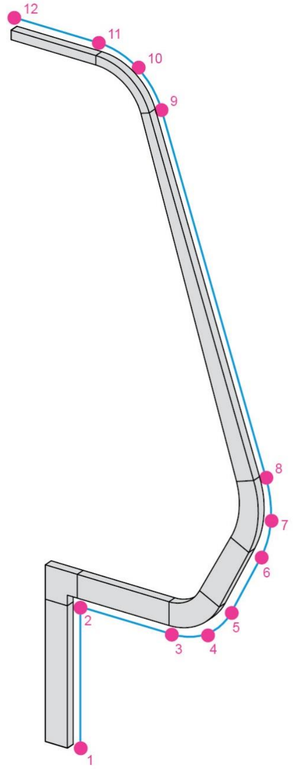
3

Place column profiles using nested family that controls offset and dimensions



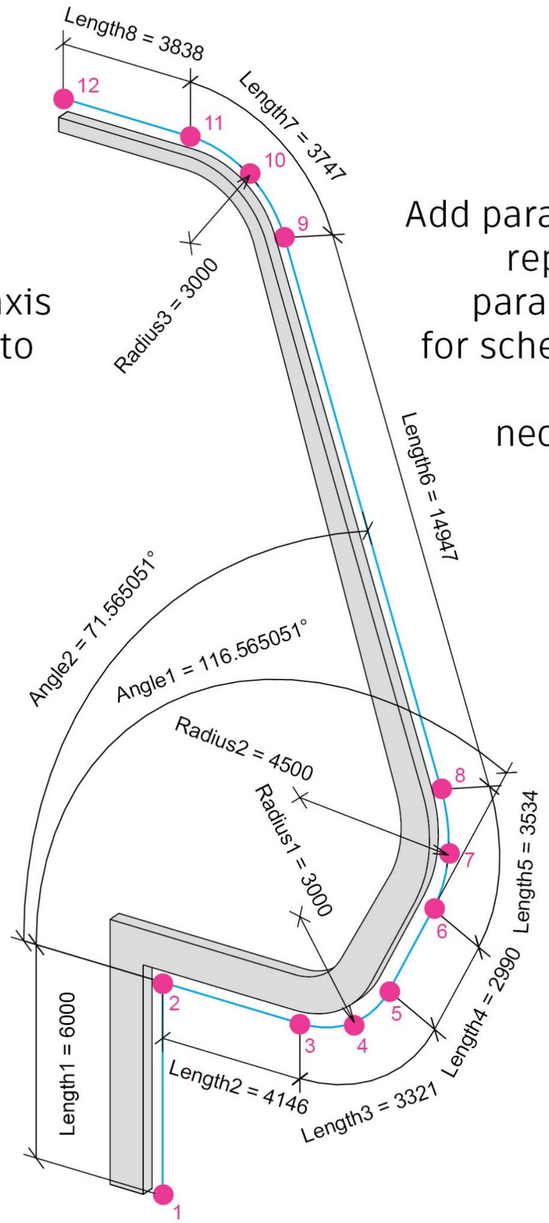
4

Formulas are used to generate variable dimensions. Column axis and profiles are used to create a swept blend



5

Add parametric reporting parameters for scheduling where necessary



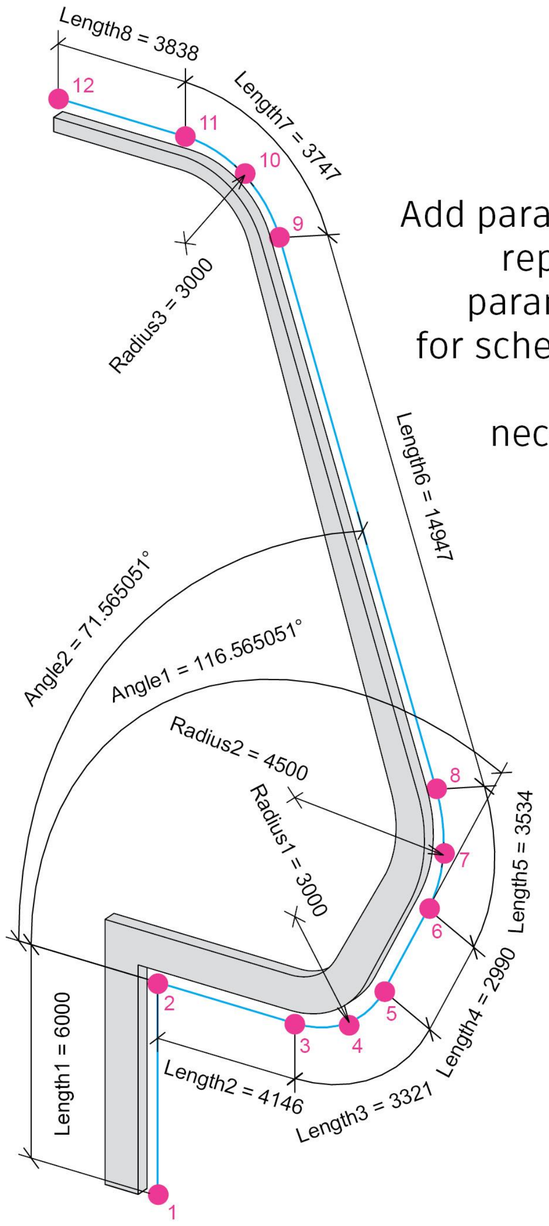
Adaptive Elements . Facade Columns

Schedule for Column geometry and dimensions

FACADE CLADDING - COLUMNS

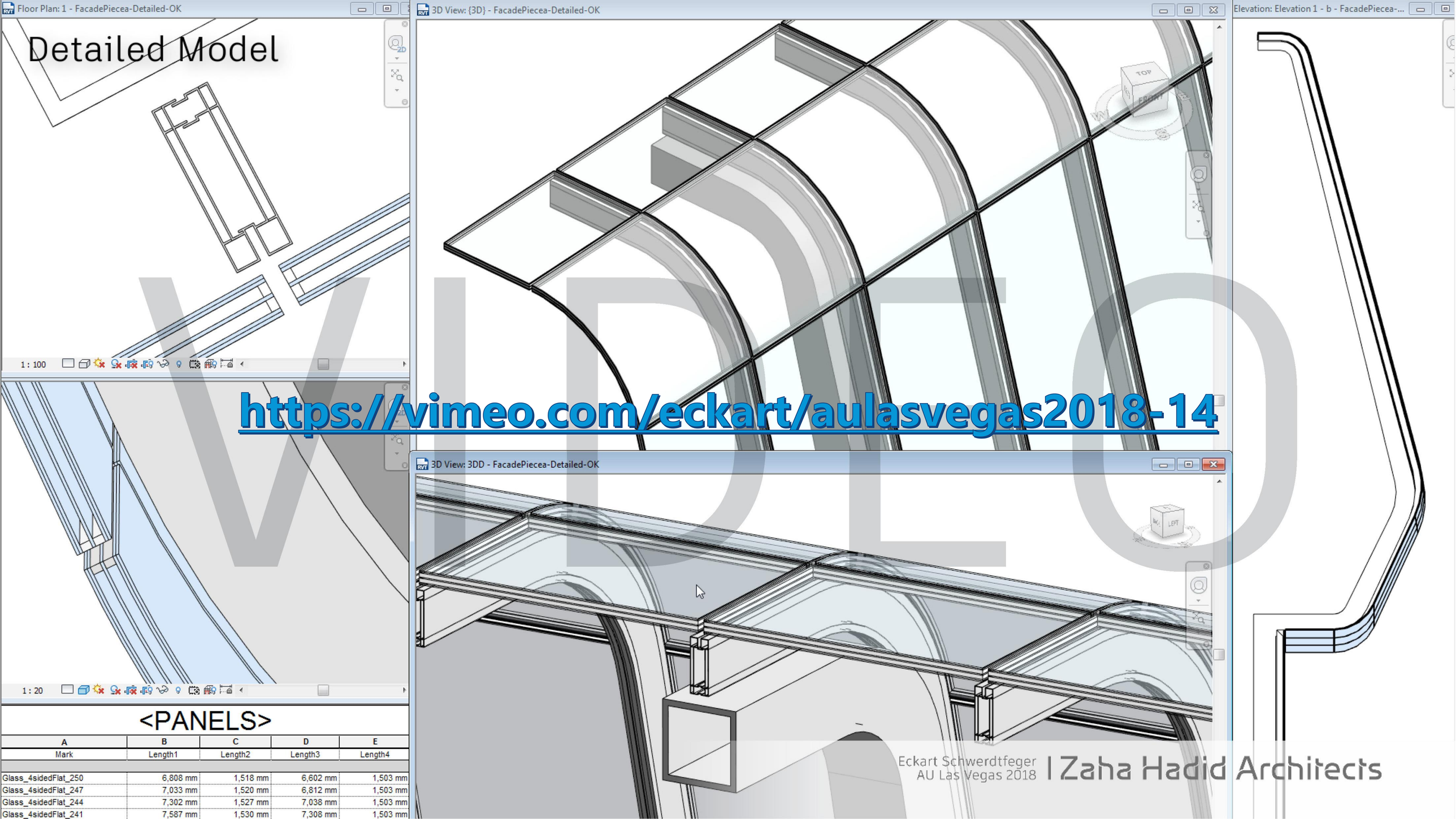
	GEOMETRY					PROFILE									BEAMS						
NAME	ANGLE 1	ANGLE 2	WIDTH	DEPTH MAX	DEPTH #5	DEPTH #6	DEPTH #8	DEPTH #9	DEPTH MIN	LENGTH 1	LENGTH 2	LENGTH 3	LENGTH 4	LENGTH 5	LENGTH 6	LENGTH 7	LENGTH 8	LENGTH TOTAL	RADIUS 1	RADIUS 2	RADIUS 3
FColumn0001	115,00°	75,00°	350 mm	900 mm	900 mm	802 mm	751 mm	350 mm	350 mm	8.580 mm	2.736 mm	1.361 mm	4.741 mm	2.443 mm	19.291 mm	1.963 mm	999 mm	42.115 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0002	115,00°	75,00°	350 mm	900 mm	900 mm	803 mm	750 mm	350 mm	350 mm	9.705 mm	2.736 mm	1.361 mm	4.450 mm	2.443 mm	18.399 mm	1.963 mm	999 mm	42.057 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0003	115,00°	75,00°	350 mm	900 mm	900 mm	805 mm	749 mm	350 mm	350 mm	10.920 mm	2.736 mm	1.361 mm	4.136 mm	2.443 mm	17.436 mm	1.963 mm	999 mm	41.995 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0004	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.805 mm	2.736 mm	1.361 mm	5.459 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0005	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.805 mm	2.736 mm	1.361 mm	5.459 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0006	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.805 mm	2.736 mm	1.361 mm	5.459 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0007	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.820 mm	2.736 mm	1.361 mm	5.455 mm	2.443 mm	21.478 mm	1.963 mm	999 mm	42.256 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0008	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.850 mm	2.736 mm	1.361 mm	5.447 mm	2.443 mm	21.454 mm	1.963 mm	999 mm	42.255 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0009	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.910 mm	2.736 mm	1.361 mm	5.432 mm	2.443 mm	21.407 mm	1.963 mm	999 mm	42.252 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0010	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	6.060 mm	2.736 mm	1.361 mm	5.393 mm	2.443 mm	21.288 mm	1.963 mm	999 mm	42.244 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0011	115,00°	75,00°	350 mm	900 mm	900 mm	799 mm	752 mm	350 mm	350 mm	6.375 mm	2.736 mm	1.361 mm	5.312 mm	2.443 mm	21.038 mm	1.963 mm	999 mm	42.228 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0012	115,00°	75,00°	350 mm	900 mm	900 mm	799 mm	752 mm	350 mm	350 mm	7.110 mm	2.736 mm	1.361 mm	5.121 mm	2.443 mm	20.456 mm	1.963 mm	999 mm	42.190 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0013	115,00°	75,00°	350 mm	900 mm	900 mm	801 mm	751 mm	350 mm	350 mm	8.535 mm	2.736 mm	1.361 mm	4.753 mm	2.443 mm	19.326 mm	1.963 mm	999 mm	42.117 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0014	115,00°	75,00°	350 mm	900 mm	900 mm	799 mm	752 mm	350 mm	350 mm	6.930 mm	2.736 mm	1.361 mm	5.168 mm	2.443 mm	20.598 mm	1.963 mm	999 mm	42.199 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0015	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	6.315 mm	2.736 mm	1.361 mm	5.327 mm	2.443 mm	21.086 mm	1.963 mm	999 mm	42.231 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0016	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	6.060 mm	2.736 mm	1.361 mm	5.393 mm	2.443 mm	21.288 mm	1.963 mm	999 mm	42.244 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0017	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.940 mm	2.736 mm	1.361 mm	5.424 mm	2.443 mm	21.383 mm	1.963 mm	999 mm	42.250 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0018	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0019	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0020	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0021	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0022	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0023	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0024	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0025	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0026	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0027	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0028	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0029	115,00°	75,00°	350 mm	900 mm	900 mm	801 mm	751 mm	350 mm	350 mm	8.565 mm	2.736 mm	1.361 mm	4.745 mm	2.443 mm	19.303 mm	1.963 mm	999 mm	42.115 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0030	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0031	115,00°	75,00°	350 mm	900 mm	900 mm	800 mm	751 mm	350 mm	350 mm	7.635 mm	2.736 mm	1.361 mm	4.988 mm	2.443 mm	20.040 mm	1.963 mm	999 mm	42.163 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0032	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0033	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0034	115,00°	75,00°	350 mm	900 mm	900 mm	799 mm	752 mm	350 mm	350 mm	7.020 mm	2.736 mm	1.361 mm	5.145 mm	2.443 mm	20.527 mm	1.963 mm	999 mm	42.195 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0035	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0036	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0037	115,00°	75,00°	350 mm	900 mm	900 mm	799 mm	752 mm	350 mm	350 mm	6.630 mm	2.736 mm	1.361 mm	5.246 mm	2.443 mm	20.836 mm	1.963 mm	999 mm	42.215 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0038	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0039	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0040	115,00°	75,00°	350 mm	900 mm	900 mm	799 mm	752 mm	350 mm	350 mm	6.375 mm	2.735 mm	1.361 mm	5.312 mm	2.443 mm	21.038 mm	1.963 mm	999 mm	42.228 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0041	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	6.210 mm	2.735 mm	1.361 mm	5.354 mm	2.443 mm	21.169 mm	1.963 mm	999 mm	42.236 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0042	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm
FColumn0043	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.800 mm	2.736 mm	1.361 mm	5.465 mm	2.443 mm	21.490 mm	1.963 mm	999 mm	42.257 mm	1.200 mm	3.500 mm	1.500 mm

	GEOMETRY					PROFILE						
NAME	ANGLE 1	ANGLE 2	WIDTH	DEPTH MAX	DEPTH #5	DEPTH #6	DEPTH #8	DEPTH #9	DEPTH MIN	LENGTH 1	LENGTH 2	LENGTH 3
FColumn0001	115,00°	75,00°	350 mm	900 mm	900 mm	802 mm	751 mm	350 mm	350 mm	8.580 mm	2.736 mm	1.361 mm
FColumn0002	115,00°	75,00°	350 mm	900 mm	900 mm	803 mm	750 mm	350 mm	350 mm	9.705 mm	2.736 mm	1.361 mm
FColumn0003	115,00°	75,00°	350 mm	900 mm	900 mm	805 mm	749 mm	350 mm	350 mm	10.920 mm	2.736 mm	1.361 mm
FColumn0004	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.805 mm	2.736 mm	1.361 mm
FColumn0005	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.805 mm	2.736 mm	1.361 mm
FColumn0006	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.805 mm	2.736 mm	1.361 mm
FColumn0007	115,00°	75,00°	350 mm	900 mm	900 mm	798 mm	752 mm	350 mm	350 mm	5.820 mm	2.736 mm	1.361 mm



5

Add parametric reporting parameters for scheduling where necessary



<PANELS>

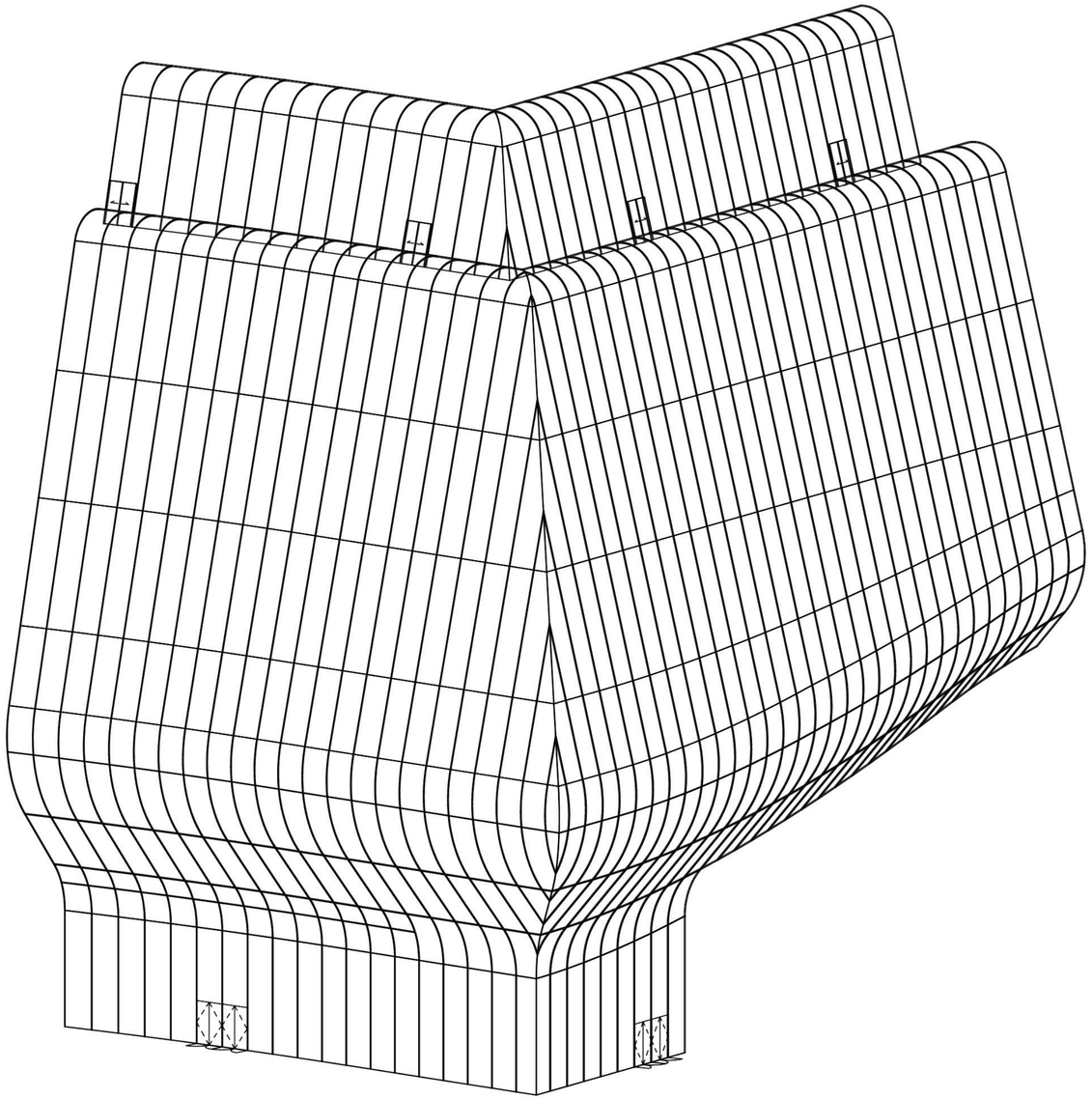
A	B	C	D	E
Mark	Length1	Length2	Length3	Length4
Glass_4sidedFlat_250	6,808 mm	1,518 mm	6,602 mm	1,503 mm
Glass_4sidedFlat_247	7,033 mm	1,520 mm	6,812 mm	1,503 mm
Glass_4sidedFlat_244	7,302 mm	1,527 mm	7,038 mm	1,503 mm
Glass_4sidedFlat_241	7,587 mm	1,530 mm	7,308 mm	1,503 mm

Facade . Perimeter

Custom panels

Where 2 facades meet the standardised facade panels need to be cut. This creates many custom-shaped panels.

How many additional families do we need?



Facade . Perimeter

Custom panels

Use standardised families only + cut corners with voids

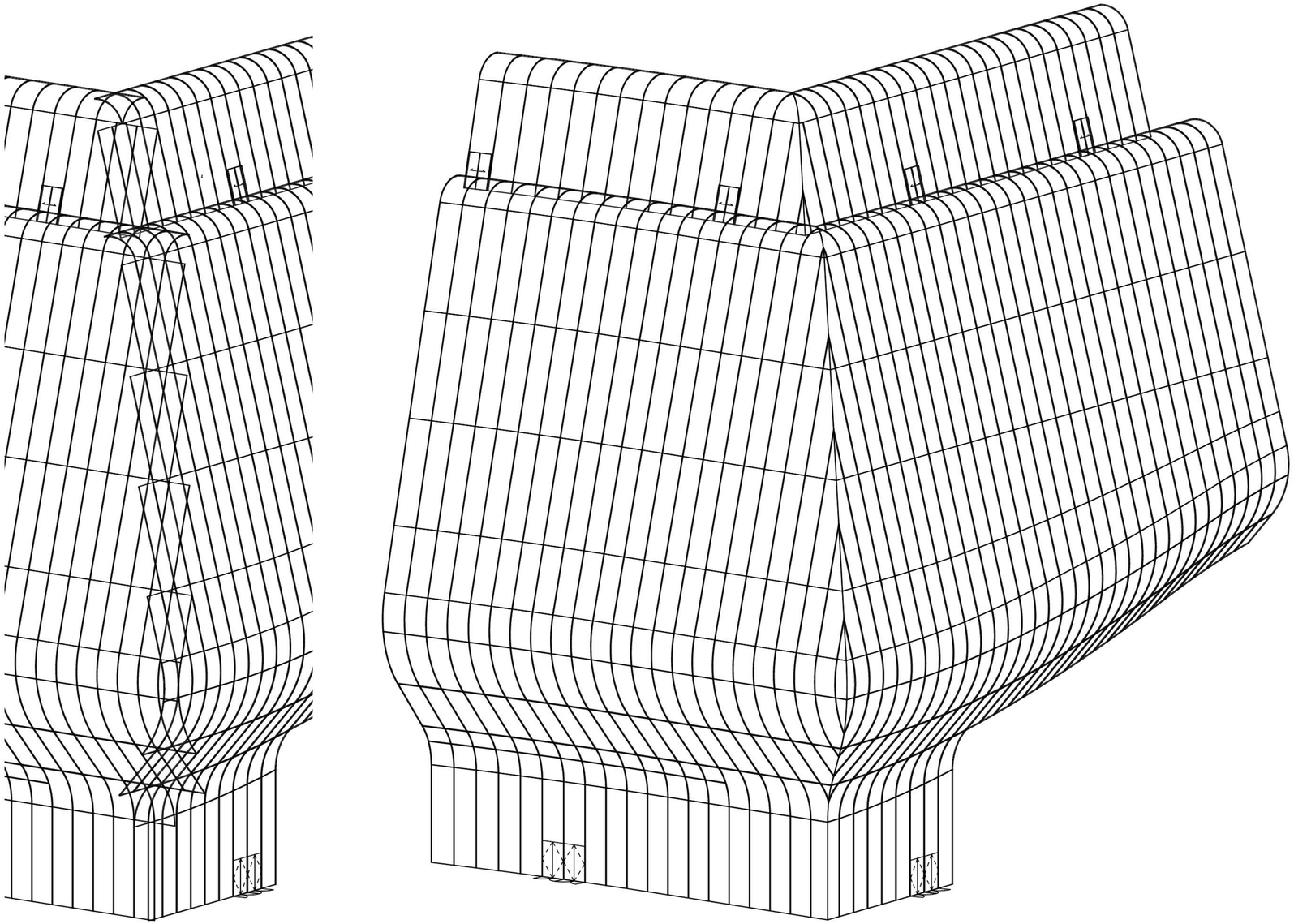
C# Macro

For every panel…

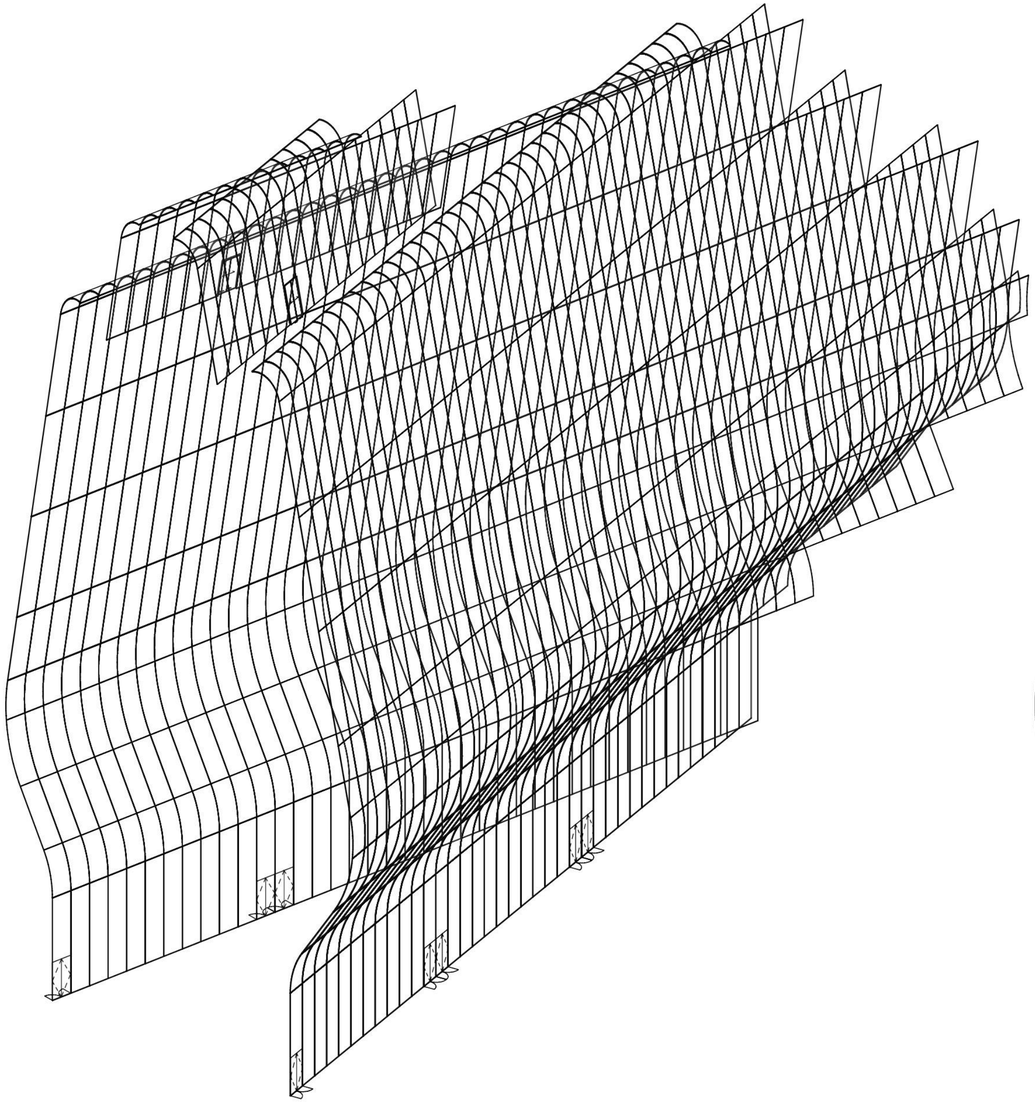
- Read parameter ‘Orientation’
- Check intersection of panel with void of same ‘Orientation’
- Upon intersection…

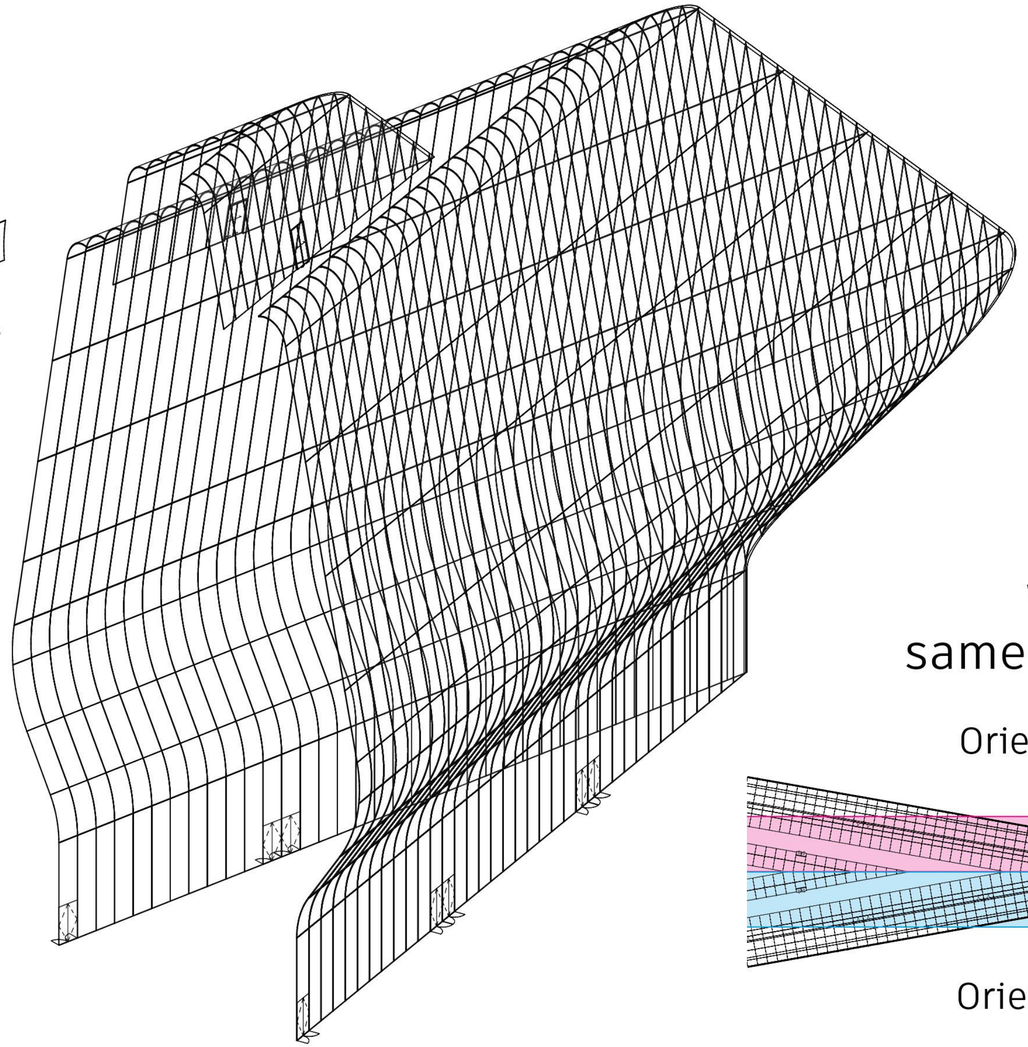
  Subtract void from element

  Update parameters ‘Cut’ + ‘Area’



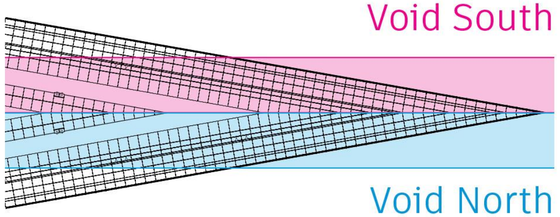
Facade . Perimeter





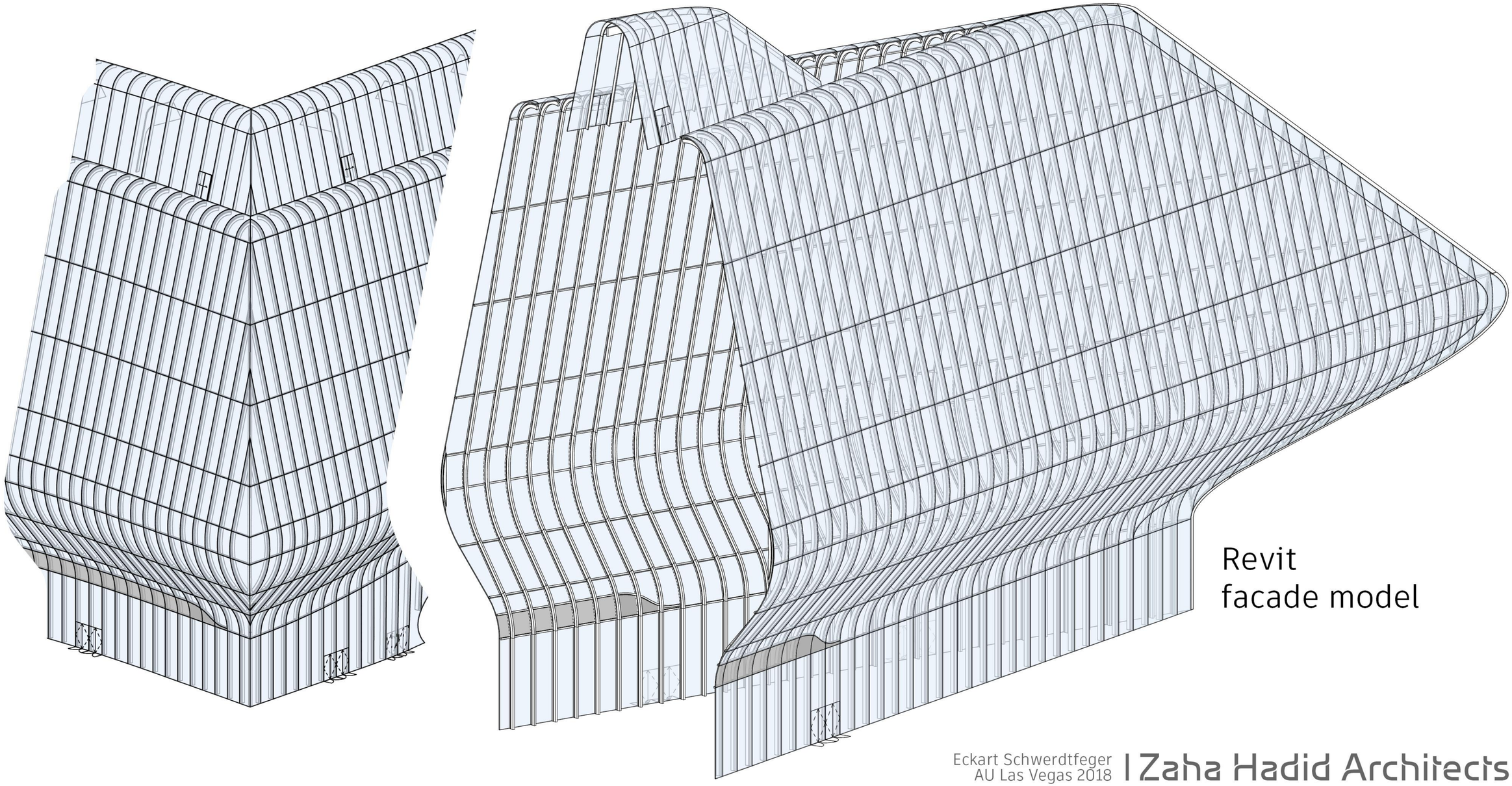
Cut panels
with void of
same orientation

Orientation = North
Void South



Void North
Orientation = South

Facade . Perimeter



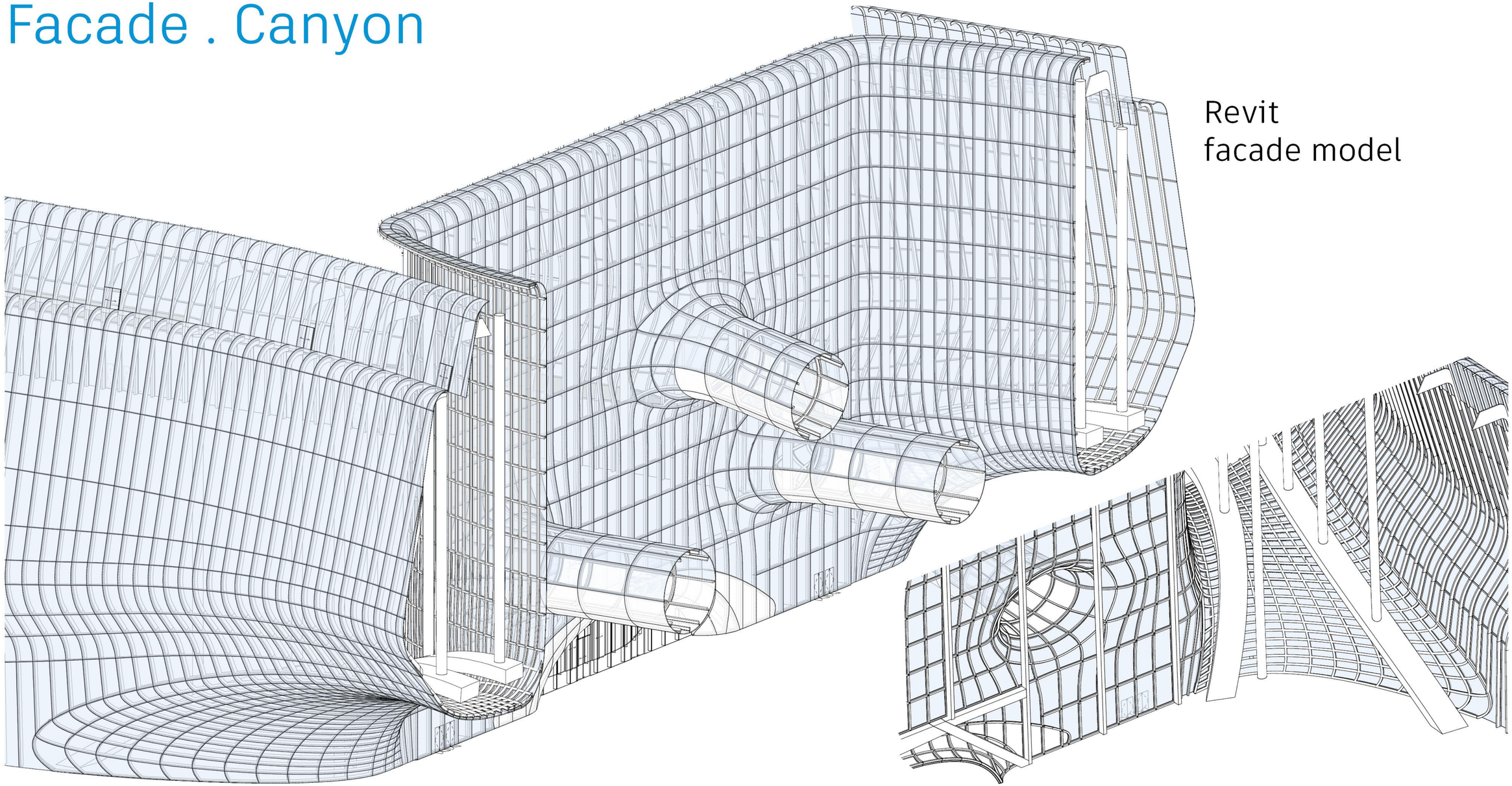
Revit
facade model

Facade . Canyon

Eckart Schwerdtfeger
AU Las Vegas 2018

Zaha Hadid Architects

Facade . Canyon



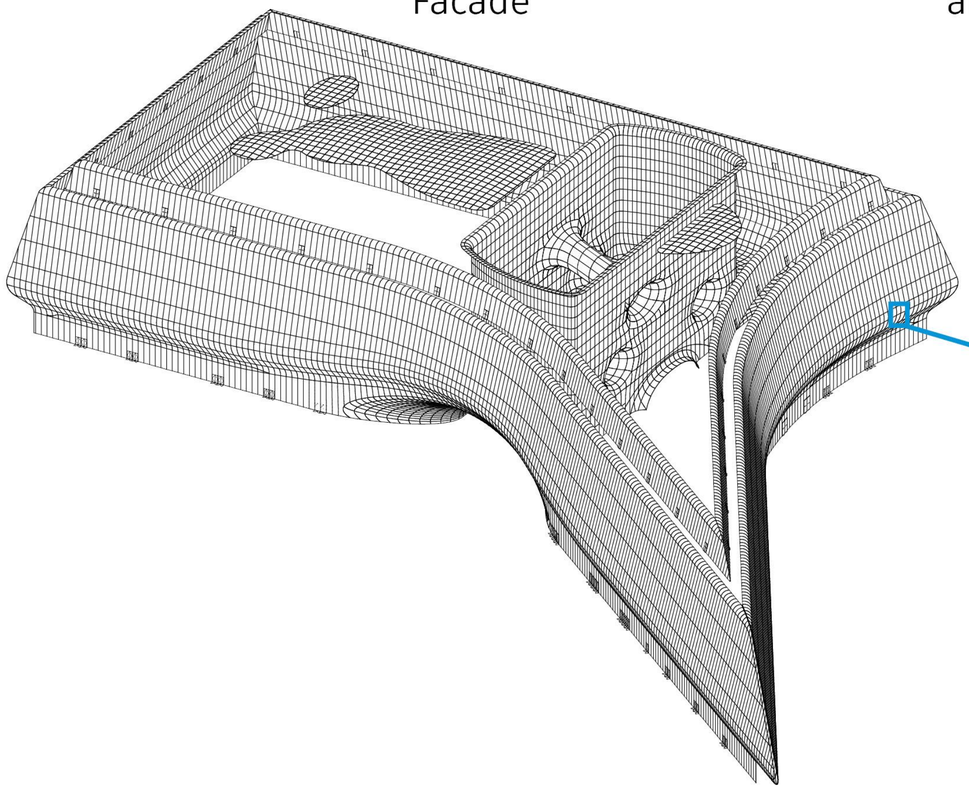
Revit
facade model

Facade . BIM Model

Building information model

- 3D model + meta data
- Custom parameters can be added to all building elements
- Using **ZHA BIM** this can already be done in Rhino + Grasshopper

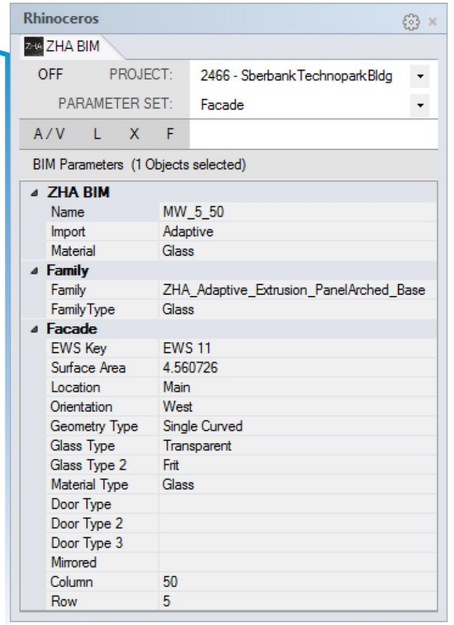
Revit 3D Model
Facade



The model combines adaptive families and imported freeform geometry where needed [double curved]

All use the same parameters

ZHA BIM
Rhino parameters

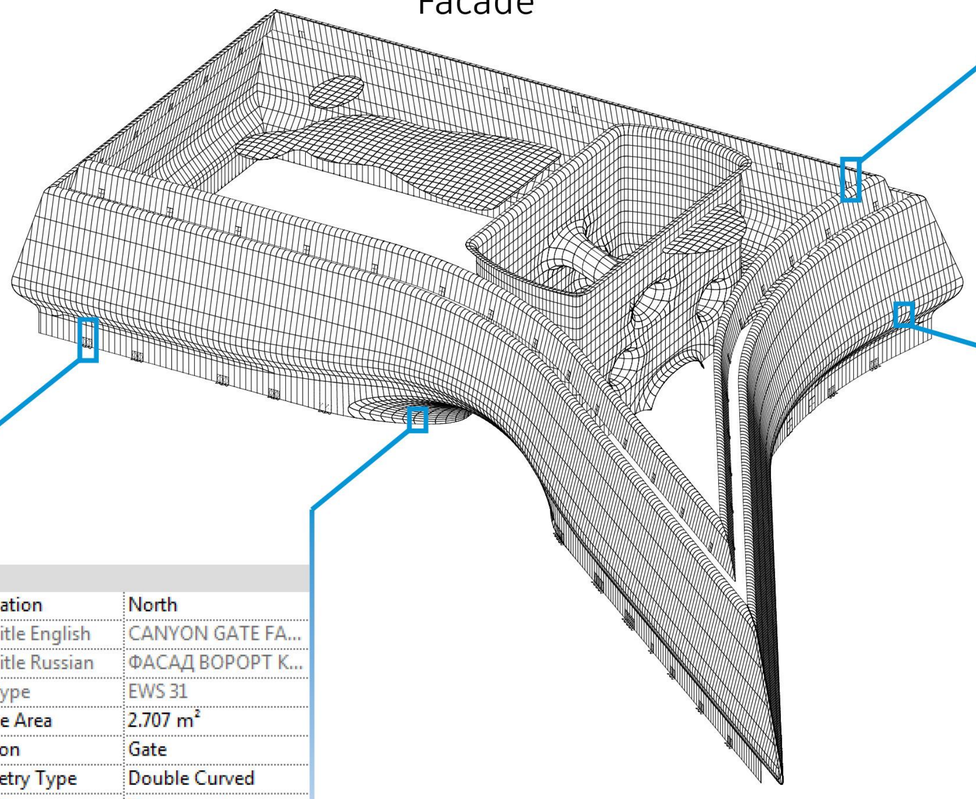


Facade . BIM Model

Building information model

- 3D model + meta data
- Custom parameters can be added to all building elements
- Using **ZHA BIM** this can already be done in Rhino + Grasshopper

Revit 3D Model
Facade



Data	
Orientation	South
EWS Title English	TERRACE FACADE
EWS Title Russian	ФАСАД ТЕРРАС
EWS Type	EWS 15
Surface Area	13.193 m²
Location	Terrace
Geometry Type	Flat
Glass Type	Transparent
Glass Type 2	No Frit
Material Type	Glass
Door Type	D6 - Terrace Door
Door Type 2	Sliding Door
Door Type 3	Double Door

ZHA BIM
Rhino parameters

Rhinoceros

ZHA BIM

OFF PROJECT: 2466 - SberbankTechnoparkBldg

PARAMETER SET: Facade

A / V L X F

BIM Parameters (1 Objects selected)

ZHA BIM	
Name	MW_5_50
Import	Adaptive
Material	Glass
Family	
Family	ZHA_Adaptive_Extrusion_PanelArched_Base
FamilyType	Glass
Facade	
EWS Key	EWS 11
Surface Area	4.560726
Location	Main
Orientation	West
Geometry Type	Single Curved
Glass Type	Transparent
Glass Type 2	Frit
Material Type	Glass
Door Type	
Door Type 2	
Door Type 3	
Mirrored	
Column	50
Row	5

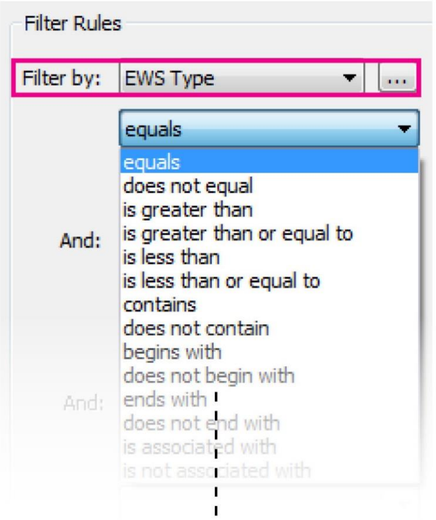
Data	
Orientation	North
EWS Title English	BASE FACADE
EWS Title Russian	НИЖНИЙ ФАСАД
EWS Type	EWS 13
Surface Area	11.976 m²
Location	Main
Geometry Type	Flat
Glass Type	Transparent
Glass Type 2	No Frit
Material Type	Glass
Door Type	D5 - Escape Door
Door Type 2	Swing Door
Door Type 3	Double Door

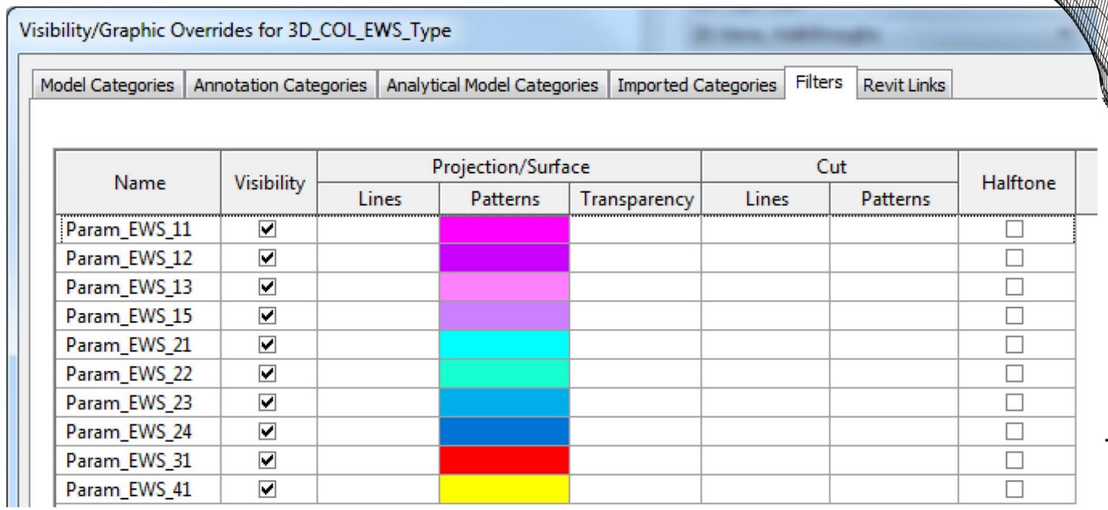
Data	
Orientation	North
EWS Title English	CANYON GATE FA...
EWS Title Russian	ФАСАД ВОРОТ К...
EWS Type	EWS 31
Surface Area	2.707 m²
Location	Gate
Geometry Type	Double Curved
Glass Type	Transparent
Glass Type 2	No Frit
Material Type	Glass
Door Type	
Door Type 2	
Door Type 3	

Revit parameters

Facade . BIM Model

Filter





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		Lines	Patterns	Transparency	Lines	Patterns	
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Param_EWS_12	☑						☐
Param_EWS_13	☑						☐
Param_EWS_15	☑						☐
Param_EWS_21	☑						☐
Param_EWS_22	☑						☐
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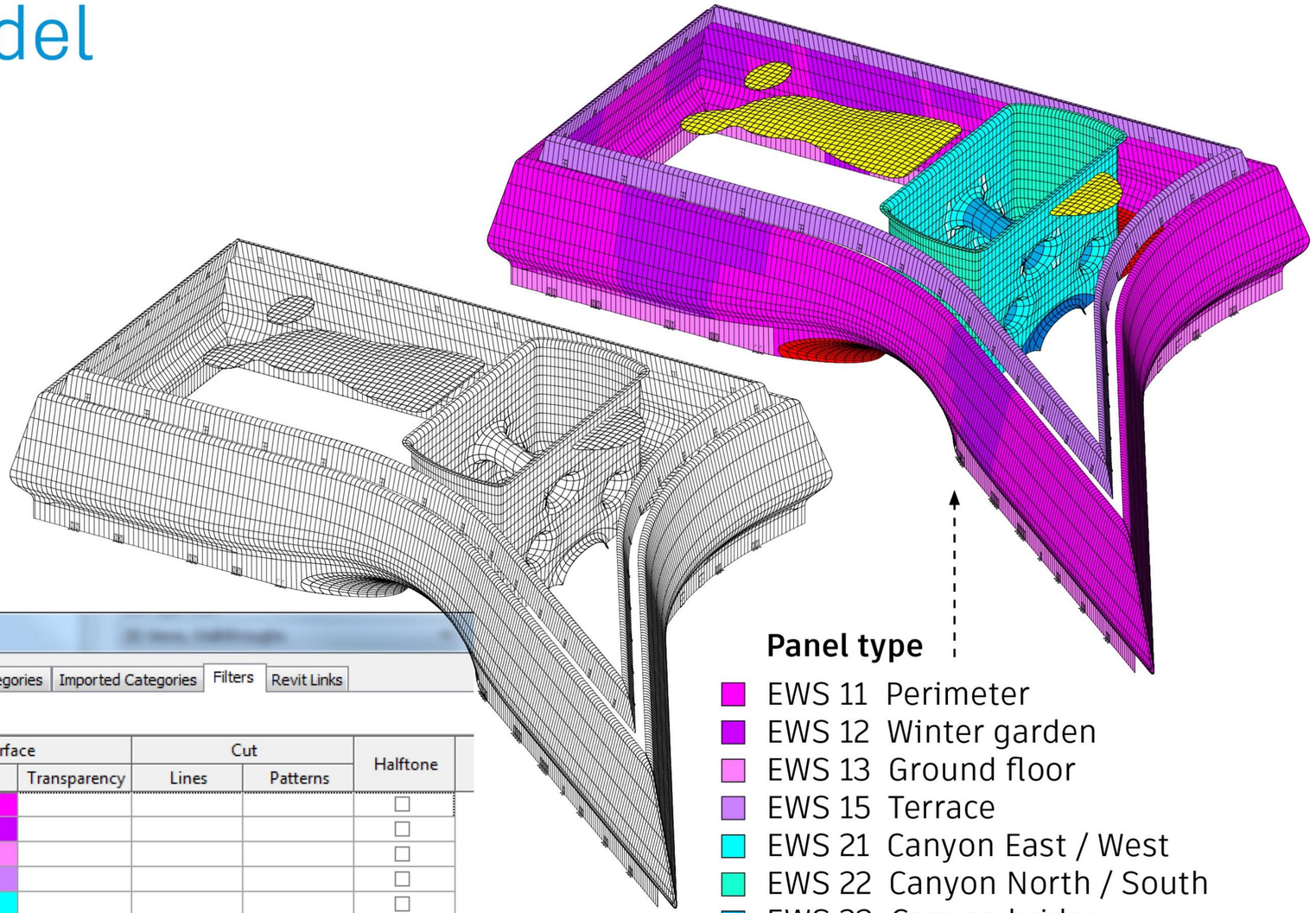
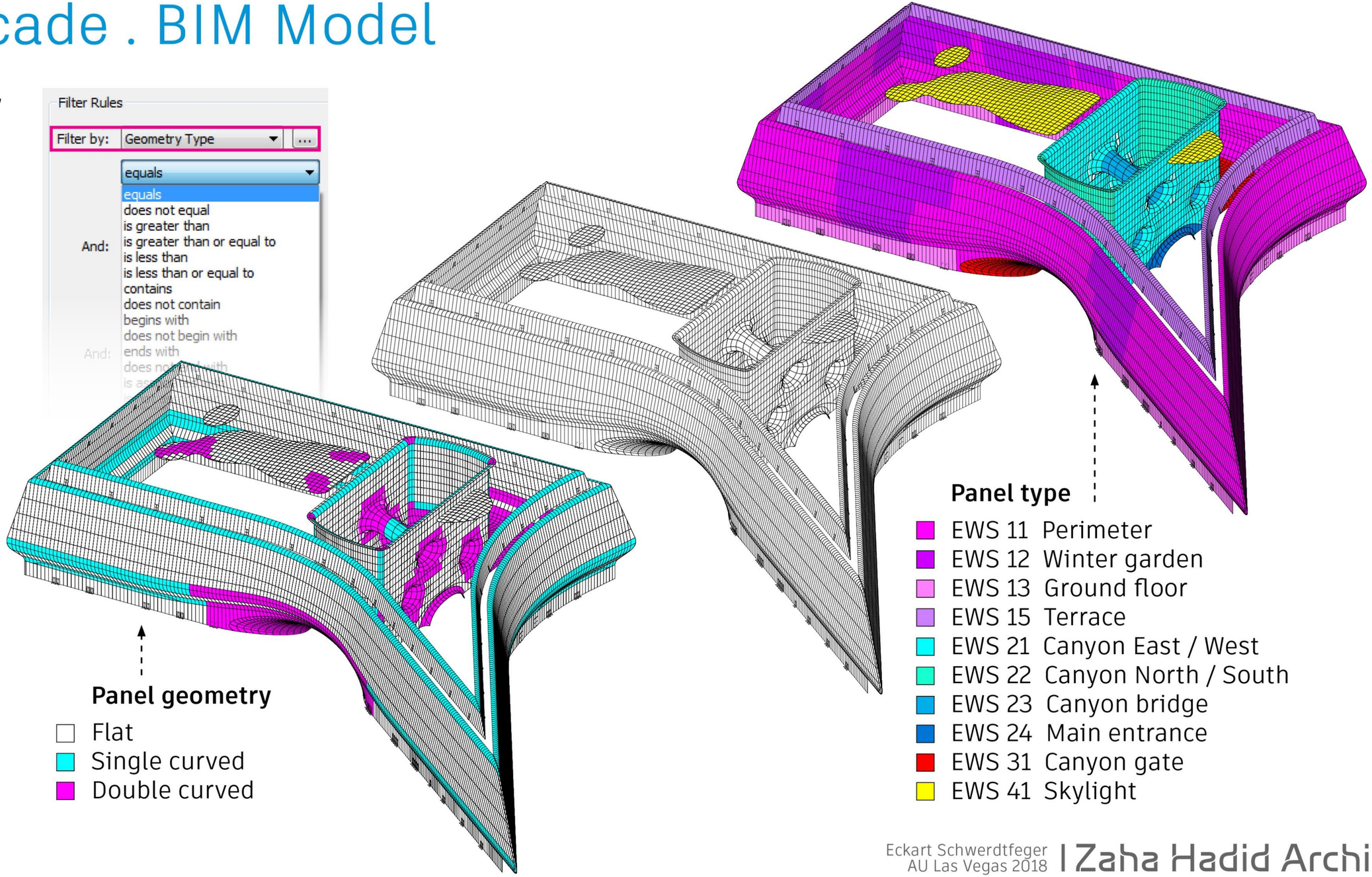


Panel type

- EWS 11 Perimeter
- EWS 12 Winter garden
- EWS 13 Ground floor
- EWS 15 Terrace
- EWS 21 Canyon East / West
- EWS 22 Canyon North / South
- EWS 23 Canyon bridge
- EWS 24 Main entrance
- EWS 31 Canyon gate
- EWS 41 Skylight

Facade . BIM Model

Filter

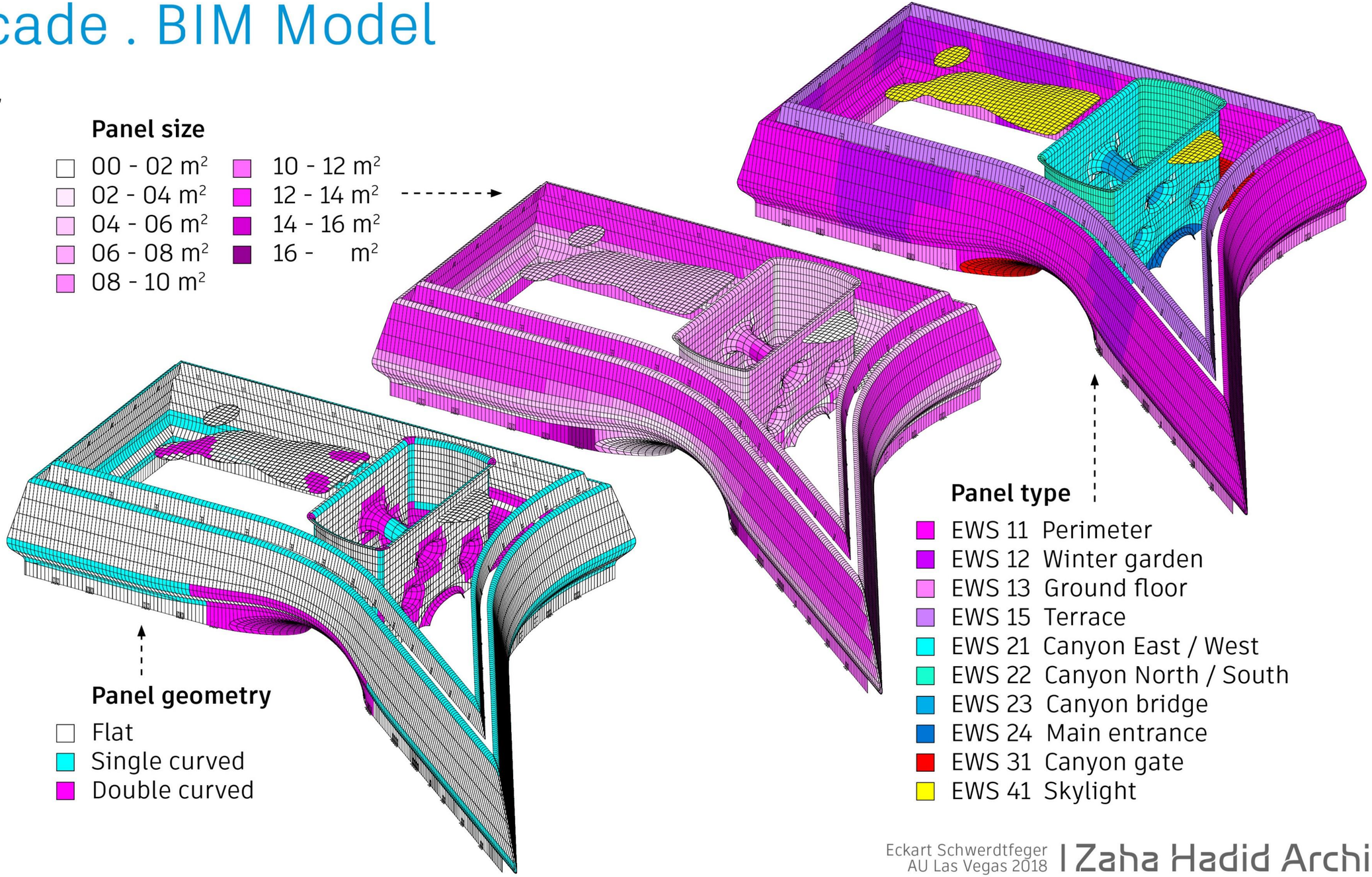


Facade . BIM Model

Filter

Panel size

- 00 - 02 m²
- 02 - 04 m²
- 04 - 06 m²
- 06 - 08 m²
- 08 - 10 m²
- 10 - 12 m²
- 12 - 14 m²
- 14 - 16 m²
- 16 - m²



Panel type

- EWS 11 Perimeter
- EWS 12 Winter garden
- EWS 13 Ground floor
- EWS 15 Terrace
- EWS 21 Canyon East / West
- EWS 22 Canyon North / South
- EWS 23 Canyon bridge
- EWS 24 Main entrance
- EWS 31 Canyon gate
- EWS 41 Skylight

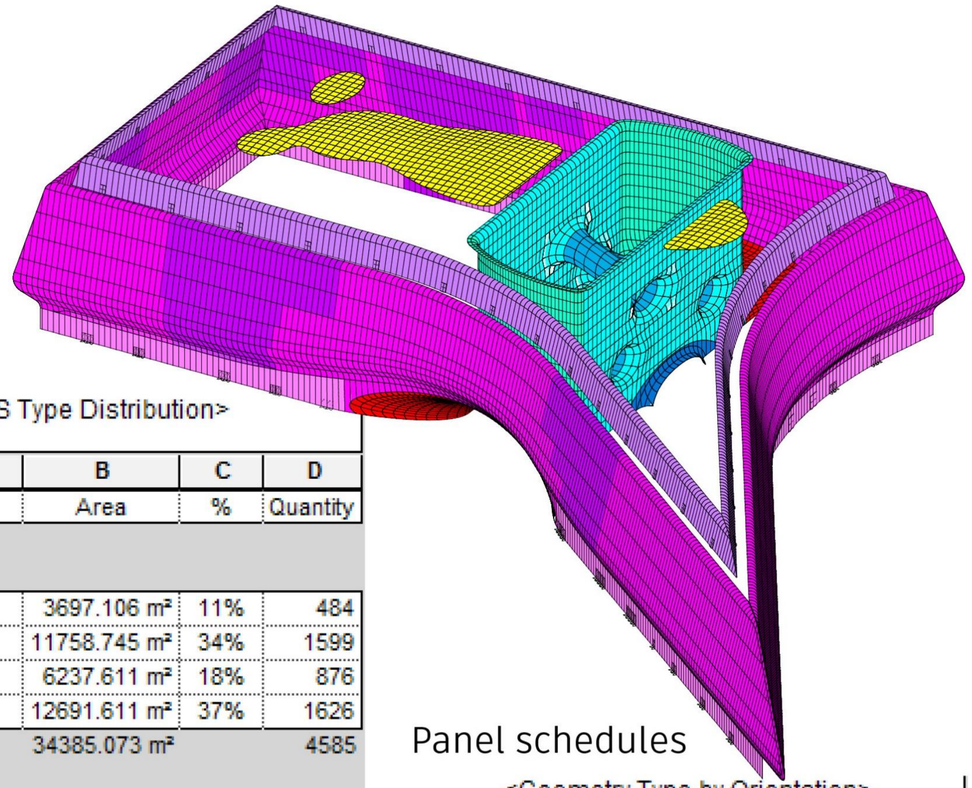
Panel geometry

- Flat
- Single curved
- Double curved

Facade . BIM Model

Building information

- Meta data + custom parameters are used to set up schedules
- Revit keeps all schedules up to date at all times
- All data can be exported for further analysis + visualisation



<EWS Type Distribution>

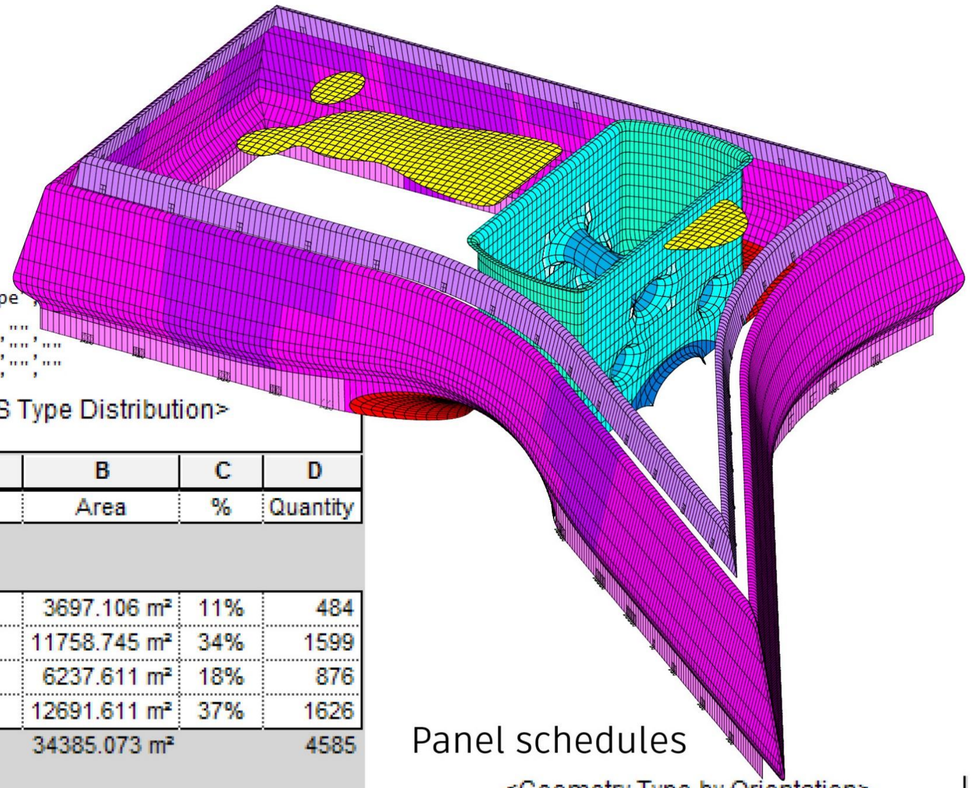
A	B	C	D
Orientation	Area	%	Quantity
EWS 11			
East	3697.106 m²	11%	484
North	11758.745 m²	34%	1599
South	6237.611 m²	18%	876
West	12691.611 m²	37%	1626
	34385.073 m²		4585
EWS 12			
East	1928.569 m²	23%	198
North	3453.077 m²	41%	407
South	3032.865 m²	36%	338
	8414.511 m²		943
EWS 13			
East	814.583 m²	16%	66
North	1788.224 m²	35%	141
South	764.305 m²	15%	61
West	1807.381 m²	35%	152
	5174.493 m²		420
EWS 15			
East	1098.766 m²	13%	114

Panel schedules

<Geometry Type by Orientation>

A	B	C	D
Geometry Type	Area	%	Quantity
Bridges			
Double Curved	2322.427 m²	64%	288
Single Curved	1326.086 m²	36%	108
	3648.513 m²		396
East			
Double Curved	821.958 m²	7%	121
Flat	7364.211 m²	64%	726
Flat Cut	929.641 m²	8%	157

Facade . BIM Model

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<EWS Type Distribution>

A	B	C	D
Orientation	Area	%	Quantity
EWS 11			
East	3697.106 m²	11%	484
North	11758.745 m²	34%	1599
South	6237.611 m²	18%	876
West	12691.611 m²	37%	1626
	34385.073 m²		4585
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East	1928.569 m²	23%	198
North	3453.077 m²	41%	407
South	3032.865 m²	36%	338
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EWS 13			
East	814.583 m²	16%	66
North	1788.224 m²	35%	141
South	764.305 m²	15%	61
West	1807.381 m²	35%	152
	5174.493 m²		420
EWS 15			
East	1098.766 m²	13%	114

Panel schedules

<Geometry Type by Orientation>

A	B	C	D
Geometry Type	Area	%	Quantity
Bridges			
Double Curved	2322.427 m²	64%	288
Single Curved	1326.086 m²	36%	108
	3648.513 m²		396
East			
Double Curved	821.958 m²	7%	121
Flat	7364.211 m²	64%	726
Flat Cut	929.641 m²	8%	157

Facade . BIM Model

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"ID","EWS Type","Orientation","Location","Area","Material","Material Type","Glass Type",
"","","","","","","","","","","",""
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"ME_1_65","EWS 13","East","Main","12.385 m²","Glass","Glass"
"ME_1_64","EWS 13","East","Main","12.385 m²","Glass","Glass"
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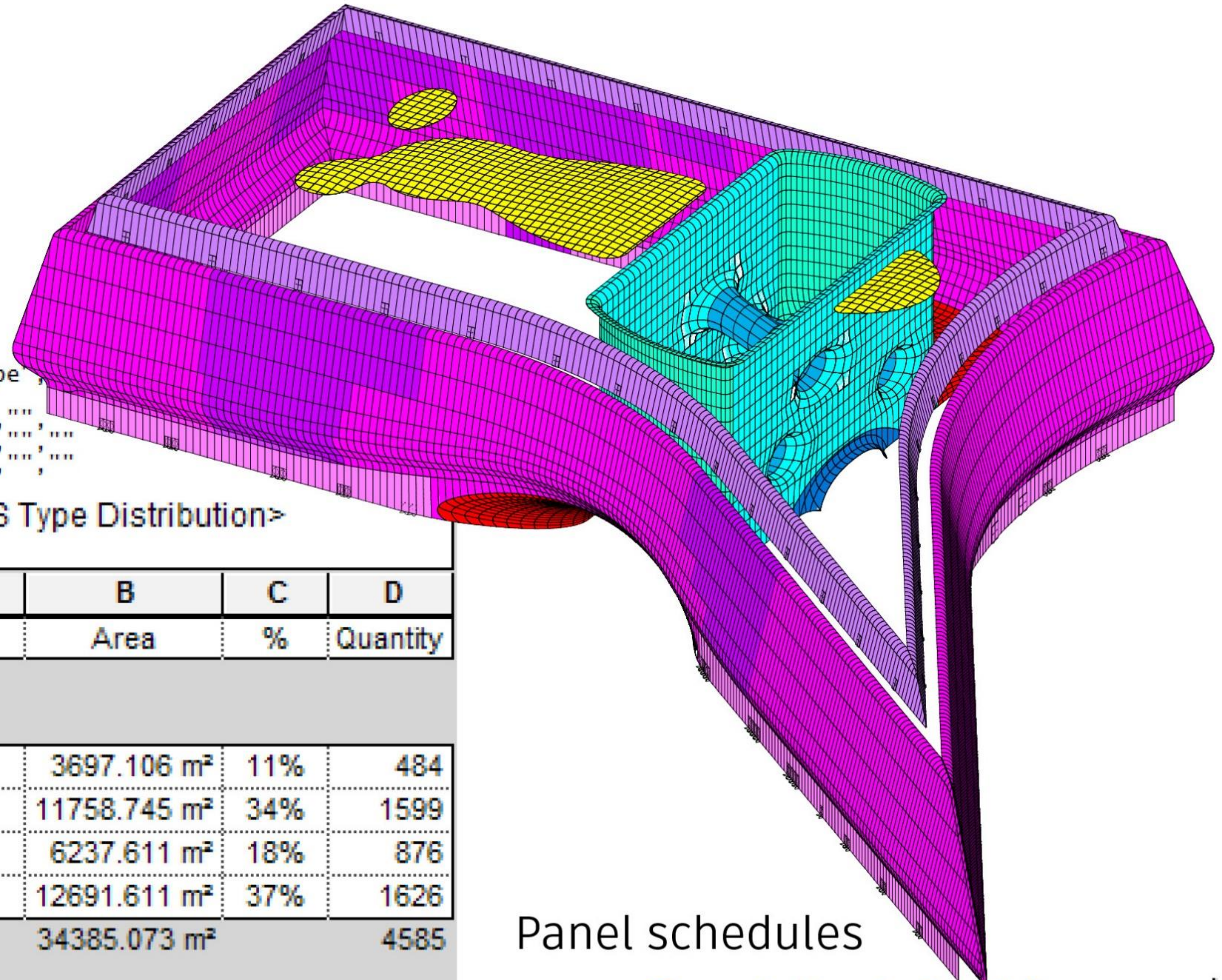

<EWS Type Distribution>

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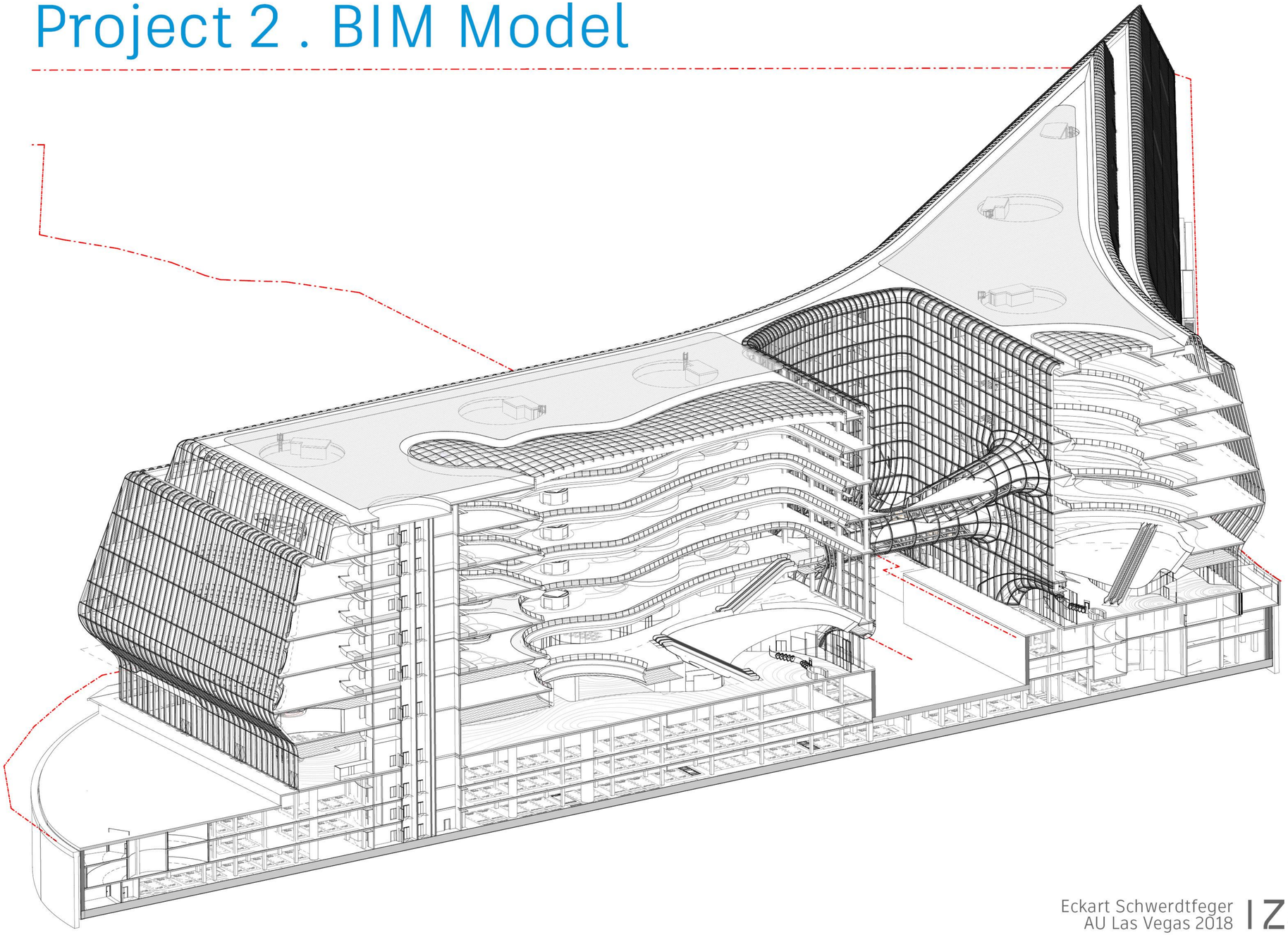
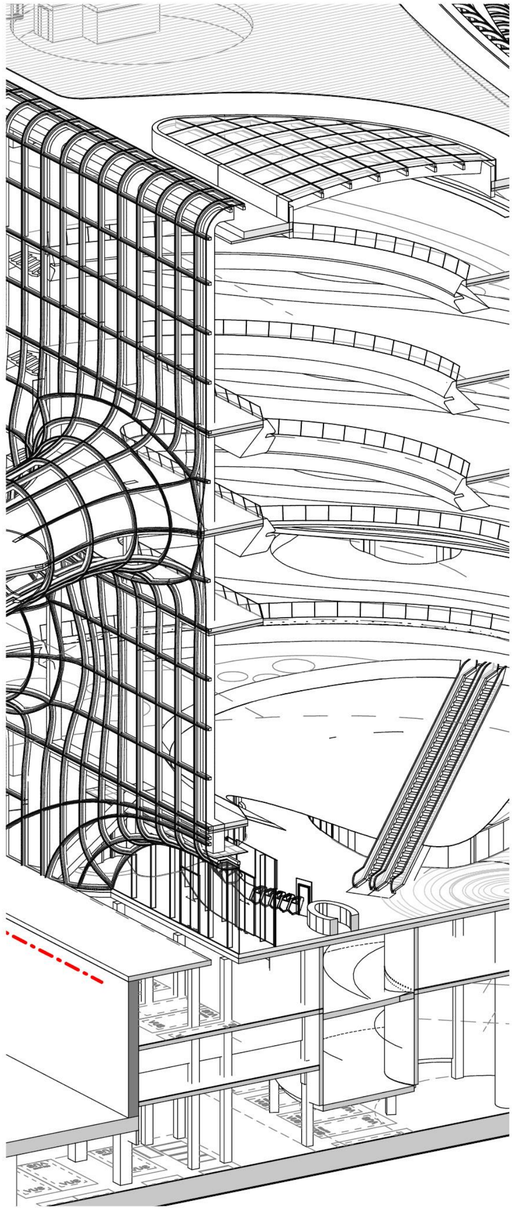
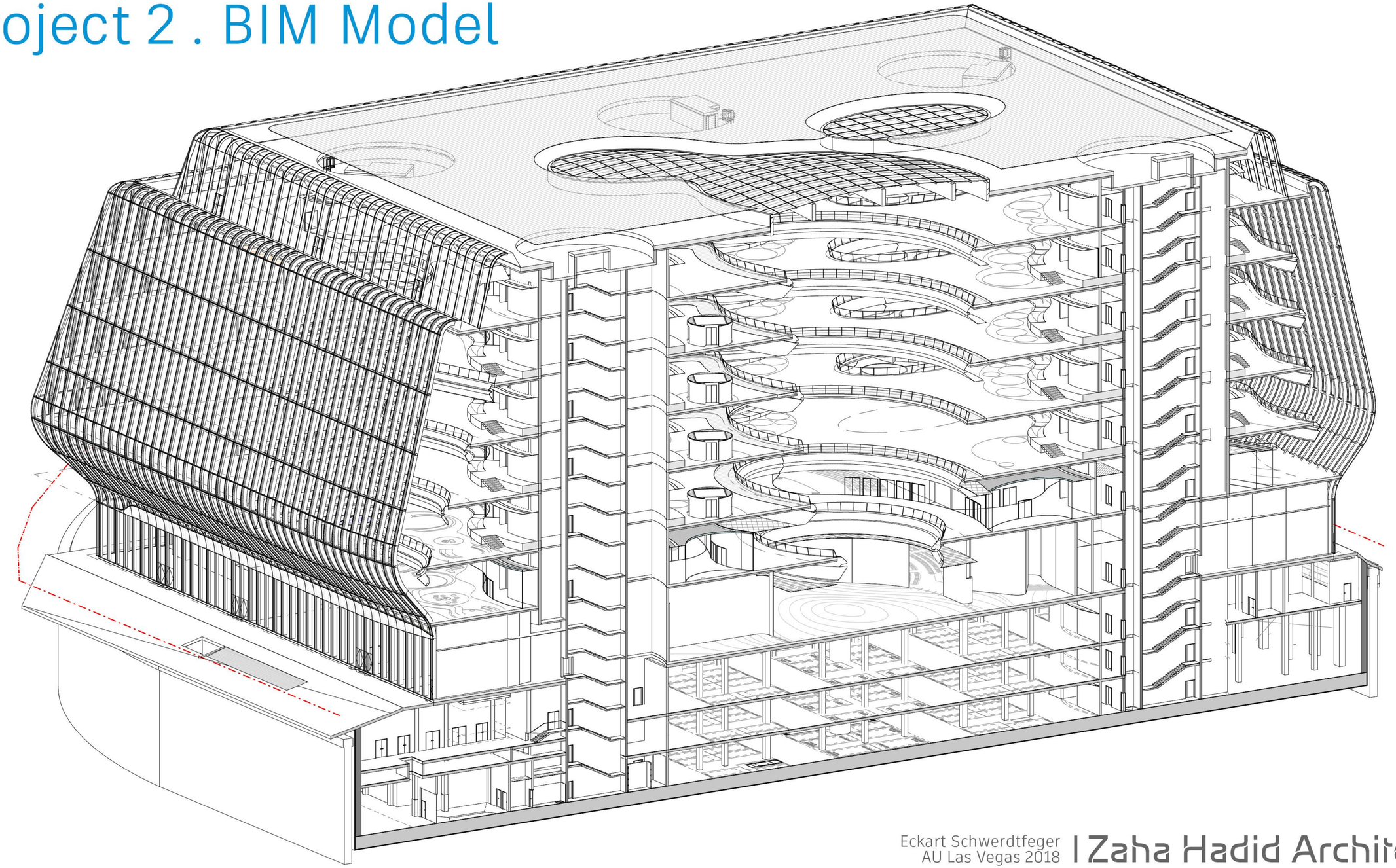
Project 2 . BIM Model





Project 2 . BIM Model




VIDEO
https://vimeo.com/eckart/aulasvegas2018-15
Eckart Schwerdtfeger
AU Las Vegas 2018
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