MEP Explore: Generative Design for MEP Designers

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RAMBOLL

AUTODESK. UNIVERSITY

About the speaker

BIM CONSULTANT

- Integrated Digital Solutions|Rambøll Denmark
- MSc. Civil Engineer | HVAC
- Digitalization and BIM development for HVAC projects

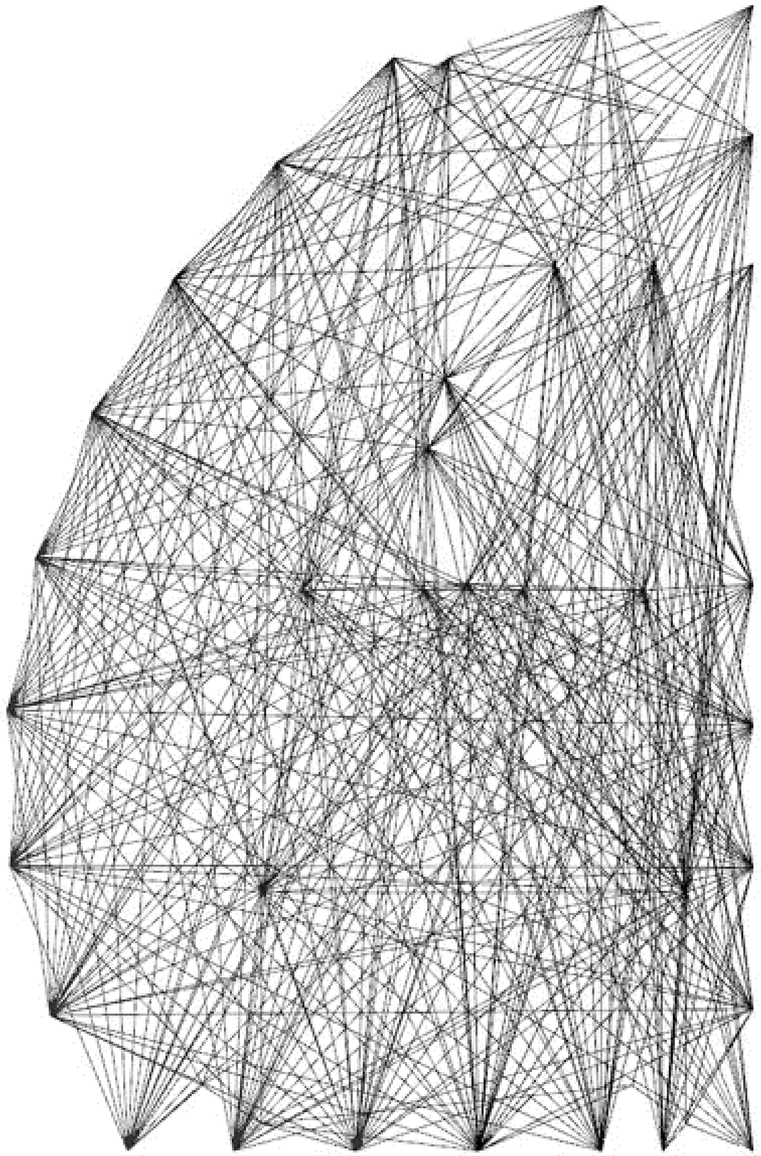
- **LEARNING OBJECTIVES**
  - 1. WHY GENERATIVE DESIGN FOR MEP
  - 2. GETTING STARTED WITH PROJECT FRACTAL
  - 3. MEP EXPLORE : GENERATIVE DESIGN WORKFLOW FOR ALLOCATION OF AIR TERMINAL DEVICES
  - 4. GENERATIVE DESIGN IMPLEMENTATION : TAKE ACTION IN YOUR ORGANIZATION

Format:
Instructional Demo

Attendee skill level:
Intermediate

Track:
Generative Design to Intelligent Automation

WHY GENERATIVE DESIGN?



AUTODESK

GENERATIVE DESIGN
FOR ARCHITECTURE

1. GENERATE

2. EVALUATE

3. EVOLVE

4. EXPLORE

By Autodesk

WHY NOT GENERATIVE DESIGN FOR MEP?

ROOMS ARE UPDATED MANY TIMES

CEILINGS PLANS ARE PROVIDED REALLY LATE

CEILINGS PLANS ARE CHANGED AGAIN

MEP CELING COORDINATION ARE PERFORMED REALLY LATE

GENERATIVE DESIGN FOR MEP
EMBRACING OPPORTUNITIES

- **MOOVING AWAY FROM TIME & MATERIAL BUSINESS MODEL**

BUSINESS SURVIVAL
BURNING PLATFORM

- **BENEFITS:**
  - HIGHER QUALITY DELIVERABLES (OPTIMIZED SOLUTIONS)
  - SPEED IN DESIGN PROCESSES (DELIVIRING FAST WITH CONFIDENT)
  - LOWER PRODUCTION COST (AUTOMATED DESIGN)

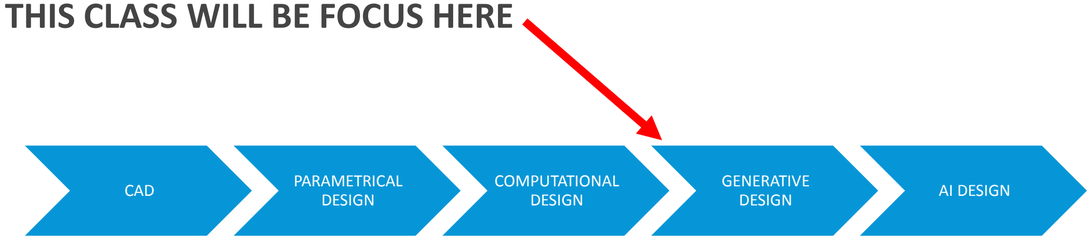
GETTING STARTED WITH GENERATIVE DESIGN FOR MEP DESIGNERS

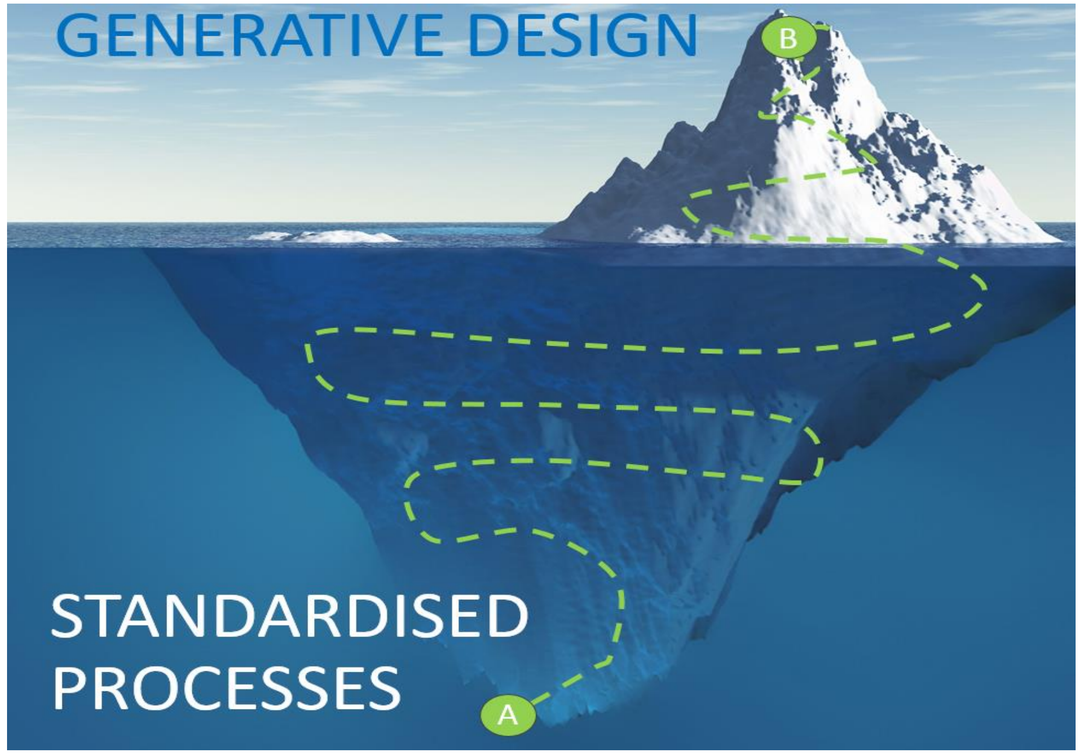
PEOPLE & PROCESSES FIRST, TECHNOLOGHY SECOND

REQUIREMENTS FOR GENERATIVE DESIGN

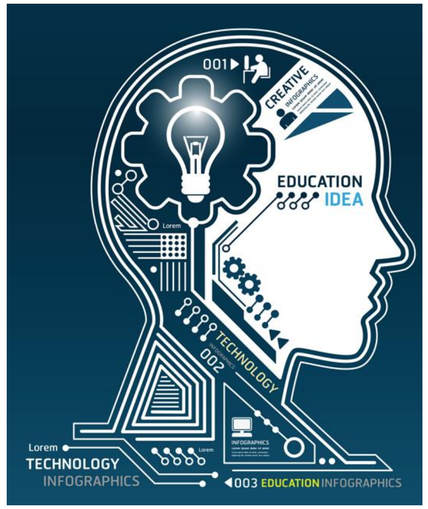
- STANDARDISED AND OPTIMIZED DESIGN PROCESSES

THIS CLASS WILL BE FOCUS HERE





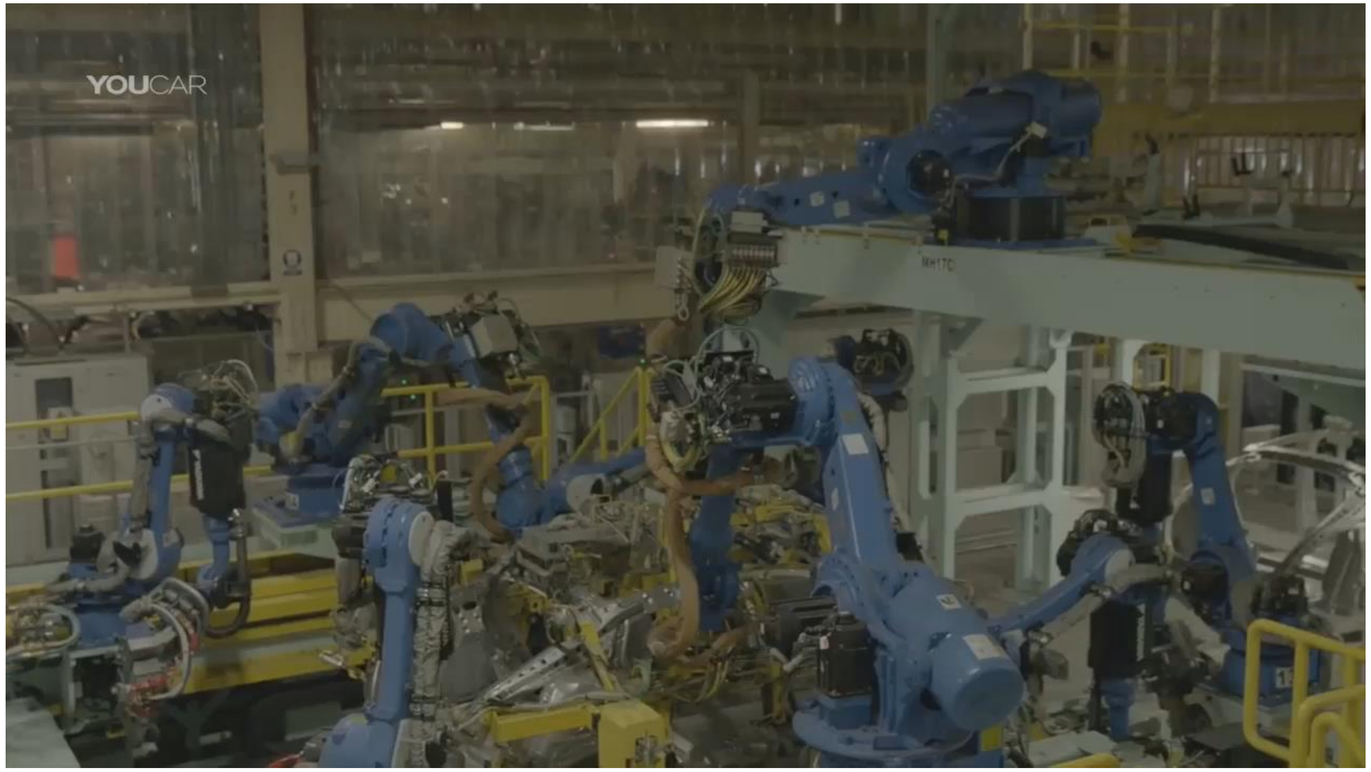
- PEOPLE'S DIGITAL MINDSET AND NEW DESIGN SKILLS
- DIGITAL LEADERSHIP



COMPARISON WITH CAR PRODUCTION HISTORY

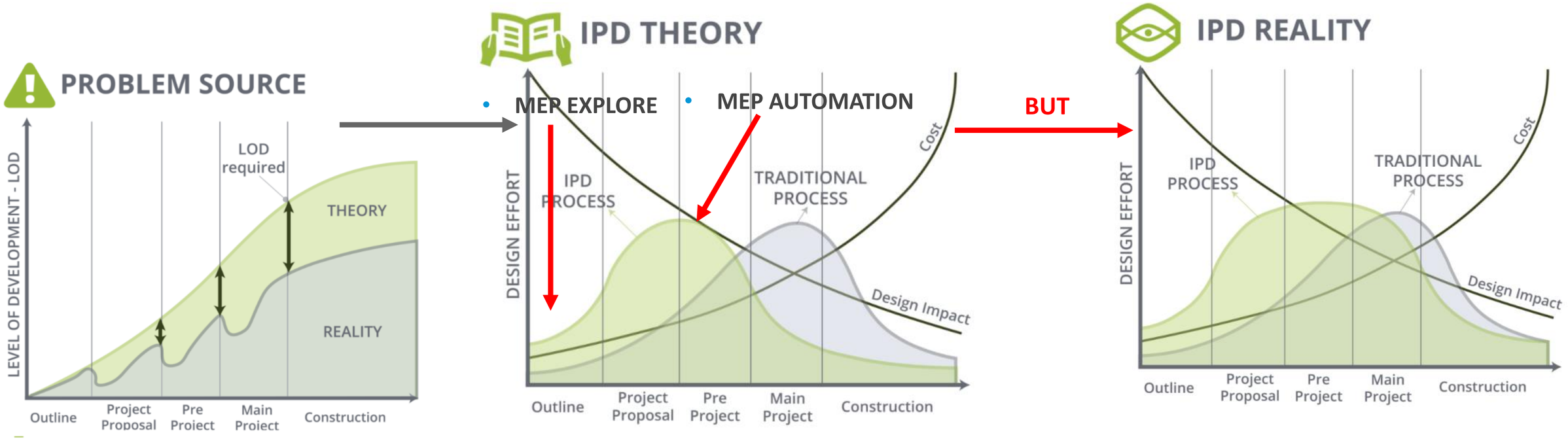
- **DETROIT 1950’s:**

- **JAPAN 2018**



GENERATIVE DESIGN SCOPE – WHEN AND WHY?

GENERATIVE DESIGN GOAL IS TO **INCREASE THE DESIGN VALUE** OF MEP SYSTEMS IN EARLY PHASES **AND REDUCE THE WASTE OR RESOURCERS** DURING THE DETAIL DESIGN PROCESSES

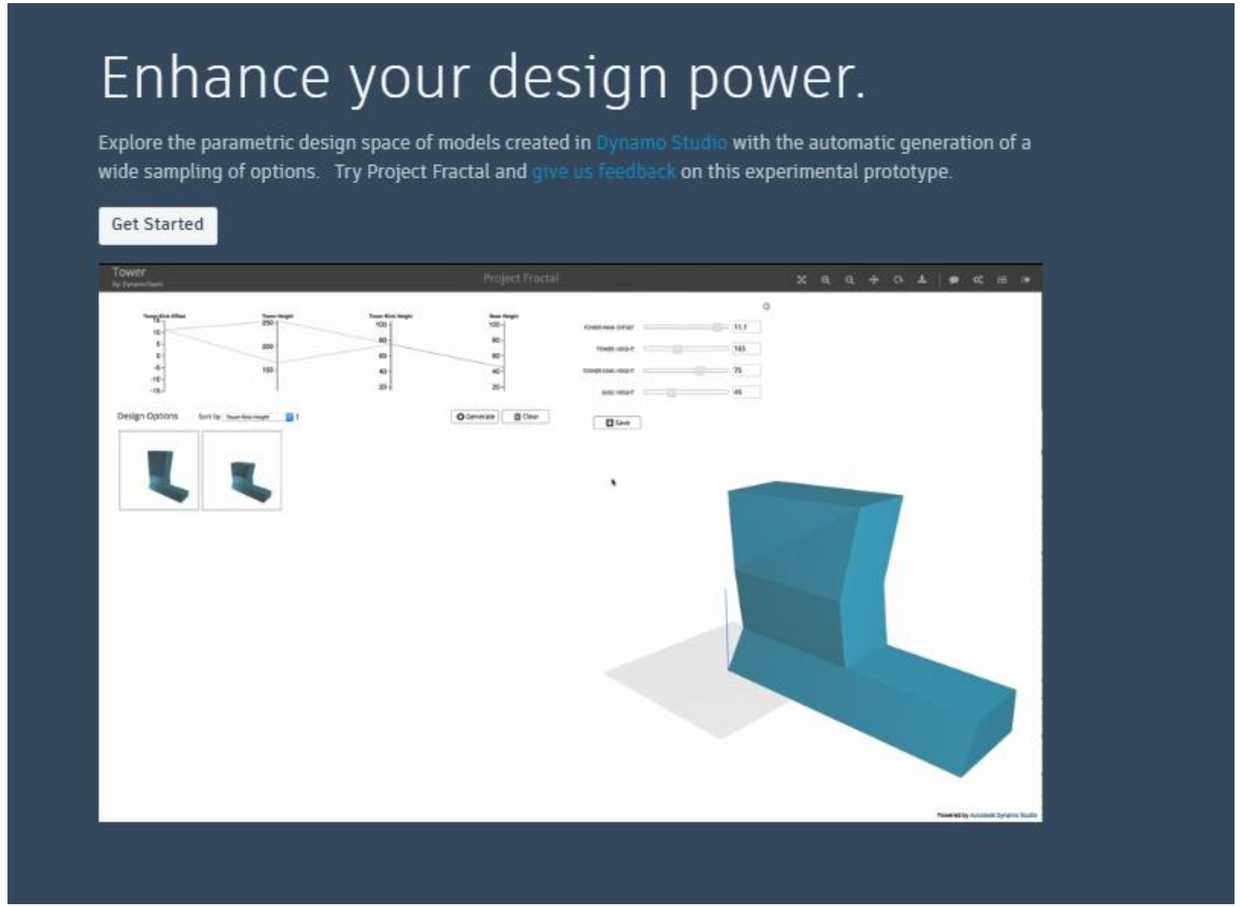


THIS IS ACHIEVED BY AUTOMATING THE DESIGN PROCESS WITH **GENERATIVE DESIGN IN EARLY PHASES AND PARAMETRICAL DESIGN IN DETAIL DESIGN PHASES**

PROJECT FRACTAL

(Cloud platform for Generative Design)

- **It’s free, you only a Dynamo Studio license**
- **https://home.fractal.live/**
- **Available since 2016**



PROJECT FRACTAL GETTING STARTED

DYNAMO STUDIO

INSTALL LATEST VERSION OF DYNAMO STUDIO

PROJECT FRACTAL

LOG IN PROJECT FRACTAL WEBSERVICE AND REQUEST YOUR FREE ACCESS TO FRACTAL

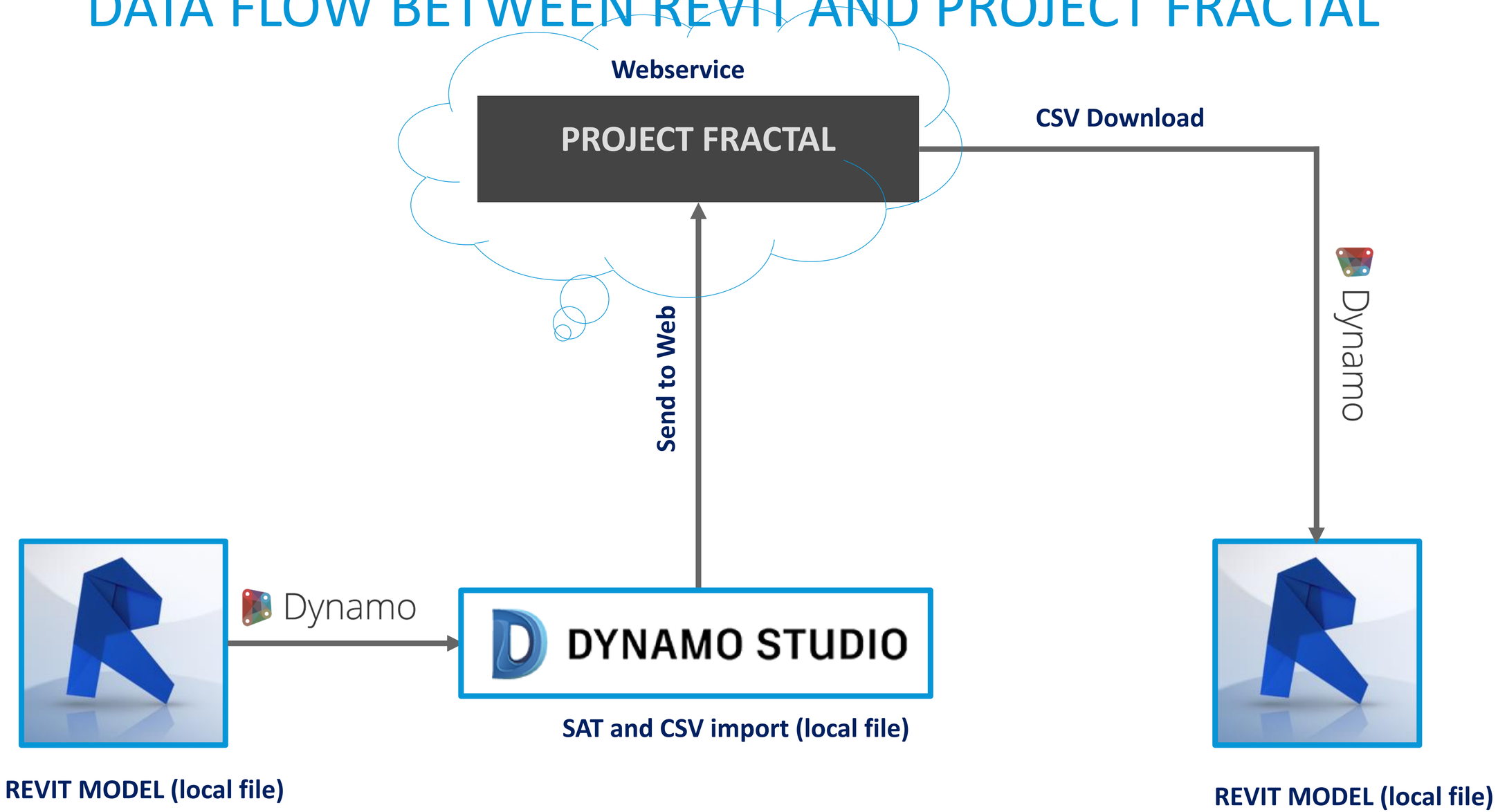
DYNAMO STUDIO

SEND TO WEB FROM DYNAMO STUDIO TO FRACTAL. BE AWARE THAT DYNAMO STUDIO CAN'T TALK DIRECTLY TO REVIT

PROJECT FRACTAL

GENERETIVE DESIGN GENERATION AND EXPLORING

DATA FLOW BETWEEN REVIT AND PROJECT FRACTAL

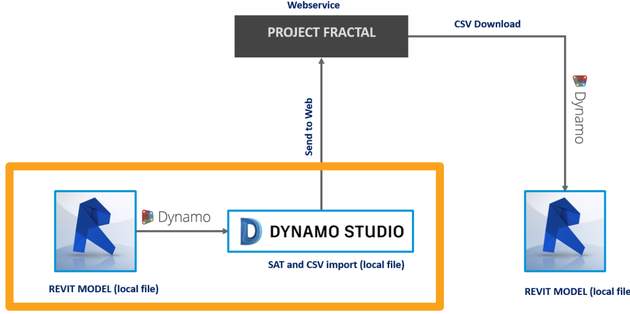


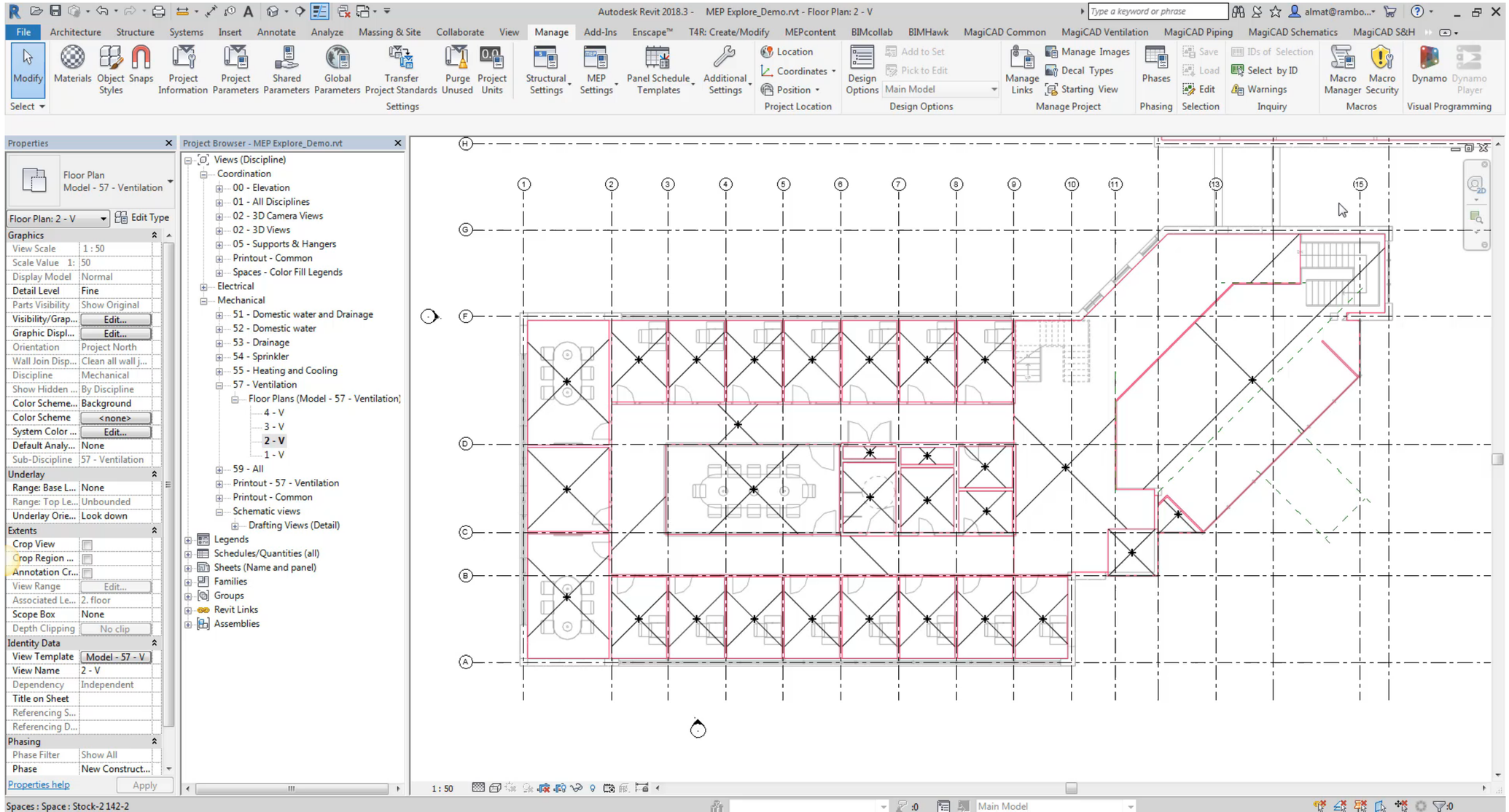
GENERATIVE DESIGN INSTRUCTIONAL
MEP Explore – AIR TERMINALS

GENERATIVE DESIGN FOR AIR TERMINAL DEVICES

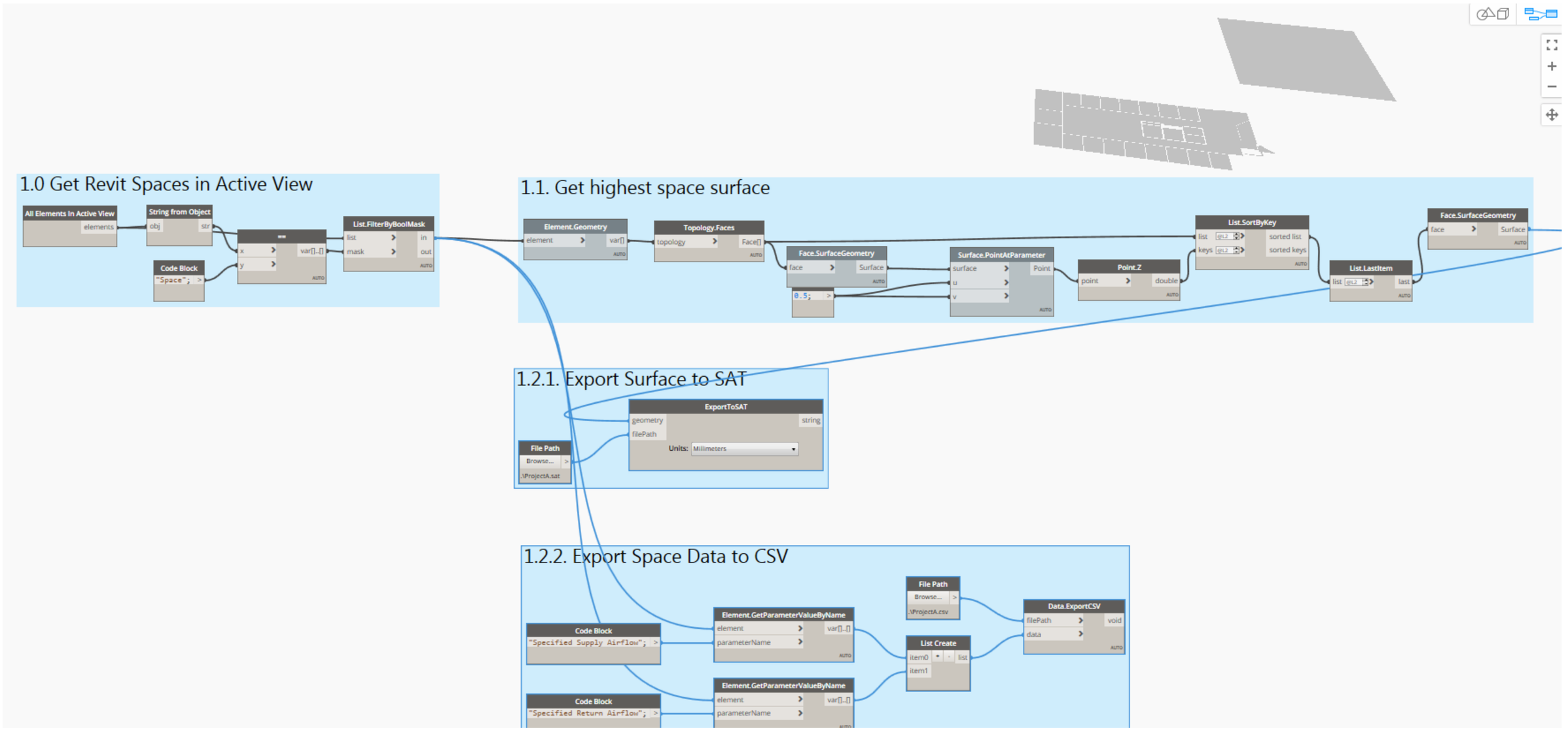
- **SECTION CONTENT:**
  - 1. EXPORT REVIT GEOMETRY TO DYNAMO STUDIO (SCRIPT)
  - 2.1. DYNAMO STUDIO – AIR TERMINAL FAMILIES (SCRIPTS)
  - 2.2. DYNAMO STUDIO – CEILING GRIDS GENERATION (SCRIPTS)
  - 2.3. DYNAMO STUDIO – PERFOMANCE SCORE GOALS (SCRIPTS)
  - 3.1. CEILING ANALYSIS EXPLORATION – PROJECT FRACTAL (WEB SERVICE)
  - 3.2. PROJECT FRACTAL RESULTS IMPORT IN REVIT (SCRIPTS)

1. EXPORT REVIT GEOMETRY TO DYNAMO STUDIO

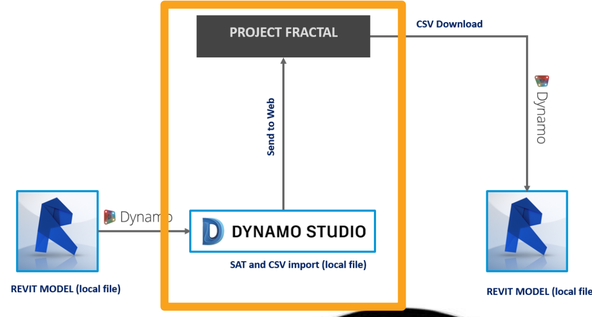




1. EXPORT REVIT GEOMETRY TO DYNAMO STUDIO



2.1 DYNAMO STUDIO - AIR TERMINAL DEVICES / LIGHTING FIXTURES



- **FROM DATA SHEET SPECIFICATION**

- **TO GENERATIVE DESIGN FAMILY**

200	58	209	70	252
160	57	207	71	255
200	67	241	84	302
250	77	277	99	356
200	83	299	100	360
250	96	346	118	425
315	112	403	139	500
250	118	425	139	500
315	133	479	163	587
400	146	526	193	695
315	145	522	173	623
400	187	673	225	810

ændpning

rets egendæmpning ΔL fra kanal til rum inklusive fleksion, se nedenstående tabel.

- MBB-S/-E									
l	PCA	Middelfrekvens Hz							
	$Ød_2$	63	125	250	500	1K	2K	4K	8K
	100	18	17	8	20	19	20	19	23
	125	19	16	7	19	18	18	18	21
	160	21	16	5	15	17	18	16	19
	125	18	13	9	20	13	19	18	19
	160	12	13	8	19	13	16	17	19
	200	18	11	5	18	13	15	15	17
	160	17	17	11	19	18	17	20	20
	200	14	14	7	21	15	16	18	19
	250	15	15	5	17	13	15	16	18
	200	15	10	6	18	17	15	19	18
	250	12	9	5	14	17	15	17	17
	315	12	7	4	11	15	14	16	15
	250	14	8	8	14	16	17	17	18
	315	12	6	6	15	15	15	16	17
	400	13	5	4	13	14	14	15	15
	315	7	9	8	14	17	16	17	21
	400	7	8	8	12	16	16	16	18

Korrektion af kastelængde $l_{0.2}$

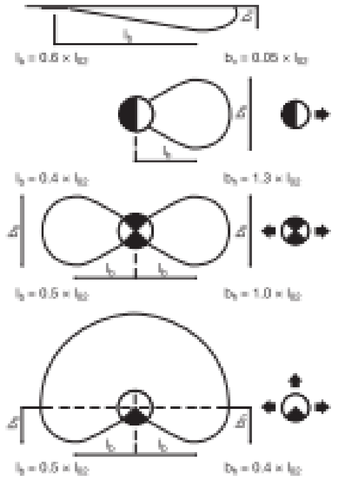
PCA Ød	1 - vejs	2 - vejs	3 - vejs
100	2.3	1.7	1.3
125	2.6	1.8	1.4
160	2.5	1.7	1.3
200	2.4	1.7	1.3
250	2.3	1.7	1.3
315	2.2	1.7	1.2
400	2.3	1.7	1.2

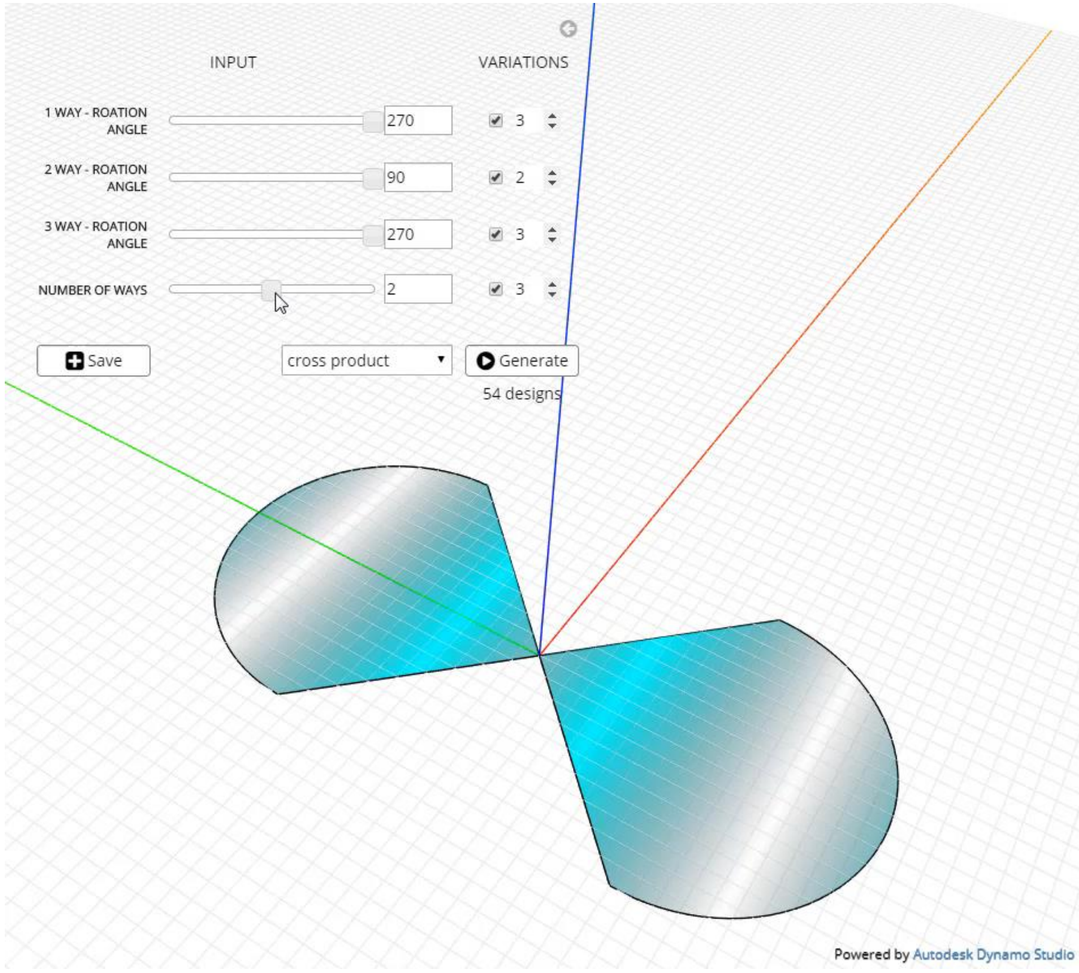
Stråleudbredelse

l_b = Afstand fra armaturet til det punkt, hvor spredningen er maksimal.

b_v = Strålens tykkelse i vertikalt plan.

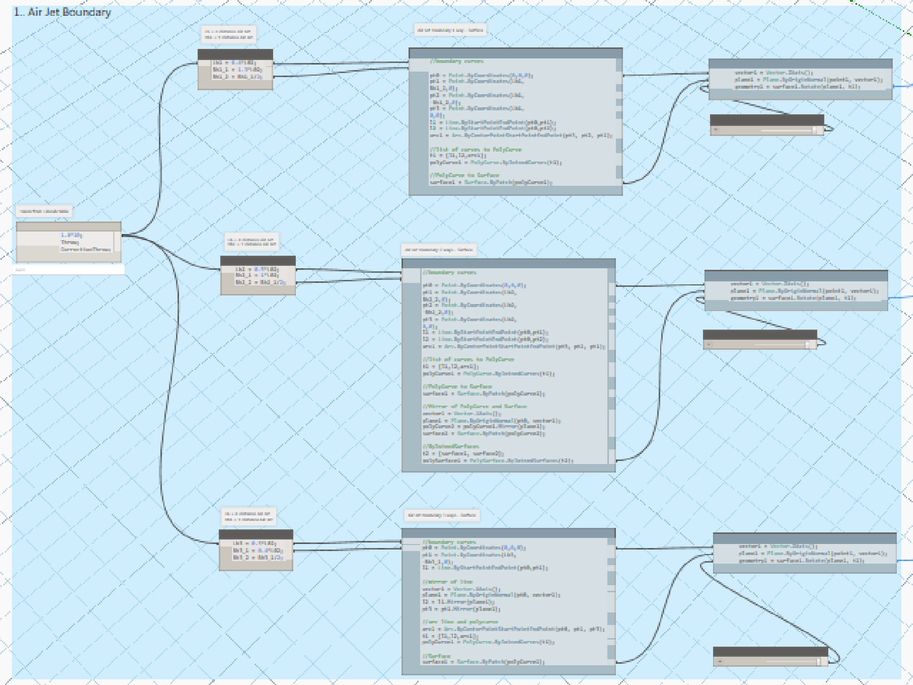
b_h = Strålens bredde i horisontalt plan.



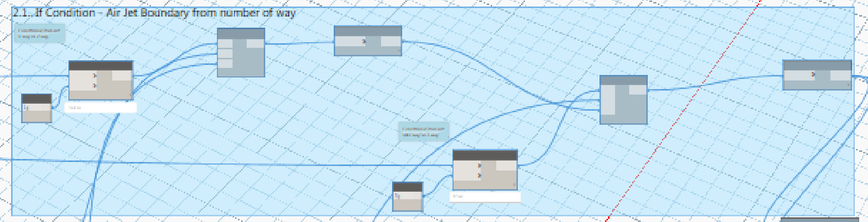


2.1 DYNAMO STUDIO - AIR TERMINAL DEVICES

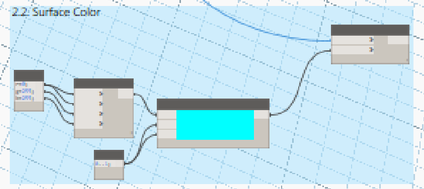
- **1. AIR JET DISTRIBUTION SURFACE**



- **2. IF CONDITION – 1 WAY, 2 WAY, 3 WAYS DEVICES**

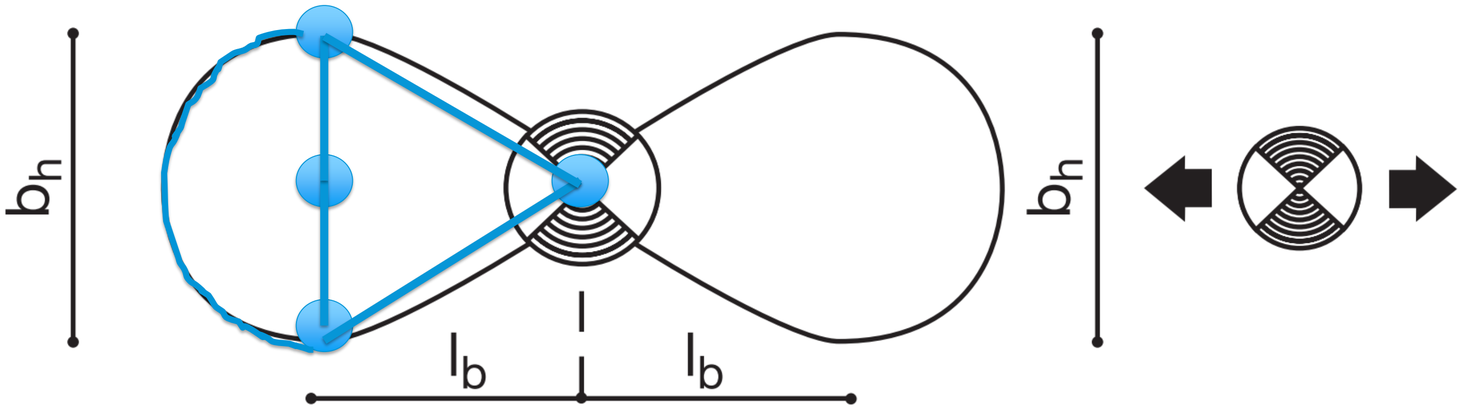


- **3. OUPUT VISUALIZATION**



2.1 DYNAMO STUDIO - AIR TERMINAL DEVICES

- **FROM PRODUCT SHEET SPECIFICATION**



$l_b = 0.5 \times l_{02}$

$b_h = 1.0 \times l_{02}$

- **TO DESIGN SCRIPT GEOMETRY DEFINITATION**

Air Jet Boundary 2 ways - Surface

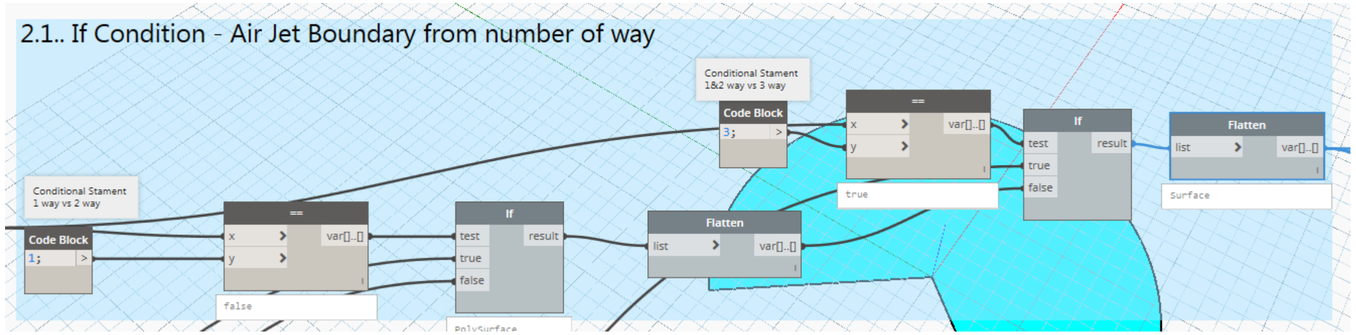
Code Block

Lb2
Bh2_2

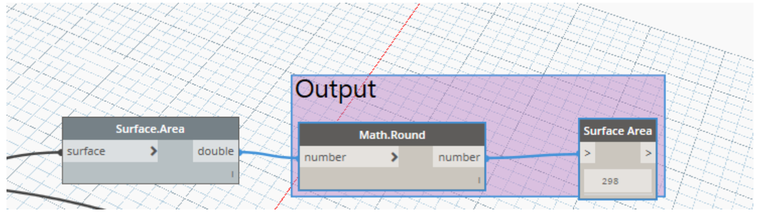
```
//boundary curves

pt0 = Point.ByCoordinates(0,0,0);
pt1 = Point.ByCoordinates(Lb2,
Bh2_2,0);
pt2 = Point.ByCoordinates(Lb2,
-Bh2_2,0);
pt3 = Point.ByCoordinates(Lb2,
0,0);
l1 = Line.ByStartPointEndPoint(pt0,pt1);
l2 = Line.ByStartPointEndPoint(pt0,pt2);
arc1 = Arc.ByCenterPointStartPointEndPoint(pt3, pt2, pt1);

//list of curves to PolyCurve
t1 = {l1,l2,arc1};
polyCurve1 = PolyCurve.ByJoinedCurves(t1);

//PolyCurve to Surface
surface1 = Surface.ByPatch(polyCurve1);

//Mirror of PolyCurve and Surface
vector1 = Vector.XAxis();
plane1 = Plane.ByOriginNormal(pt0, vector1);
polyCurve2 = polyCurve1.Mirror(plane1);
surface2 = Surface.ByPatch(polyCurve2);

//ByJoinedSurfaces
t2 = {surface1, surface2};
polySurface1 = PolySurface.ByJoinedSurfaces(t2);
```

2.1 DYNAMO STUDIO - AIR TERMINAL DEVICES

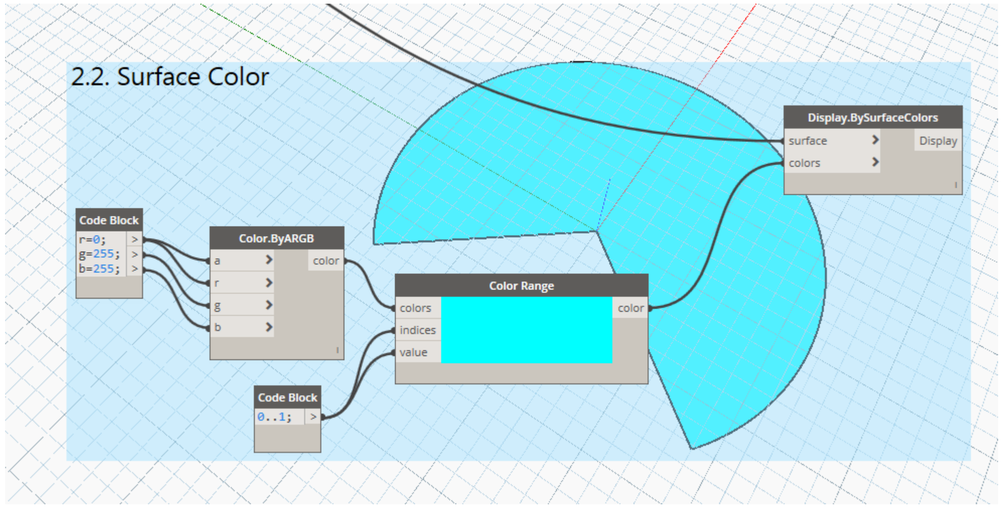
- **2.1. IF CONDITION – 1 WAY, 2 WAY, 3 WAYS DEVICES**



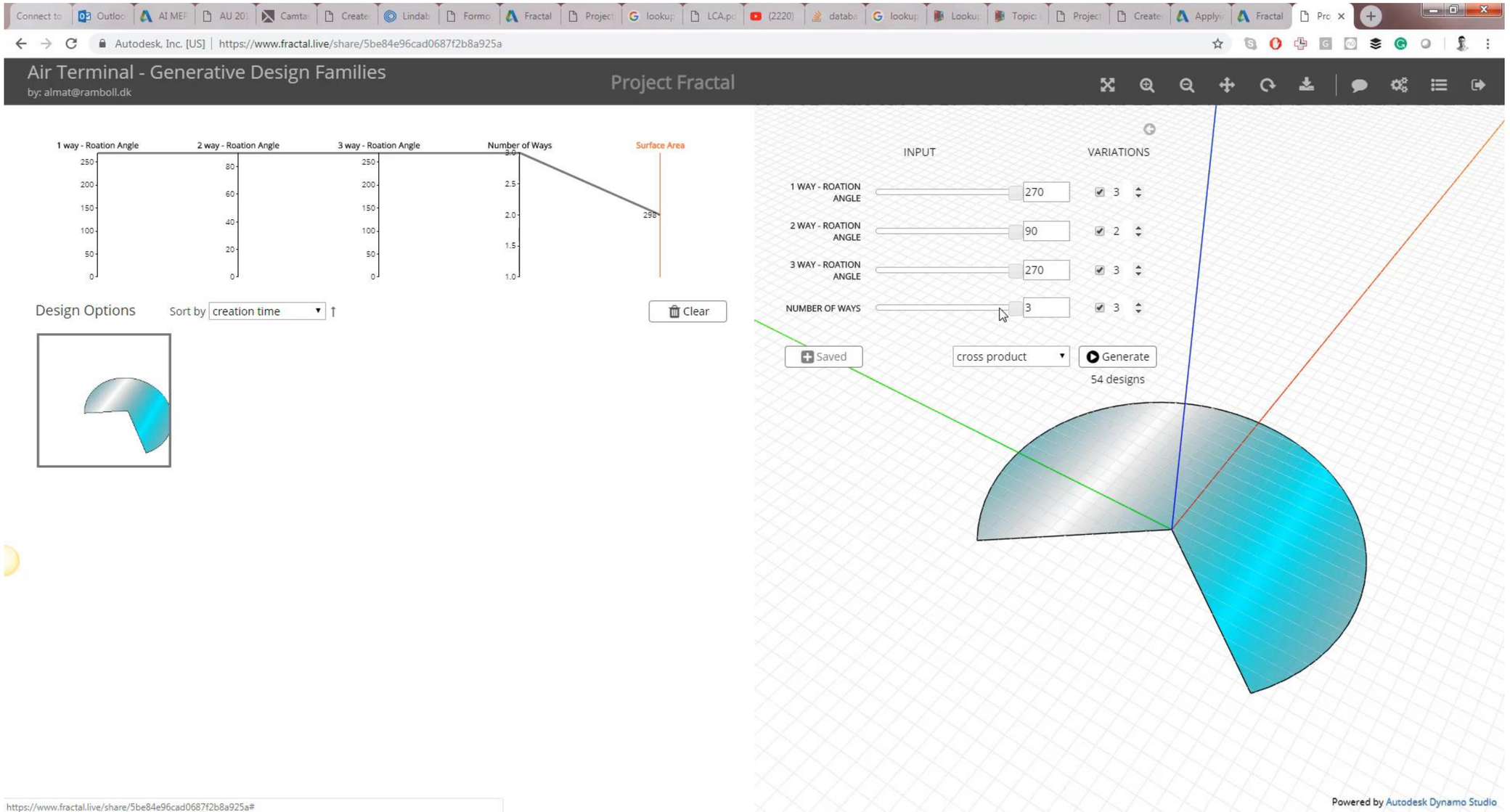
- **2.2. JET DISTRUBTION SURFACE AREA**



- **3. COLOUR VISUALIZATION**

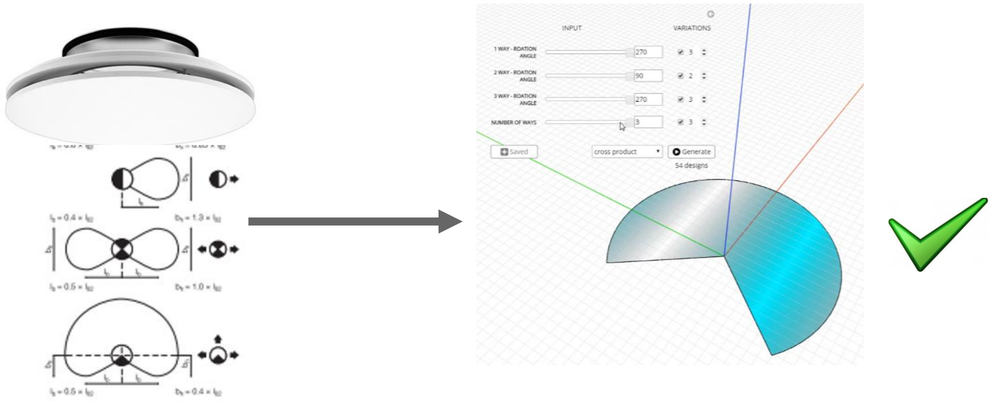


2.1 DYNAMO STUDIO - AIR TERMINAL DEVICES
FRACTAL – COMPUTATIONAL DESIGN FAMILIES

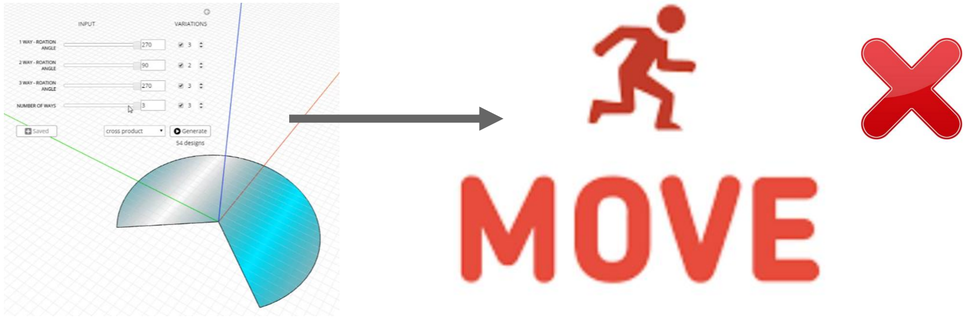


Which features make an object to be generative design friendly?

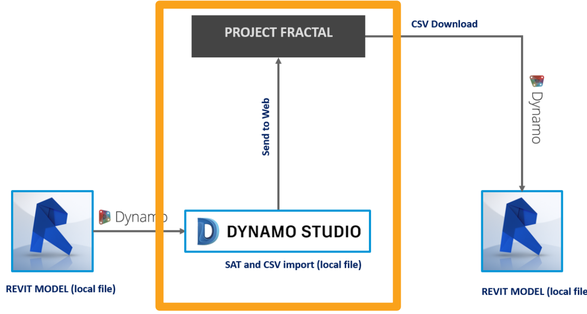
1. **To be a computational design object**



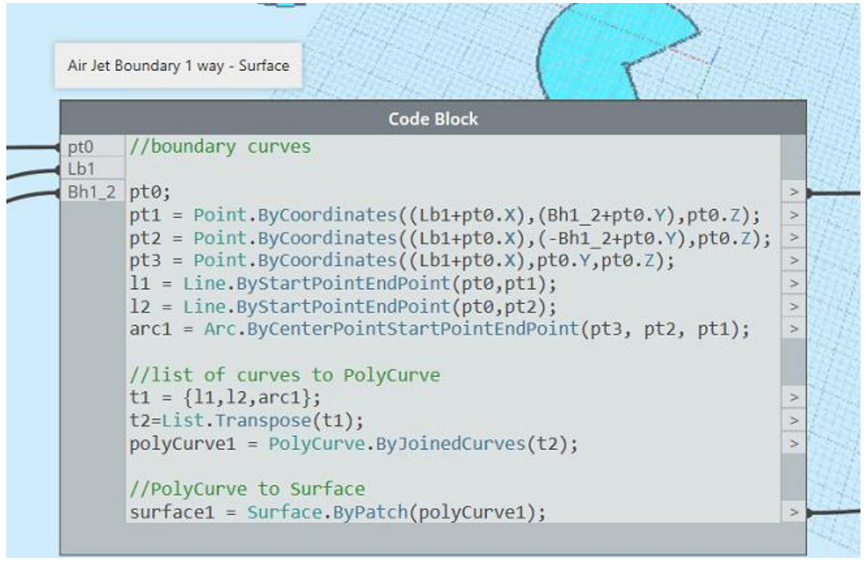
1. **To have movement within a geometrical space**



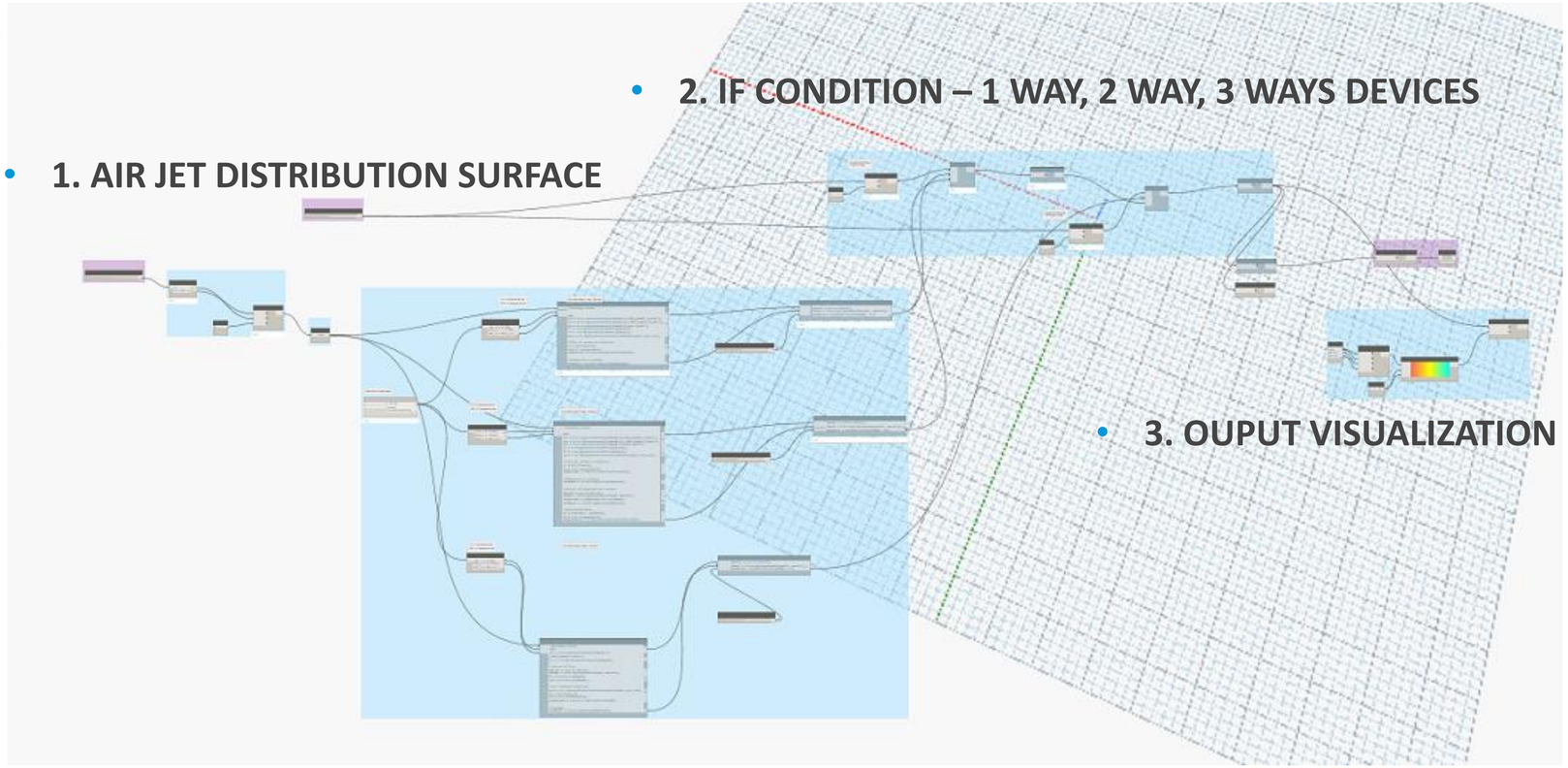
2.1 DYNAMO STUDIO - AIR TERMINAL DEVICES FRACTAL – GENERATIVE DESIGN FAMILIES



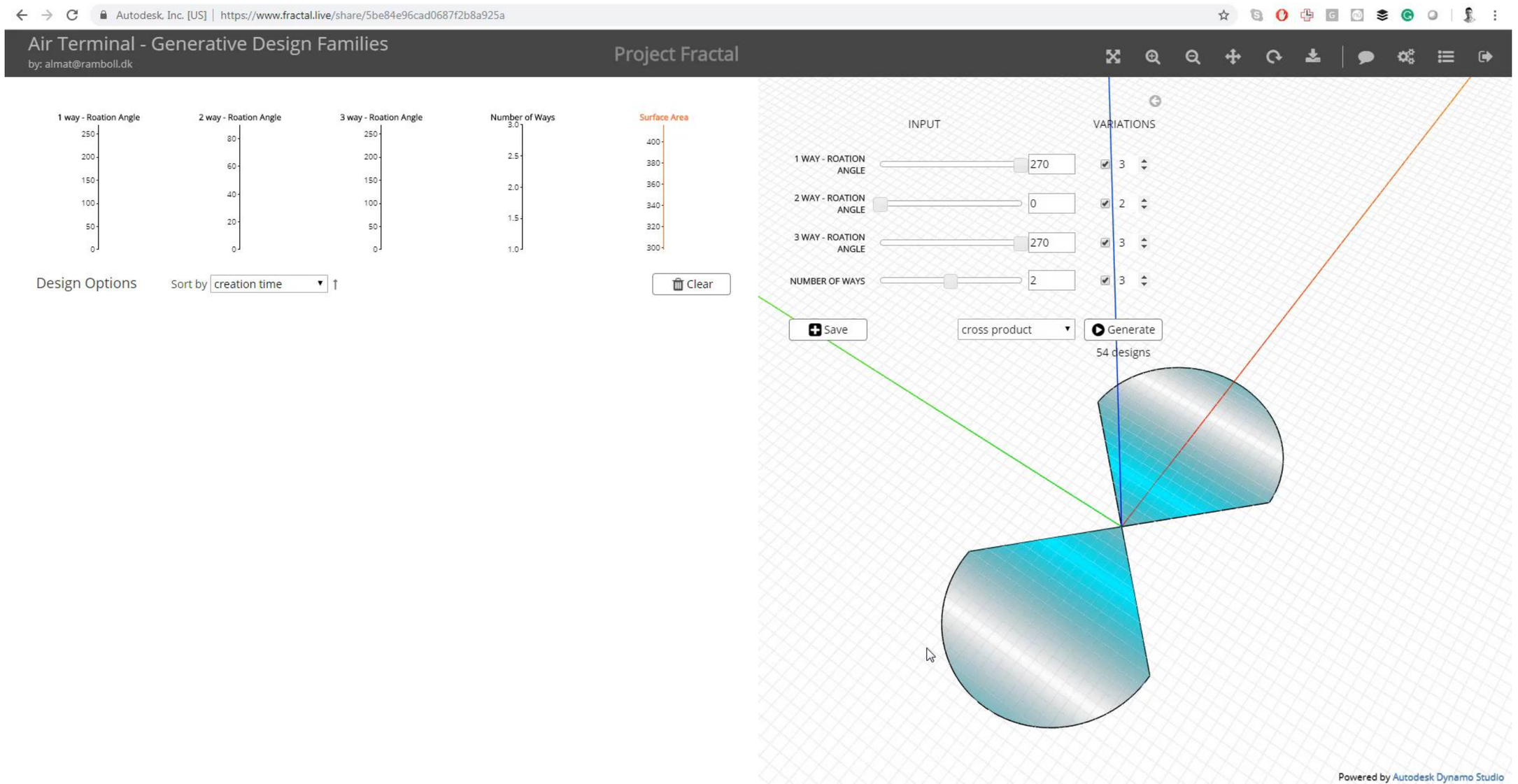
- SAME SCRIPTS THAN BEFORE, HOWEVER BOUNDARY **POINTS** ARE DEFINED **AS UNKNOWN VARIABLES**



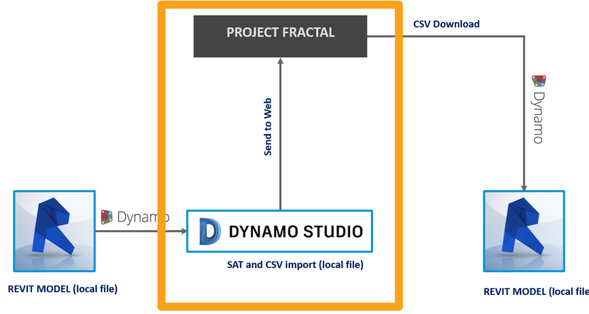
- **1. AIR JET DISTRIBUTION SURFACE**
- **2. IF CONDITION – 1 WAY, 2 WAY, 3 WAYS DEVICES**
- **3. OUPUT VISUALIZATION**



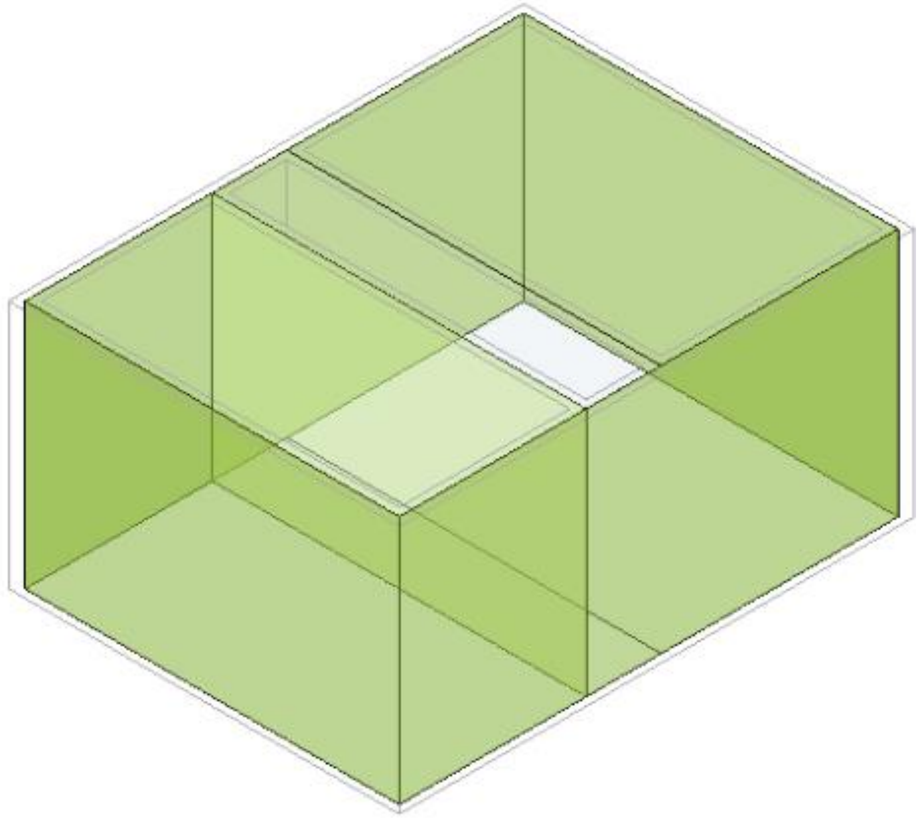
2.1 DYNAMO STUDIO - AIR TERMINAL DEVICES FRACTAL – GENERATIVE DESIGN FAMILIES

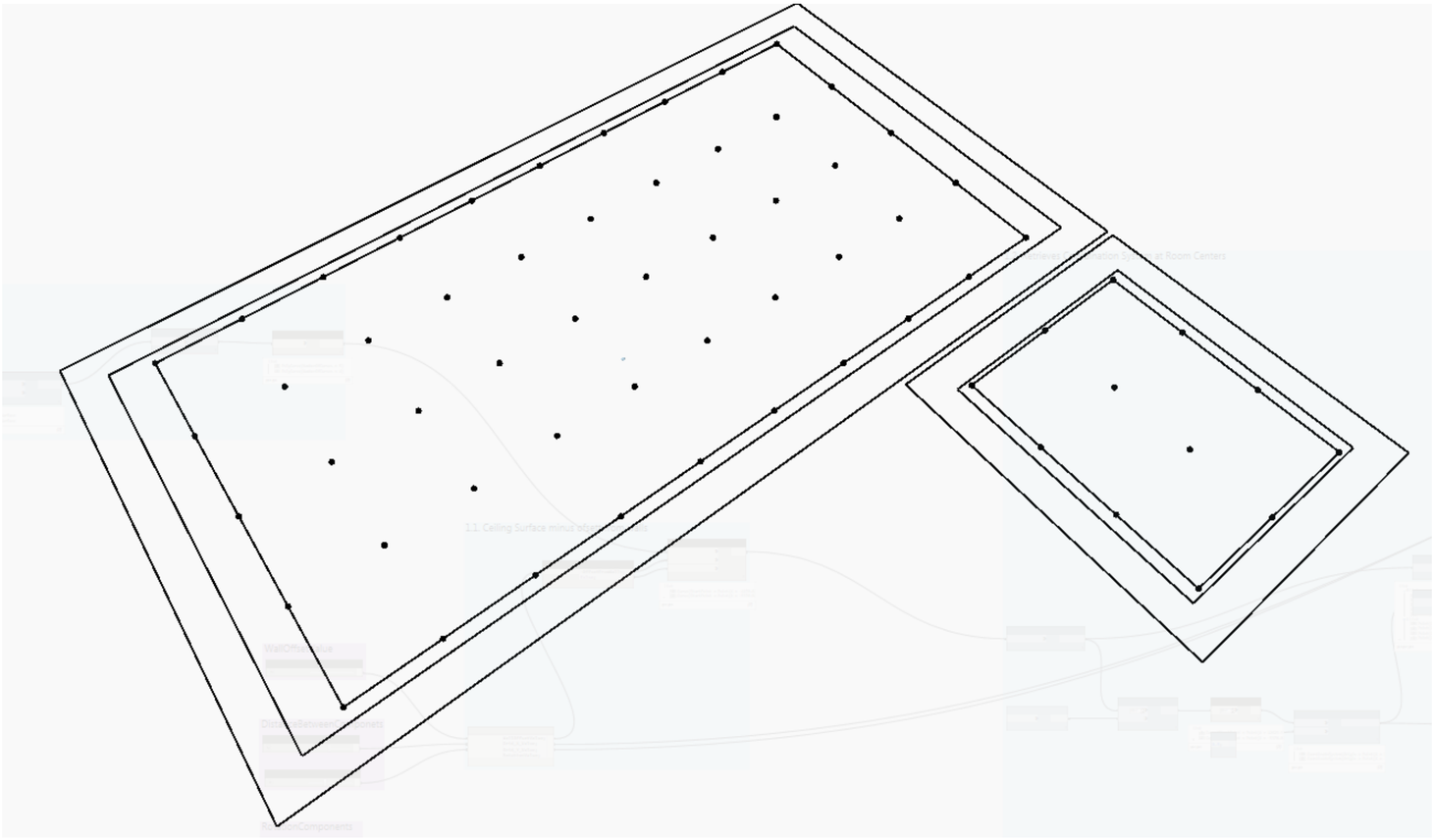


2.3 DYNAMO STUDIO - CEILING ANALYSIS



- **FROM SPACES** → **TO CONCEPTUAL VENTILATION DESIGN ANALYSIS WITH DYNAMO STUDIO**

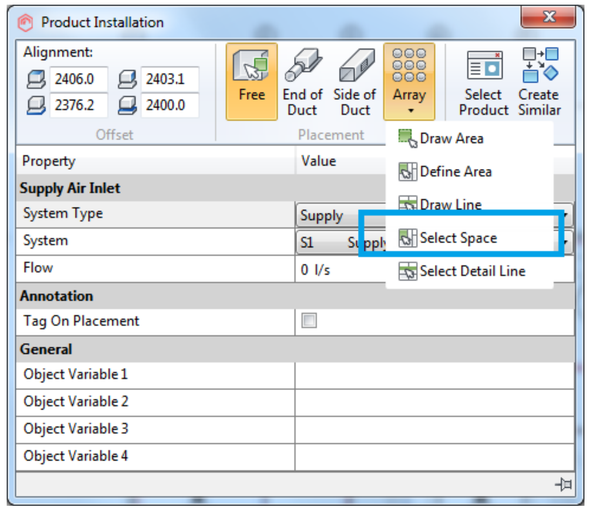




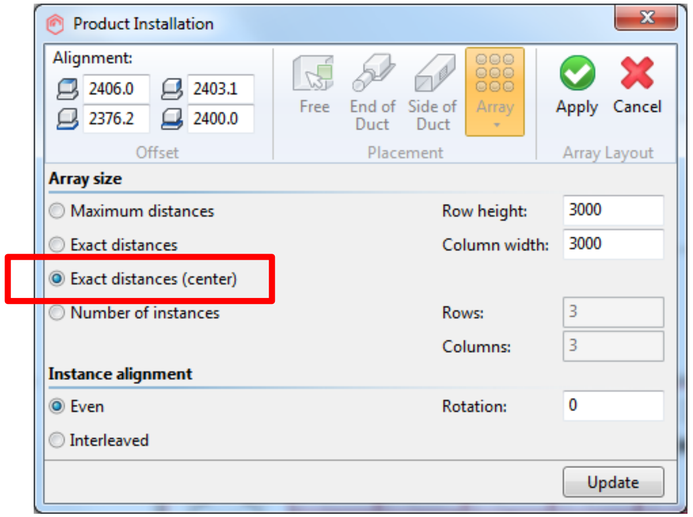
2.3 DYNAMO STUDIO - CEILING ANALYSIS EXISTING PROCESS – INSPIRATION

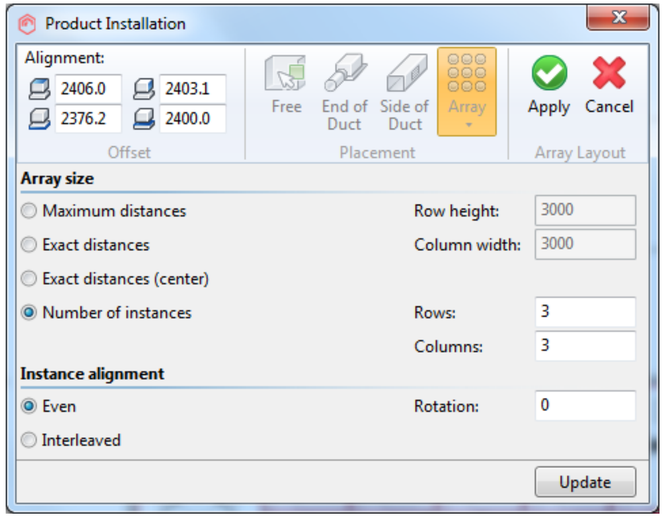
MagiCAD

- **1. SELECT SPACE**

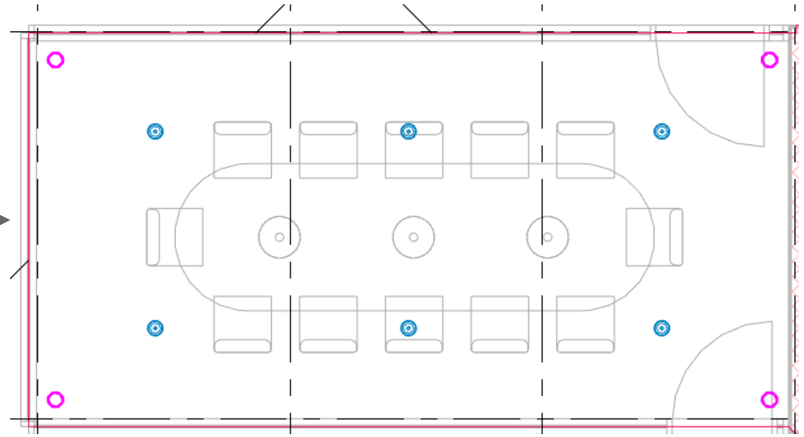


- **2. AIR TERMINALS ARRAY GENERATION**

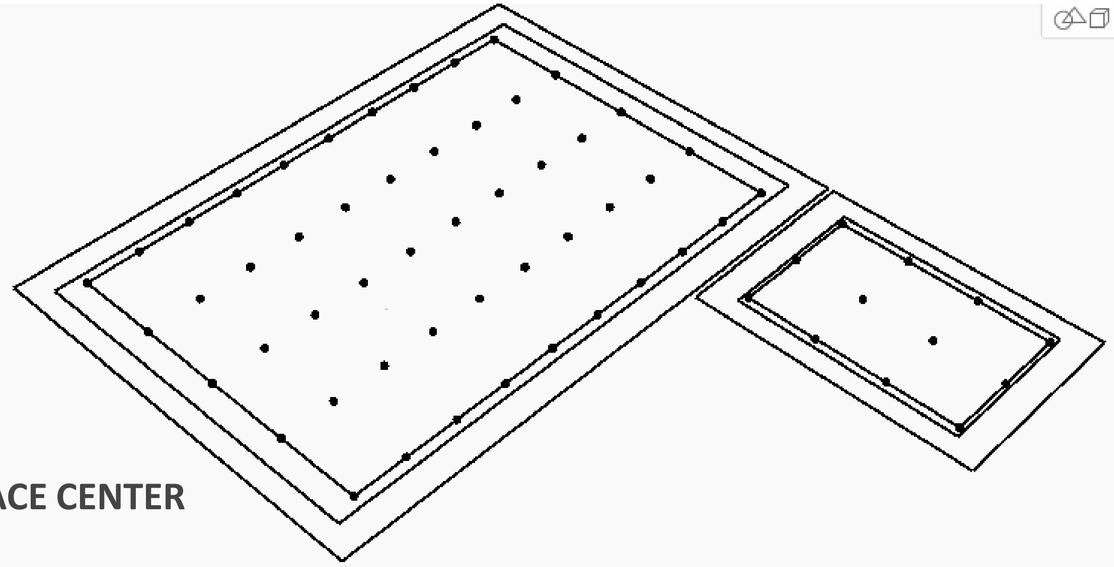




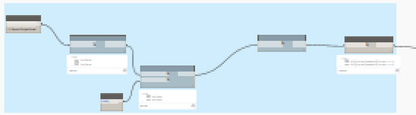
- **3. AUTOMATIC MODELLING**



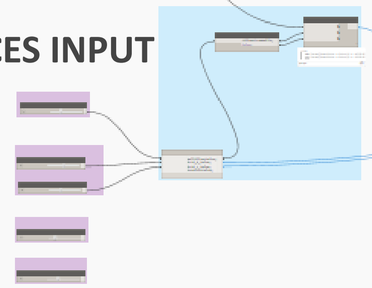
2.3 DYNAMO STUDIO - CEILING ANALYSIS



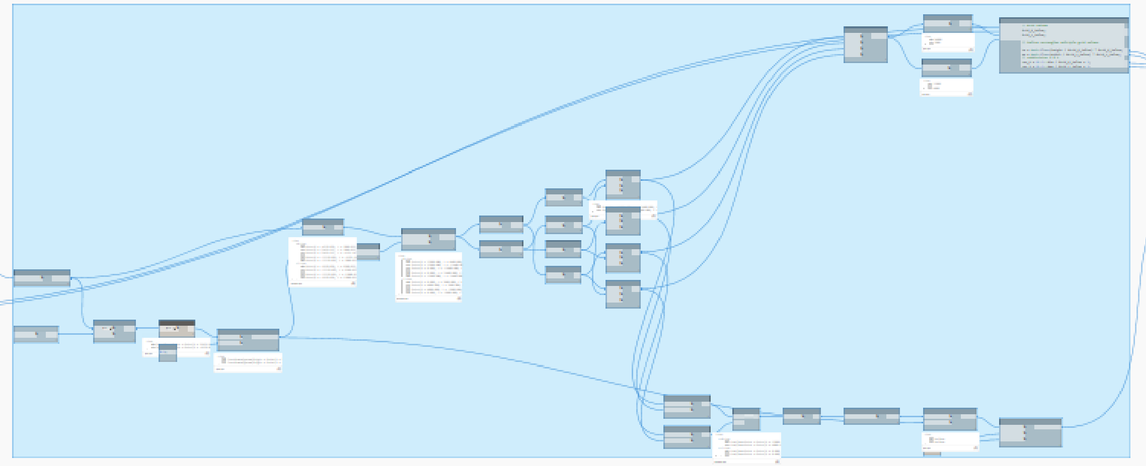
- 0. SPACES – IMPORT



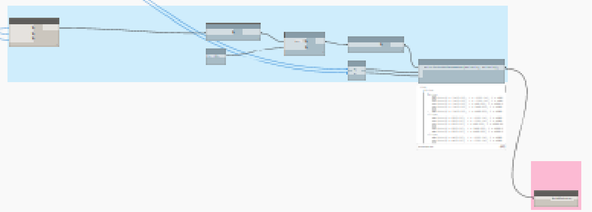
- 1. GRID DISTANCES INPUT



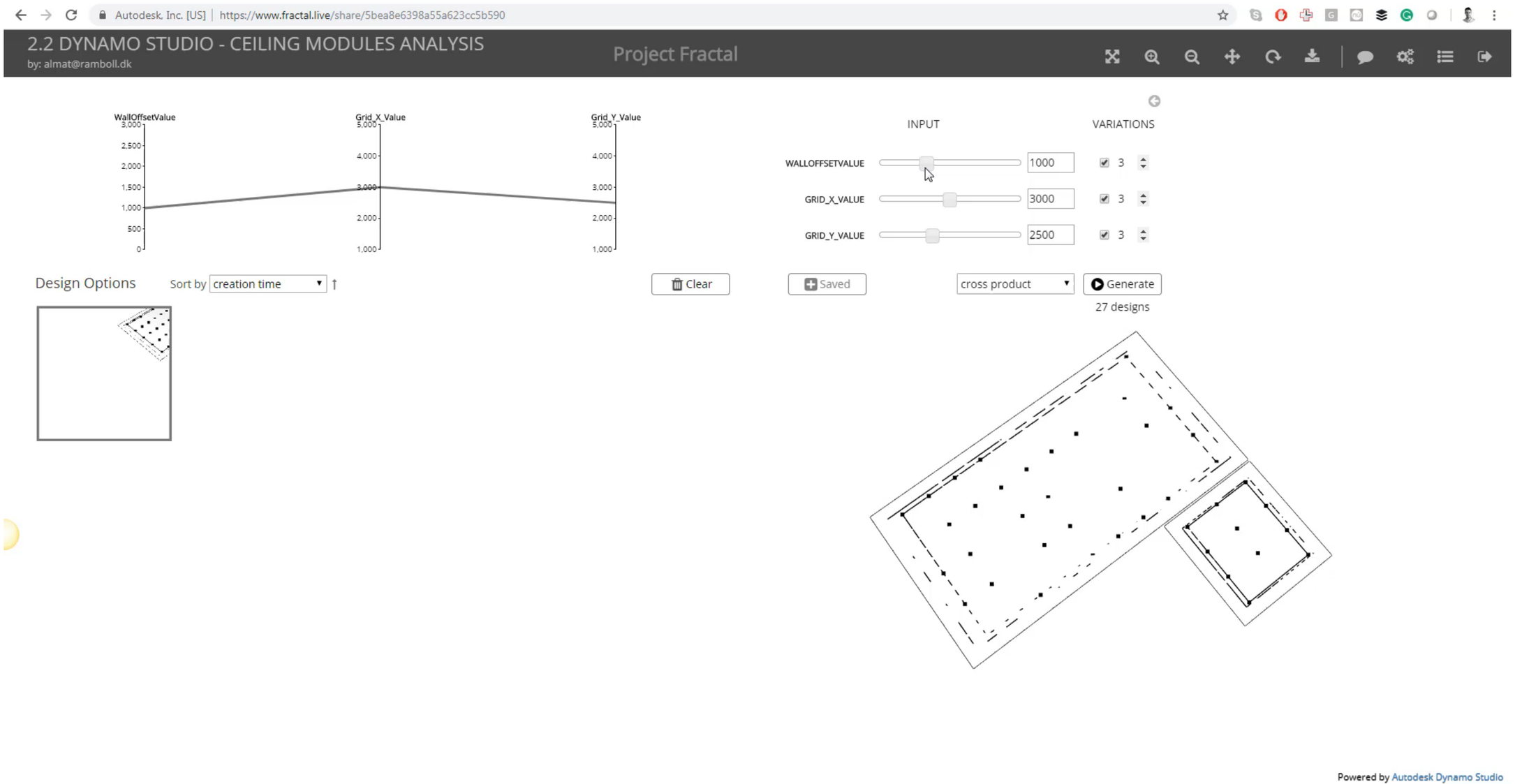
- 2. COORDINATION SYSTEM AT SPACE CENTER



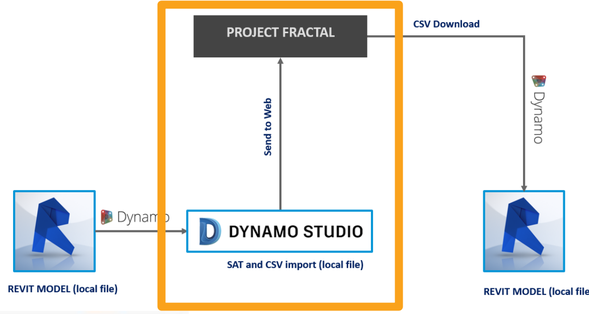
- 3. POINTS GENERATION



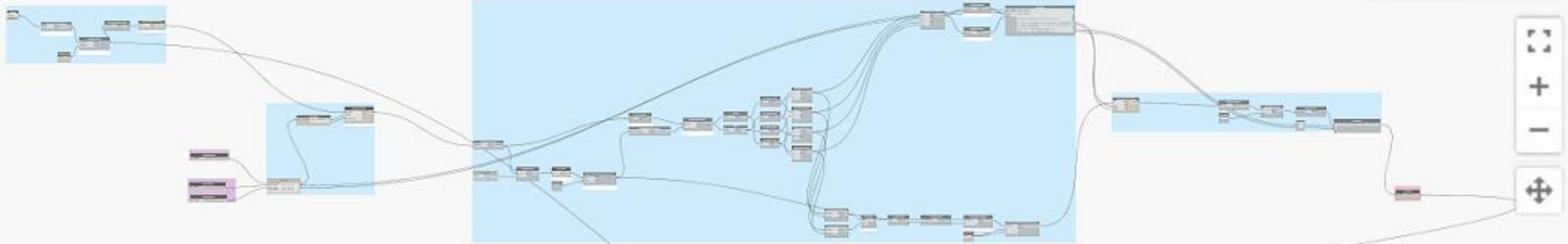
2.3 DYNAMO STUDIO - CEILING MODULES ANALYSIS



2.4 DYNAMO STUDIO - EXPLORING LAYOUT OF AIR TERMINAL DEVICES

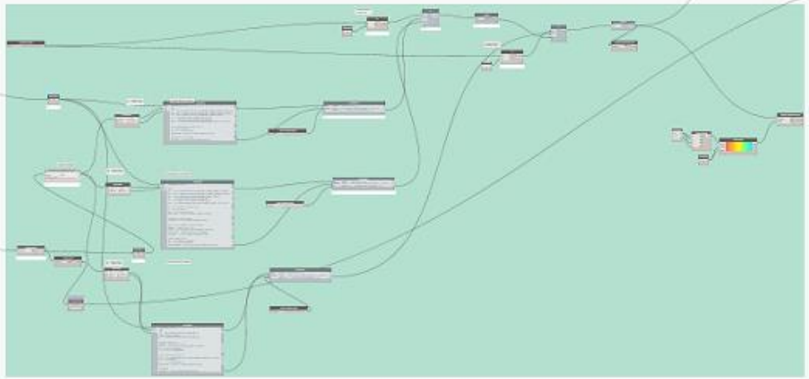


- 1. IMPORT REVIT GEOMETRY (SAT)
- 3. CEILING ANALYSIS



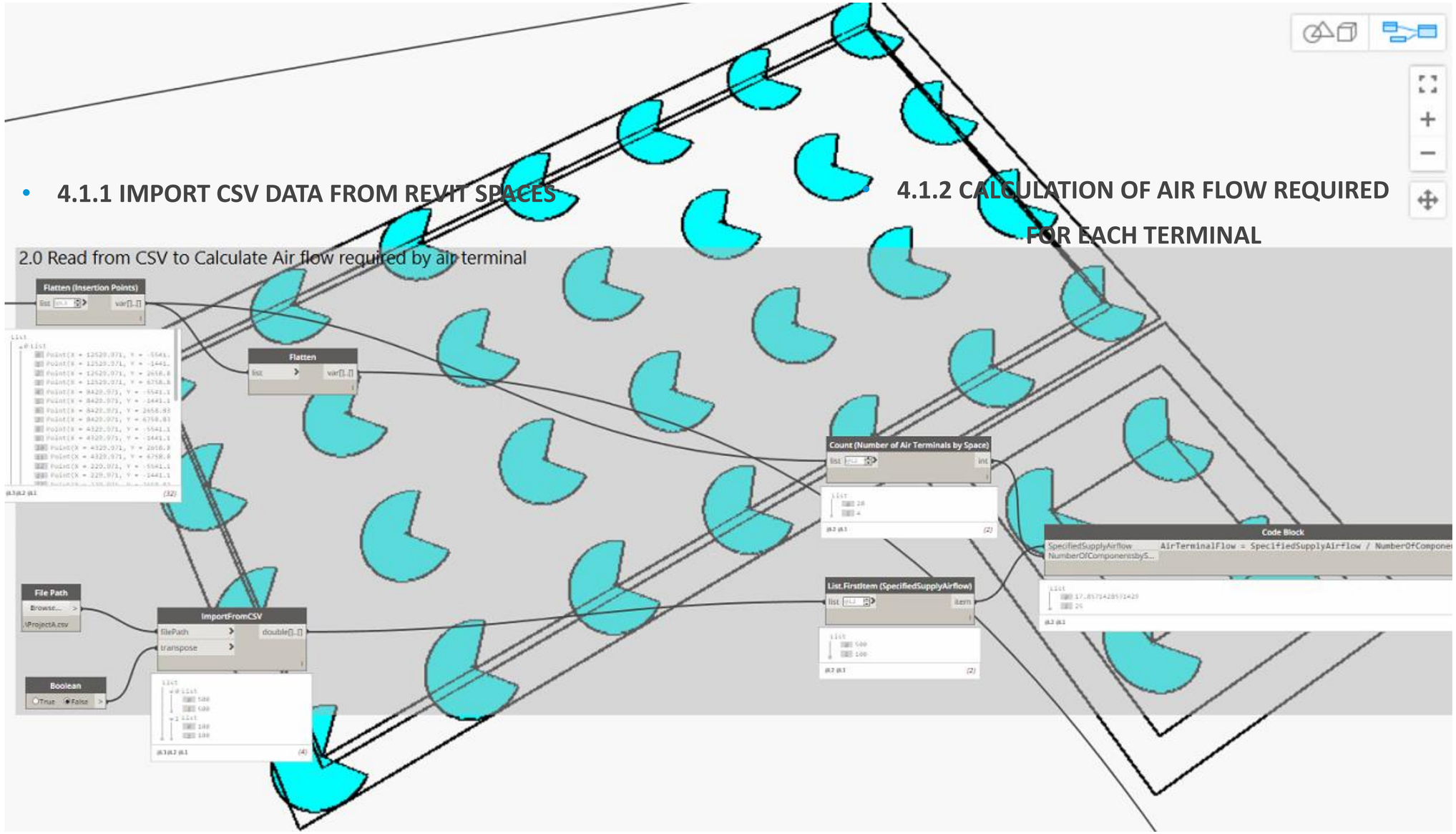
- 4.1 IMPORT CSV DATA FROM REVIT SPACES
- 4.2 PERFORMANCE ANALYSIS

- 2. GENERATIVE DESIGN “FAMILIES”



2.4.1 DYNAMO STUDIO - EXPLORING IMPORT CSV DATA FROM REVIT SPACES

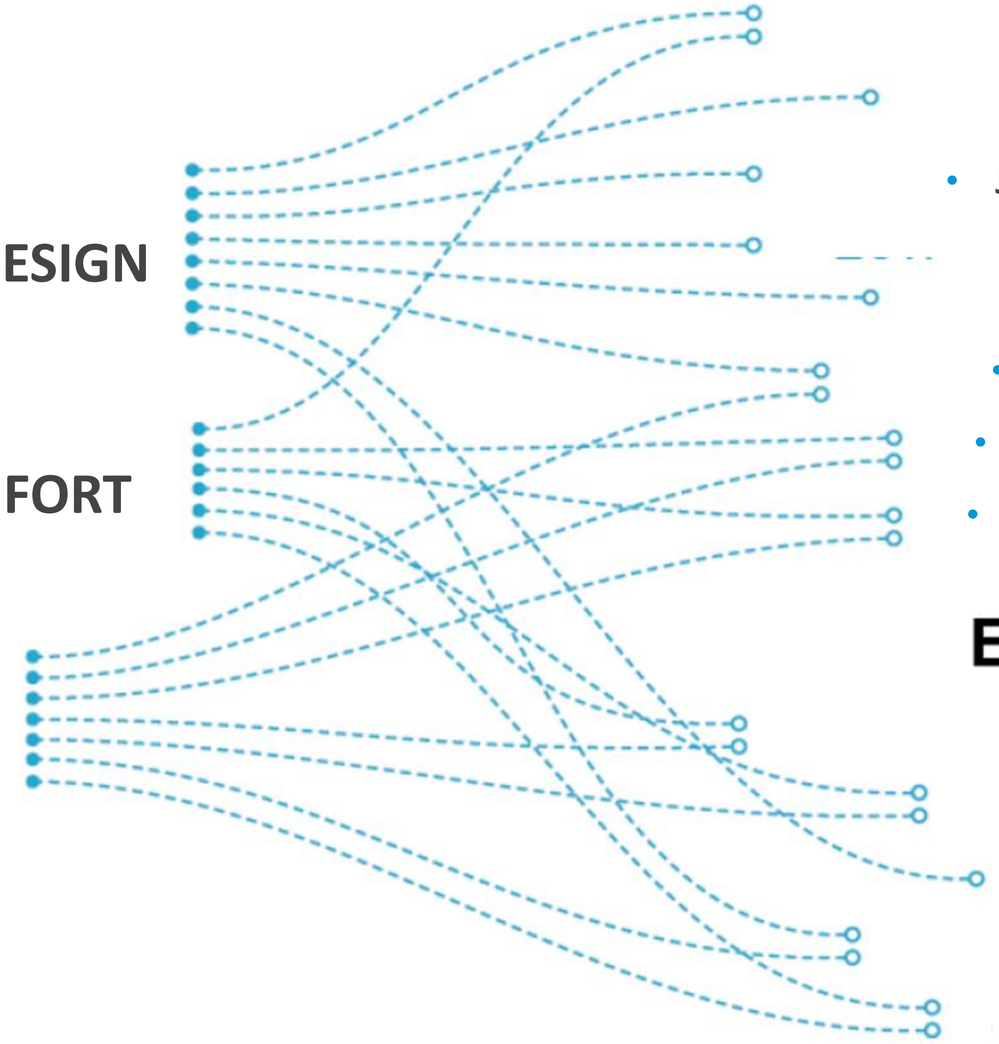
- **4.1.1 IMPORT CSV DATA FROM REVIT SPACES**
- **4.1.2 CALCULATION OF AIR FLOW REQUIRED FOR EACH TERMINAL**



2.4.2 DYNAMO STUDIO - EXPLORING PERFORMANCE ANALYSIS – GENERATIVE DESIGN THEORY

Goals

- HIGH-PERFORMACE – EARLY DESIGN
- COMFORT
- MATERIAL REDUCTION



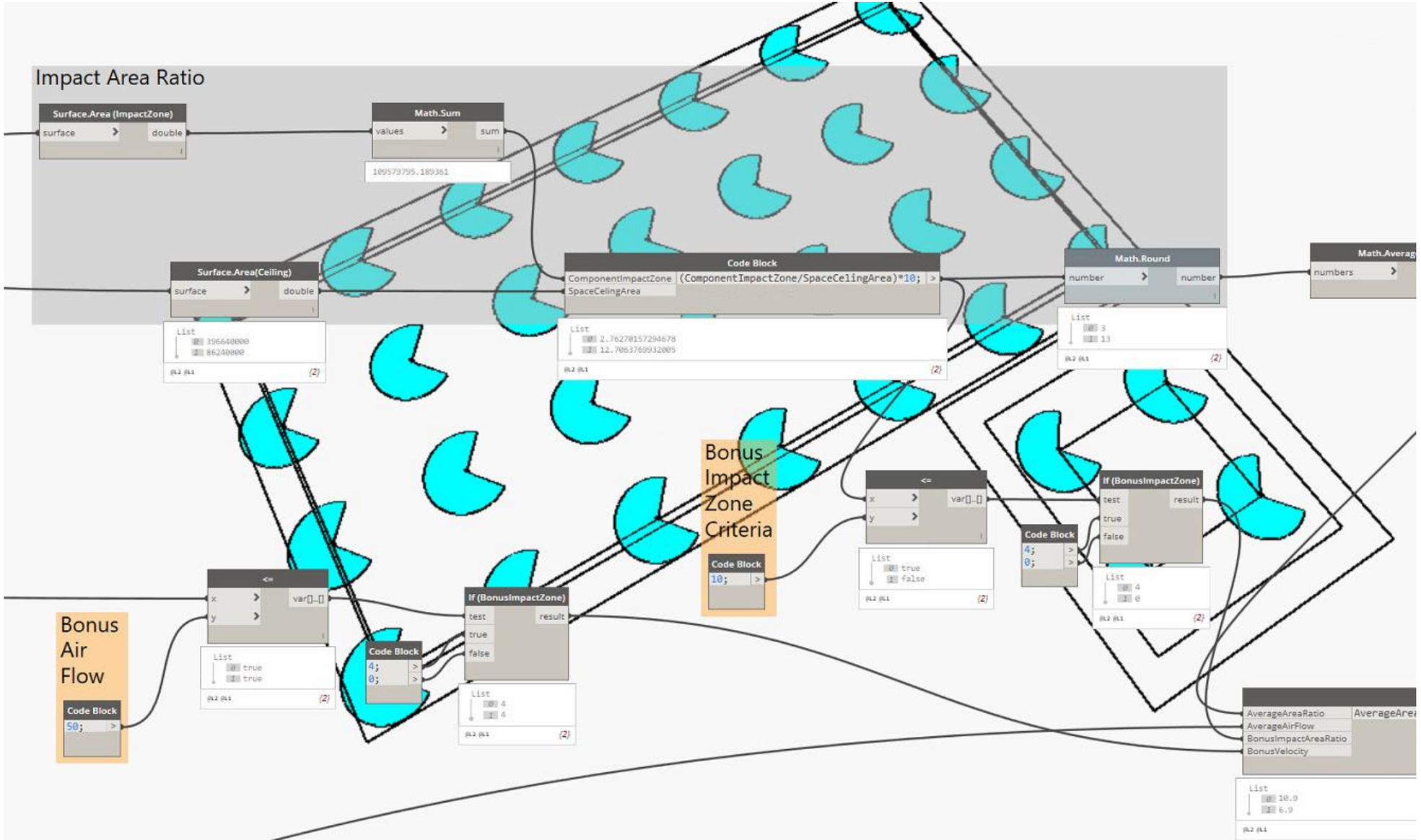
Metrics

- AIR FLOW RATE
- JET DISTRIBUTION AREA
- IMPACT AREA RATIO
- PERFORMANCE SCORE
- DESIGN BONUS RATING

Elements

- AIR TERMINAL DEVICES
- LIGTING FIXTURES
- CEILING
- WALLS
- MEP SPACES

2.4.2 DYNAMO STUDIO - EXPLORING PERFORMANCE ANALYSIS

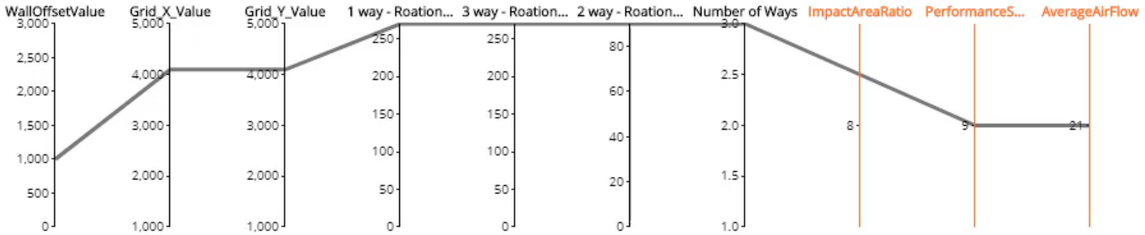


2.4.2 DYNAMO STUDIO – MEP EXPLORING DEMO

Autodesk, Inc. [US] | https://www.fractal.live/share/5beacbe298a55a623cc5b62d

MEP Explore Demo : Ventilation
by: almat@ramboll.dk

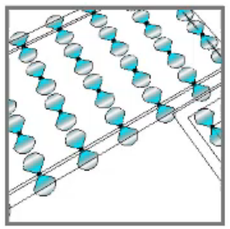
Project Fractal

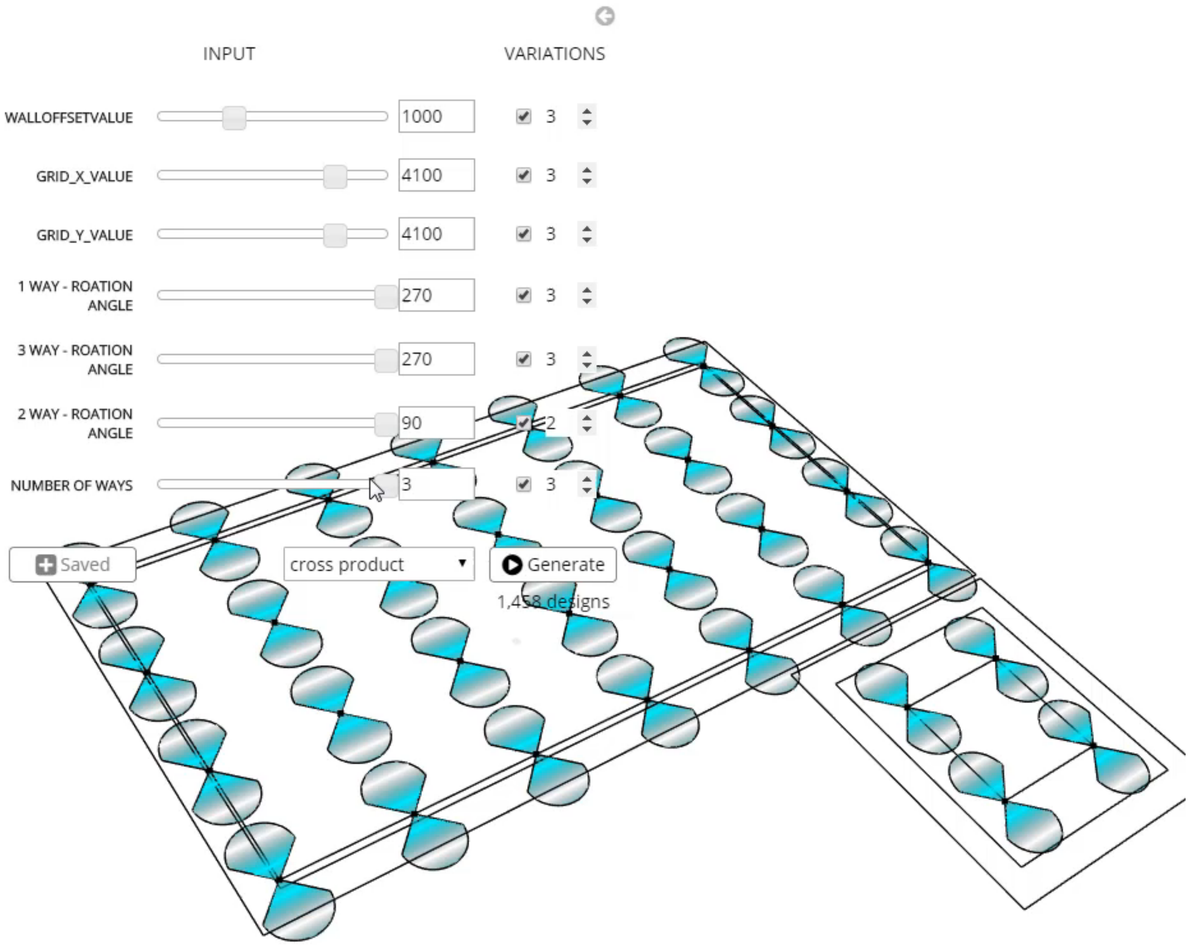


Design Options

Sort by creation time

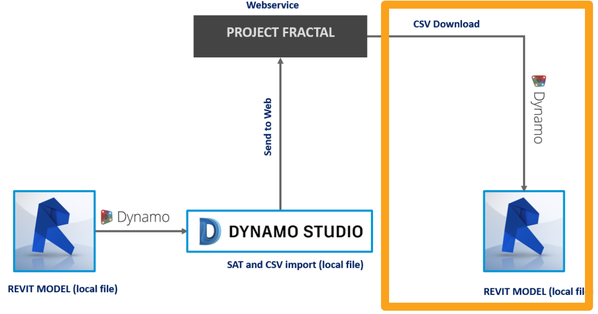
Clear



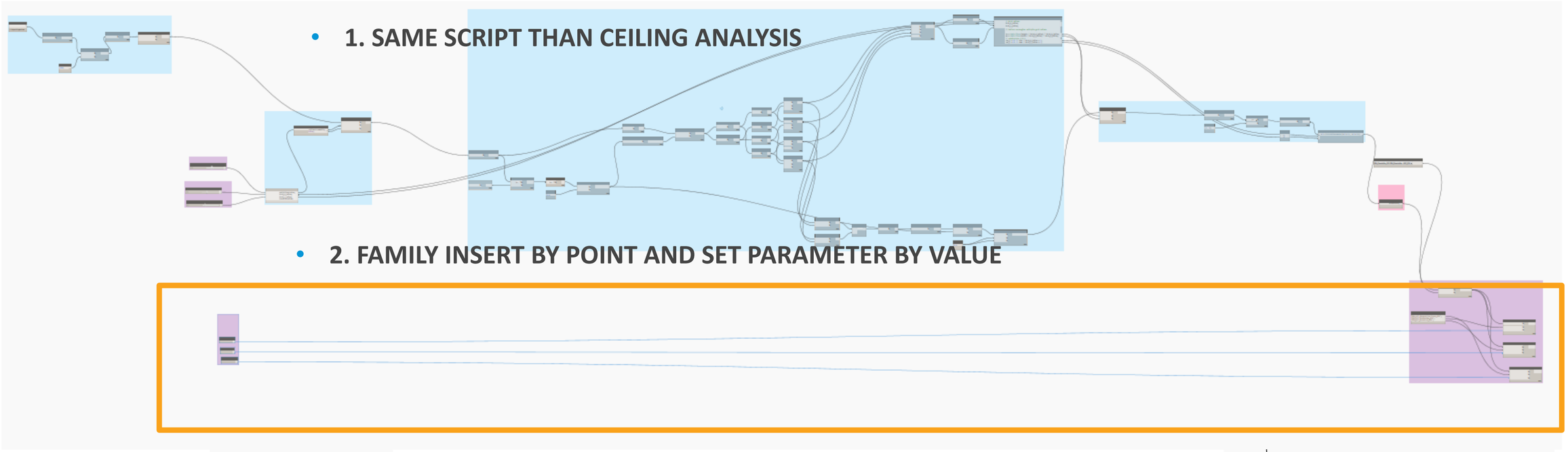


Powered by Autodesk Dynamo Studio

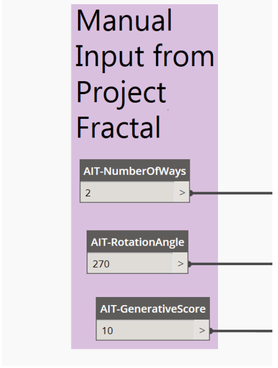
2.4 FRACTAL TO REVIT – PROJECT DOCUMENTATION

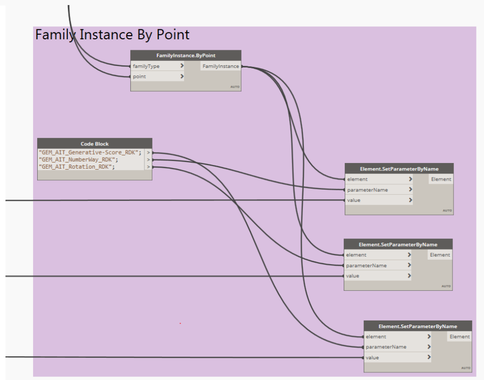


- **1. SAME SCRIPT THAN CEILING ANALYSIS**

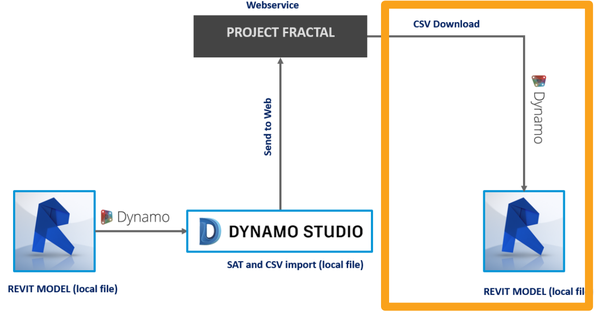


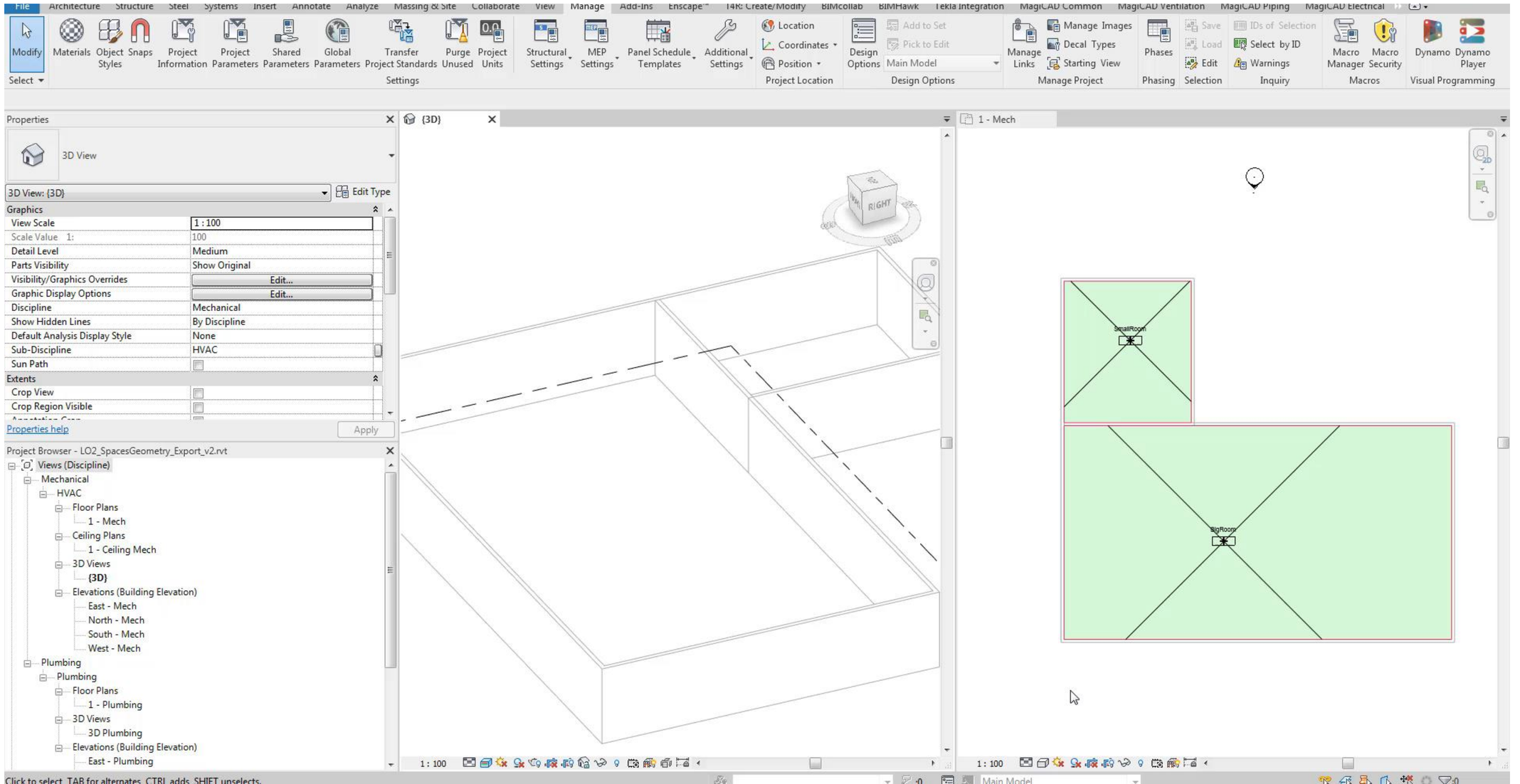
- **2. FAMILY INSERT BY POINT AND SET PARAMETER BY VALUE**



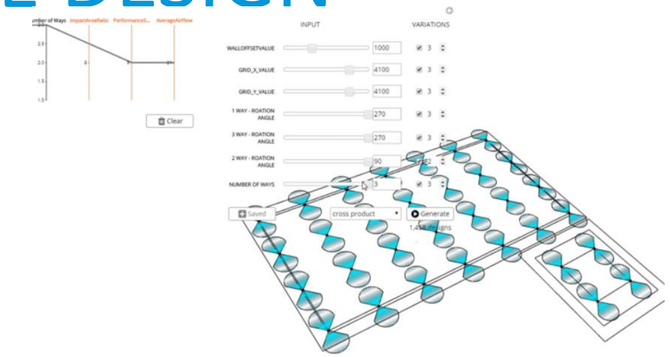


2.4 FRACTAL TO REVIT – PROJECT DOCUMENTATION



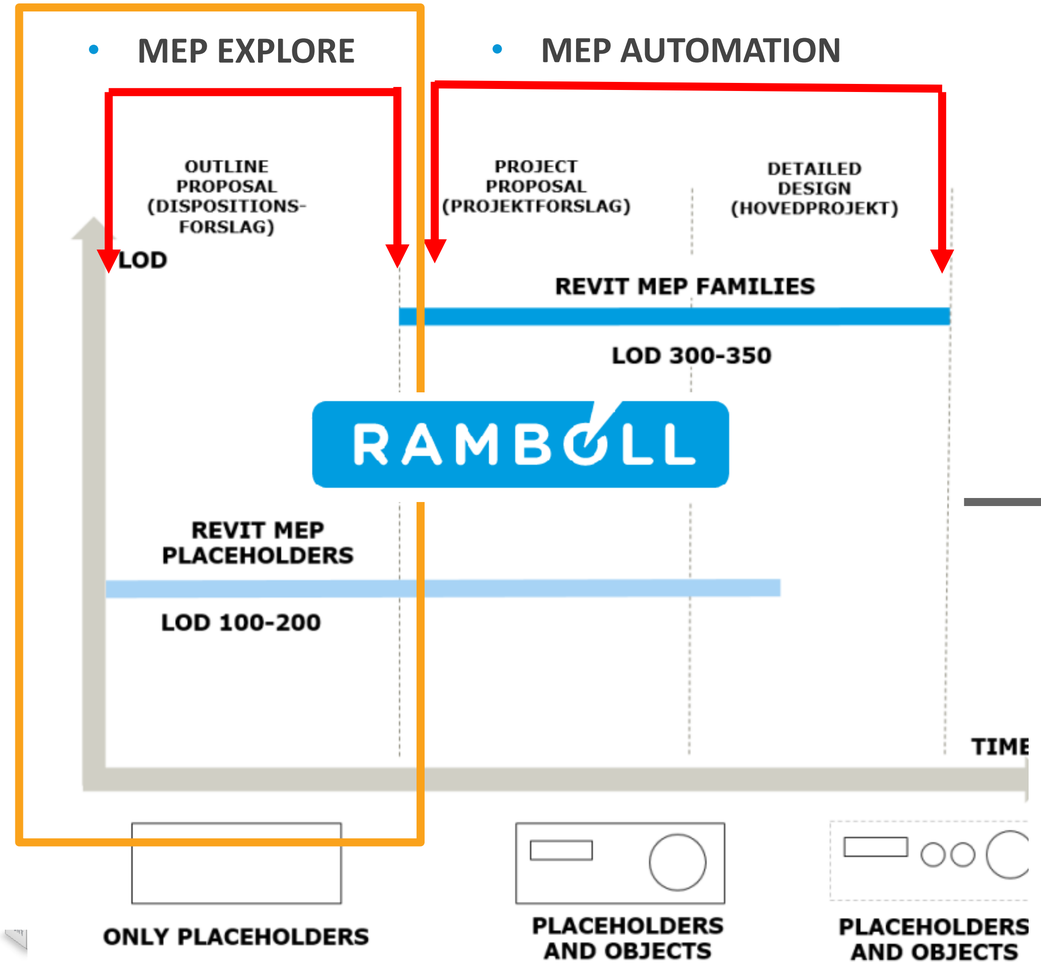


FINDINGS : MEP EXPLORE - GENERATIVE DESIGN

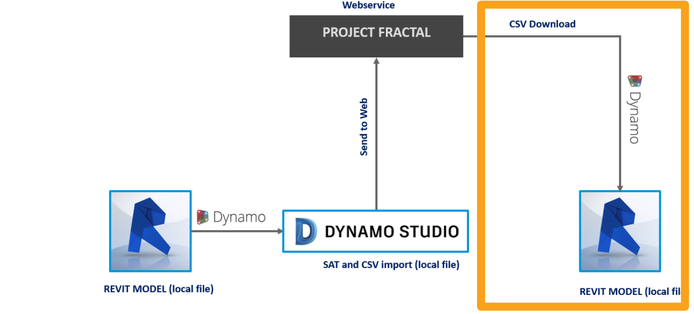


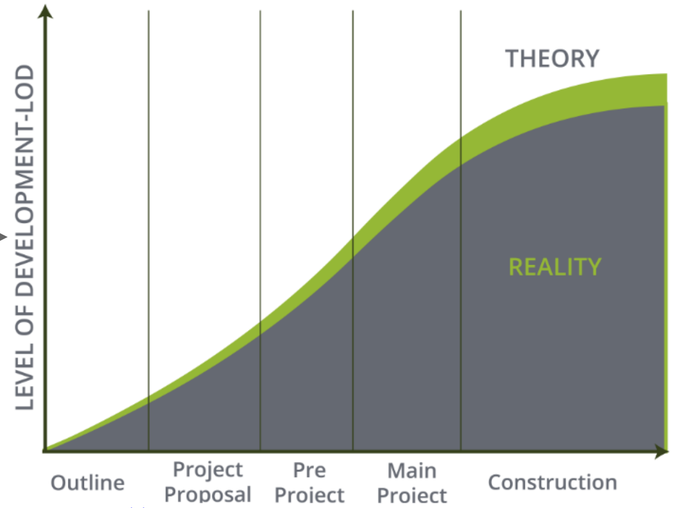
- Generative Design can be also used for MEP Design
- Process Standardization and people comes first
- Available technology is primary for prototyping and it’s difficult to scale up.
- Most of MEP companies of not ready get. Missing to fix the basics

2.4 FRACTAL TO REVIT – PROJECT DOCUMENTATION PROCESS

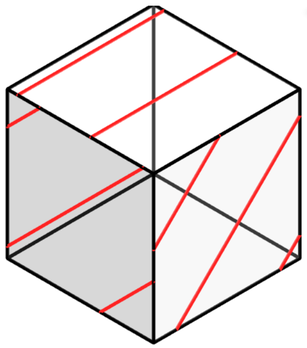


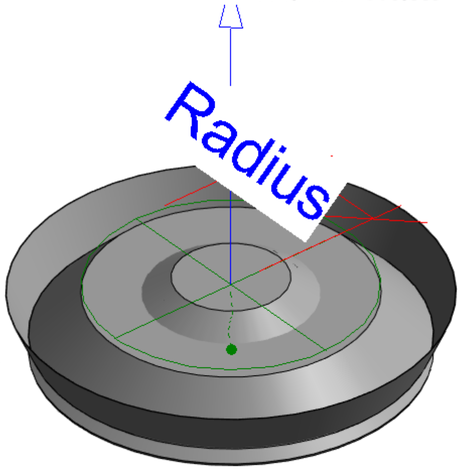
The graph is showing use of placeholders and objects in the different phases.
LOD = Level of Development.





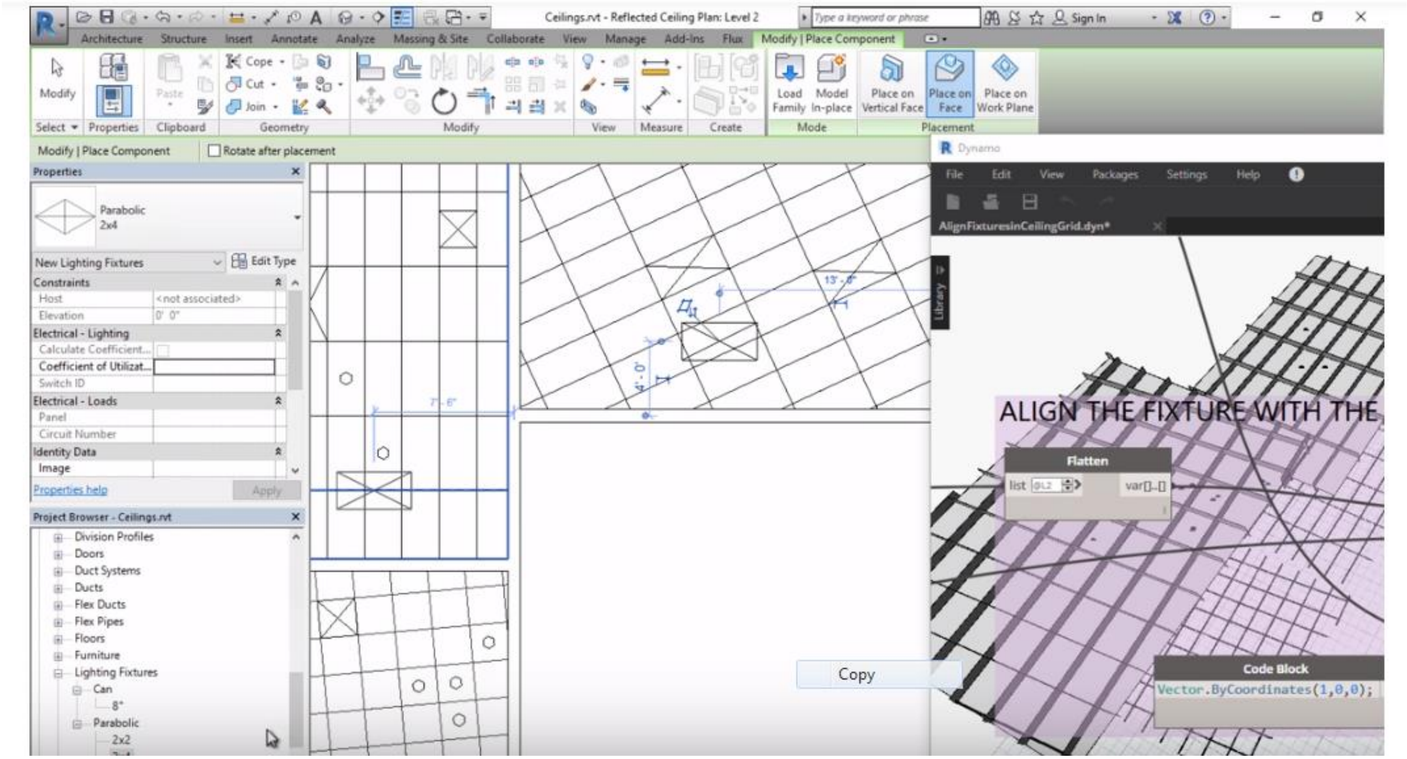
- PLACEOLDER





- GENERATIVE DESIGN

EXAMPLE OF DETAIL DESIGN- MEP AUTOMATION CESAR SCALANTE



Align & Center Fixtures on Ceiling Grids w Dynamo

Cesar Escalante
Offentliggjort den 1. maj 2017

- Source: https://www.youtube.com/watch?v=PRU2zOKi1DU&t=3s **by CESAR ESCALANTE**

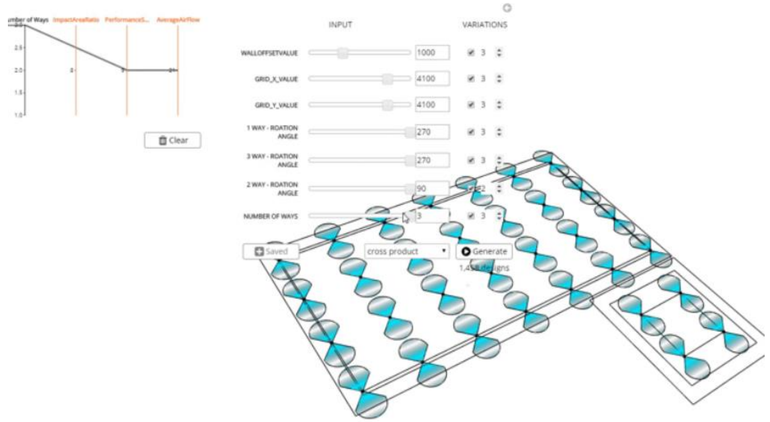
RAMBOLL EXAMPLE – ADVANCED MEP DESIGN INNOVATION PROJECT

ADVANCED MEP DESIGN
GENERATIVE DESIGN
RAMBOLL AUTODESK WORKSHOP – JUNE 2018

RAMBOLL

FINDINGS : MEP EXPLORE - GENERATIVE DESIGN

GENERATIVE DESIGN CAN BE ALSO USED FOR MEP DESIGN



DIFFICULT TO SCALE UP AT THE MOMENT

PROCESS AND PEOPLE COMES FIRT

JUST TECHNOLOGHY

VS

PEOPLE AND STANDARD TECHNOLOGHY

MANY OF MEP COMPANIES ARE NOT READY

MEP GENERATIVE DESIGN

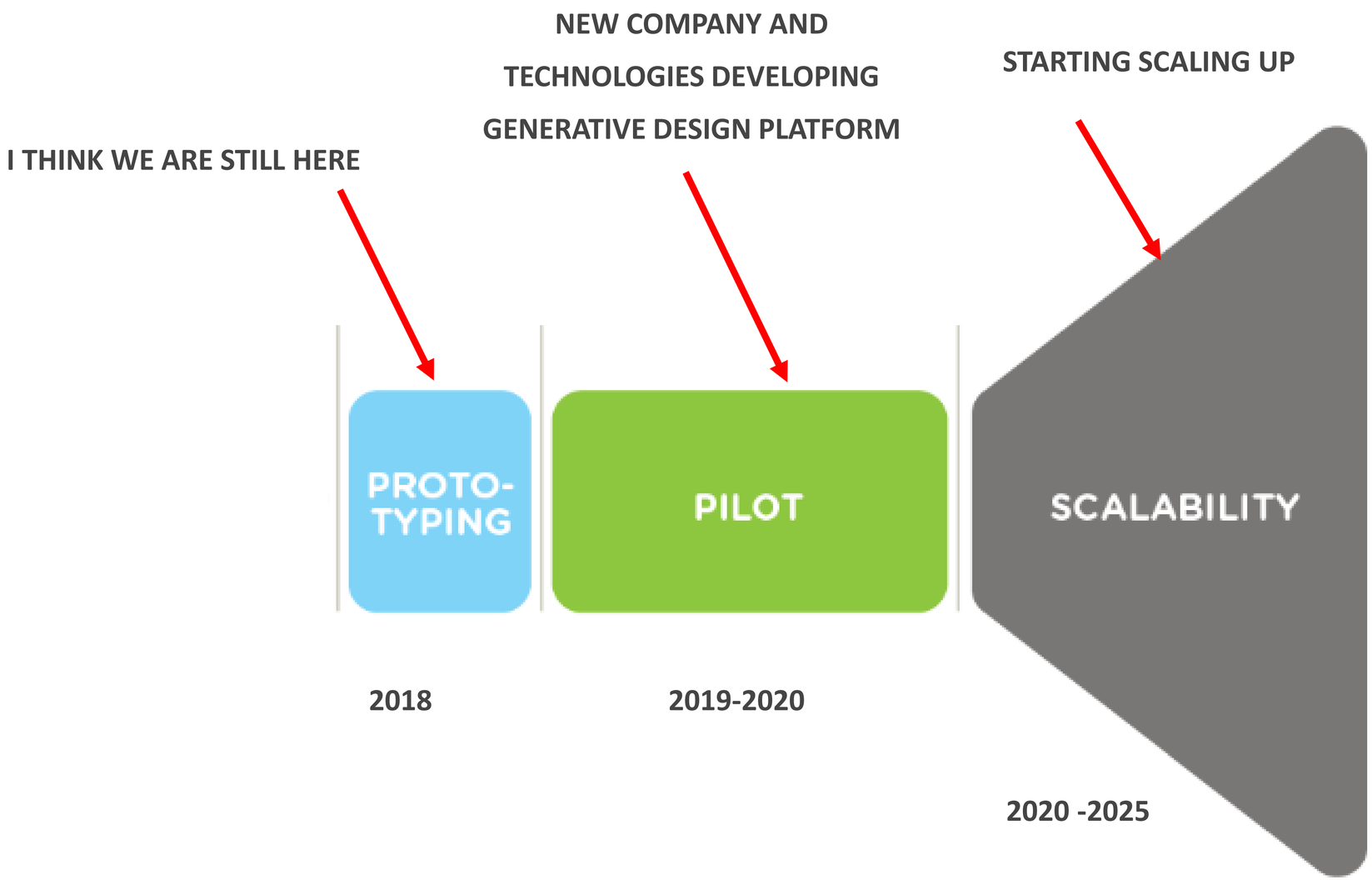
ROBUS BIM PROCESSES

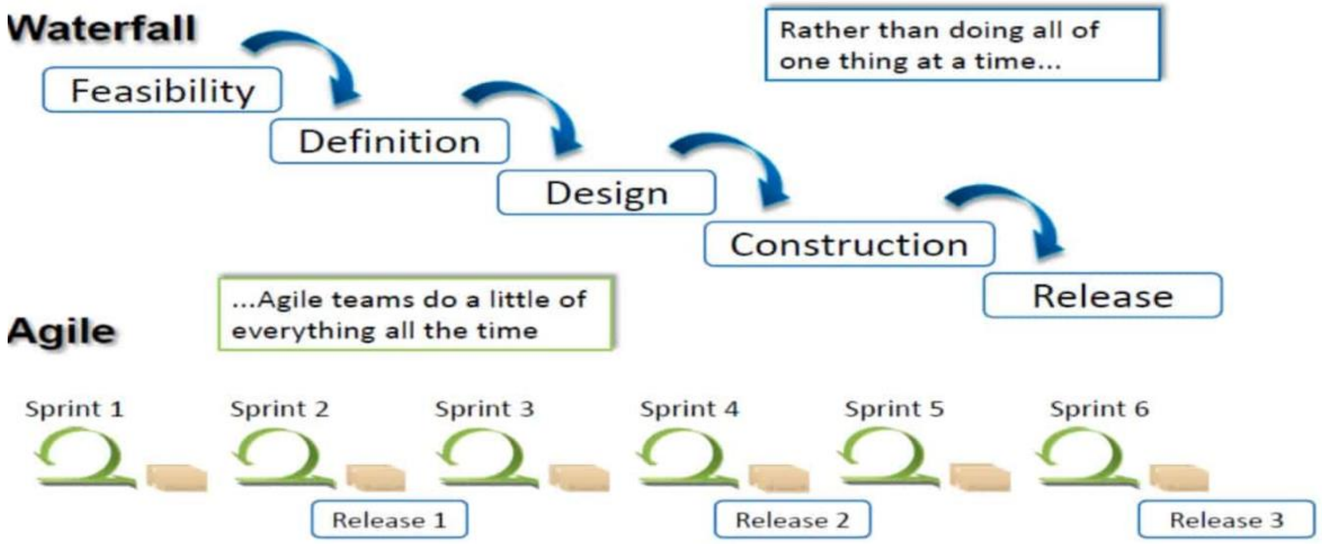
STANDARD DIGITAL ASSETS

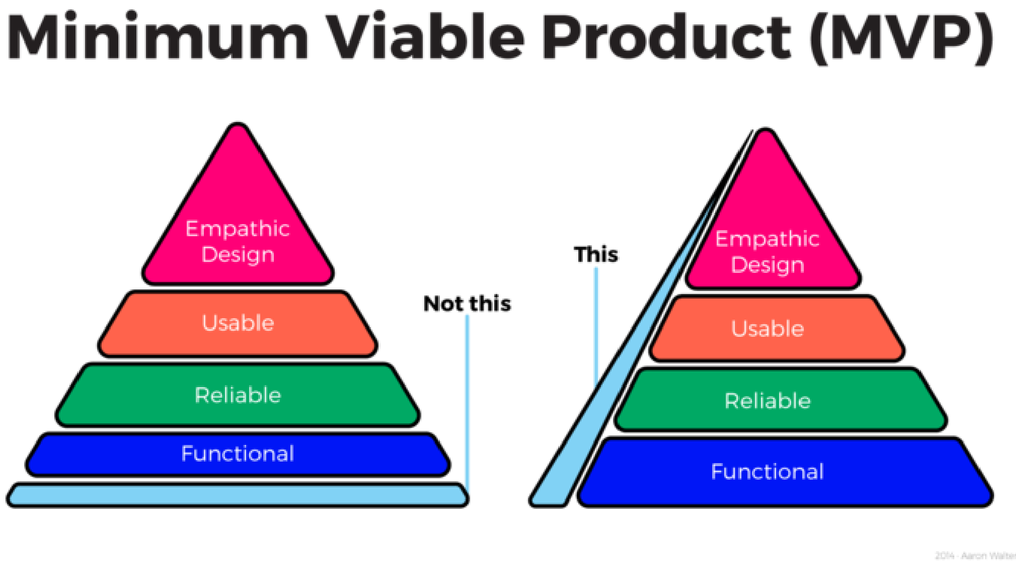
PEOPLE SKILL AND MINSET

Implementation & moving forward

IMPLEMENTATION ROAD MAP - OPPORTUNITIES





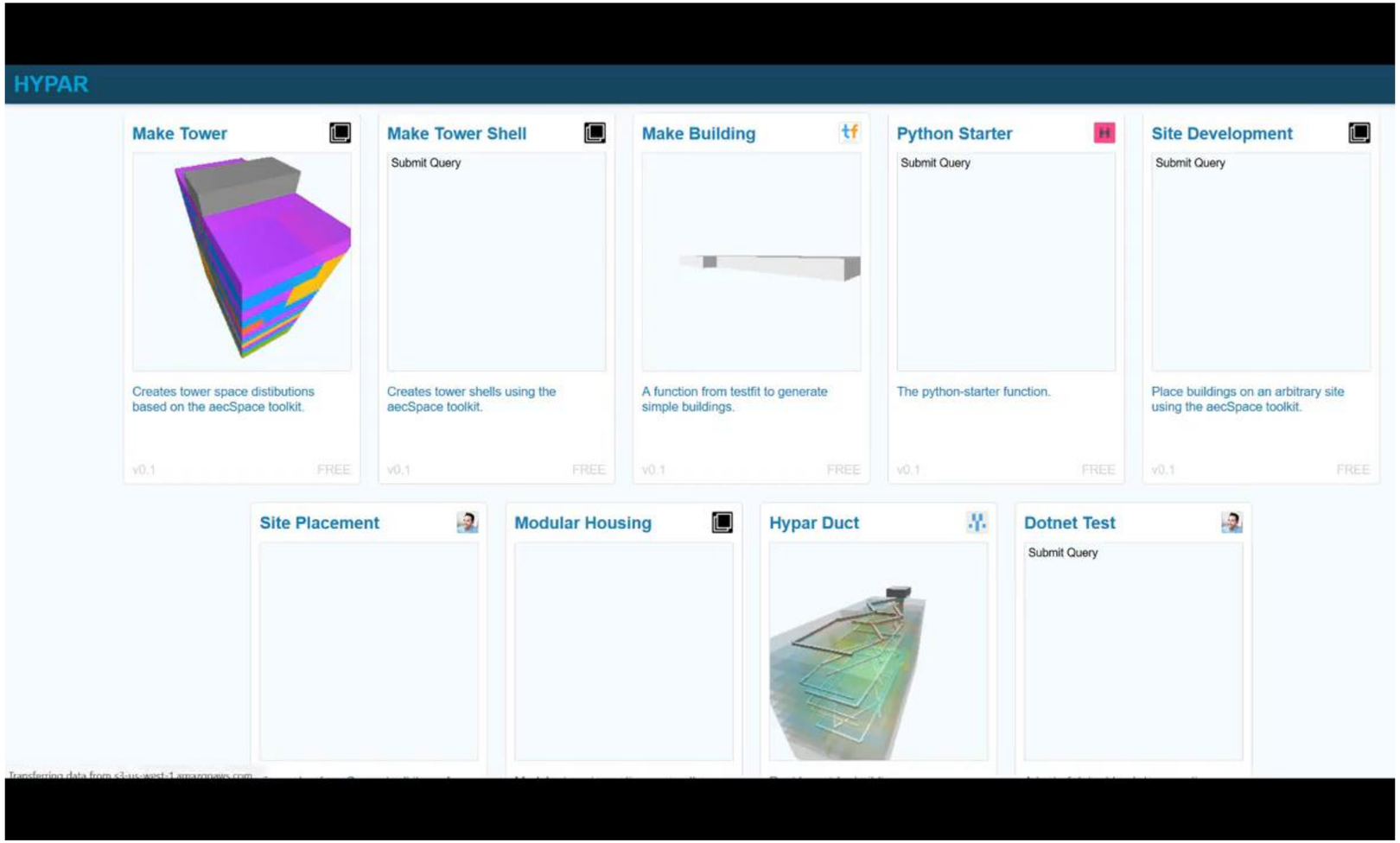


IMPLEMENTATION ROAD MAP - OPPORTUNITIES

- Generative technology and design process improves productivity and quality of AEC projects
- To get value from generative design approach, people and processes need to be ready. Don’t follow the waterfall
- Think BIG, start small (Minimum Valuable Product)

NEW GENERATIVE DESIGN TECHNOLOGHY IS COMINGS– STARTUPS

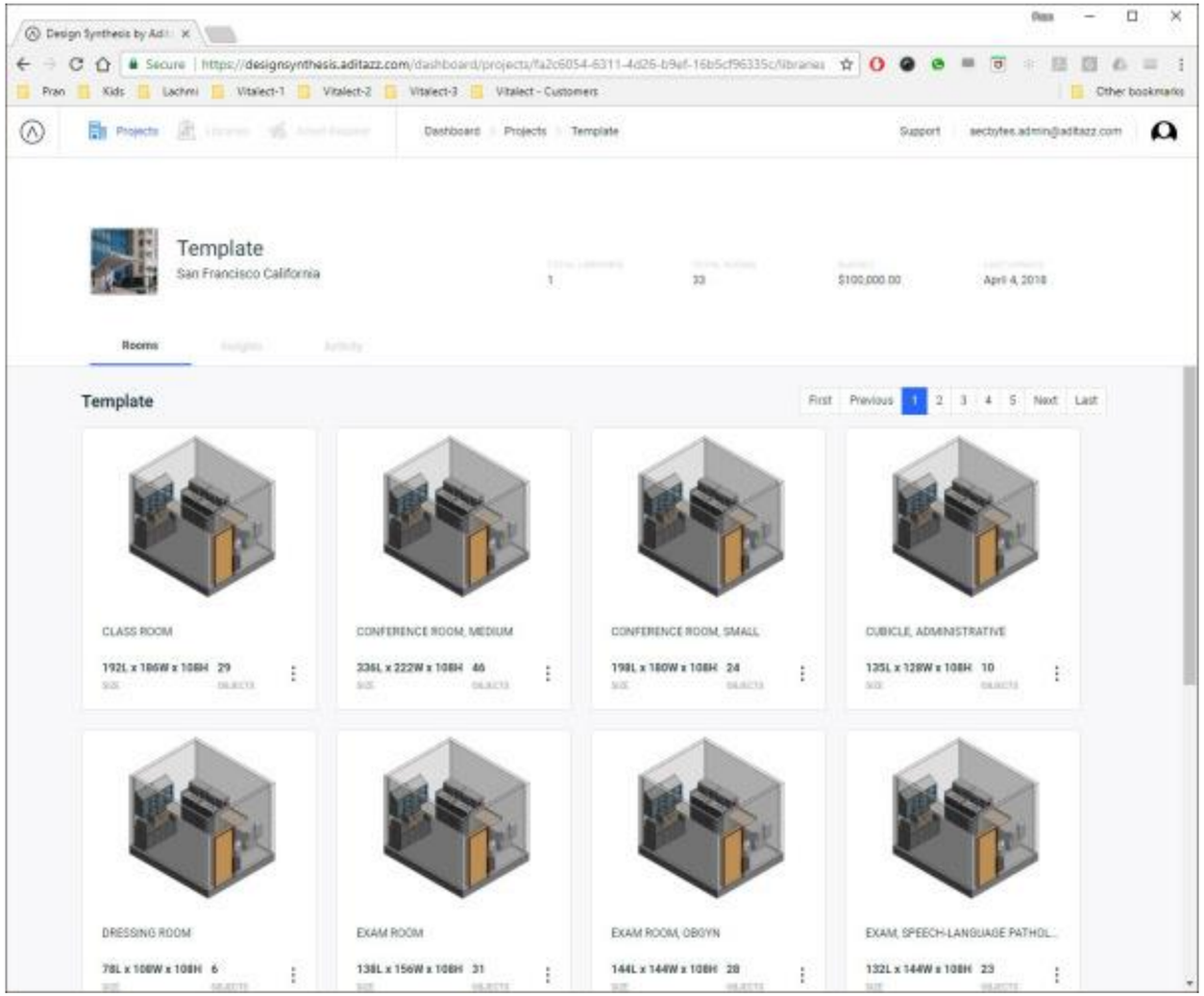
HYPAR.IO – GENERATIVE DESIGN CLOUD COMPUTING PLATFORM



- Higher computing power and stability
- Protection of intellectual property rights

NEW GENERATIVE DESIGN TECHNOLOGHY IS COMINGS– STARTUPS

DITAZZ.COM – SYNTHESIS DESING CLOUD COMPUTING



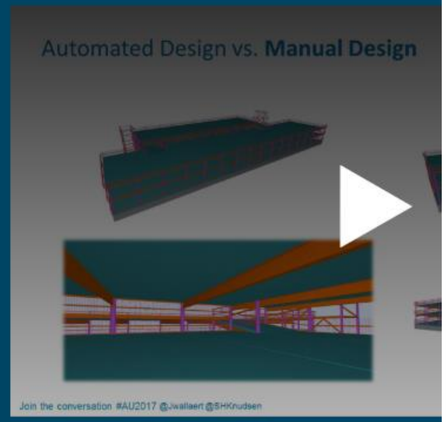
- Higher computing power and stability
- Only generate design solutions that complies with design project requirements

OTHER AU CLASSES FOR LEARN MORE ABOUT AEC GENERATIVE DESIGN

JESPER WALLAERT

BLD124387: Applying Generative AEC Dynamics to a Parking Garage

(Duration 50:12)



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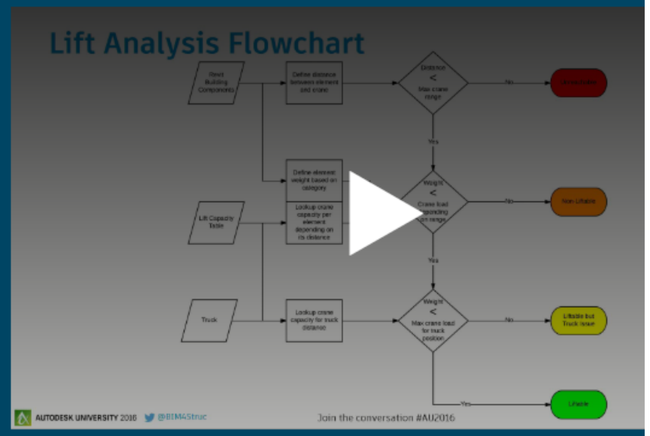
DIETER VERMEULEN

CS21553: Construction Dynam(o)ite– Explode Productivity with Dynamo

(Duration 01:34:47)



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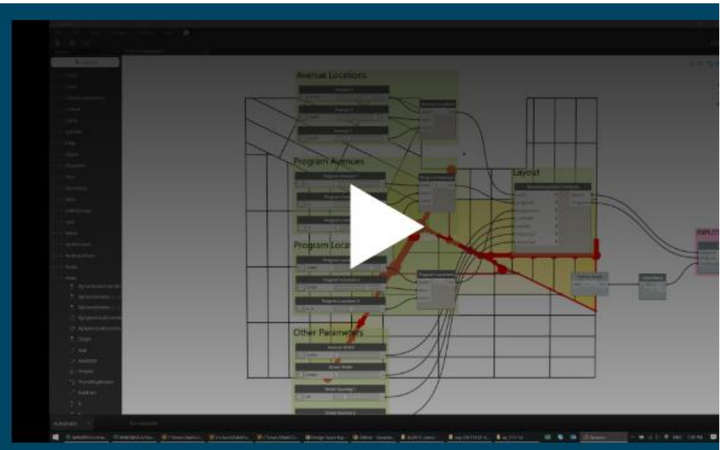
LORENZO VILLAGGI

AS124721: Generative Design for Architectural Space Planning: The Case of the Autodesk University 2017 Layout

(Duration 01:00:25)



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ALL DYNAMO STUDIO SCRIPTS FROM THIS CLASS WILL BE SHARE WITH YOU

Image caption goes here

Thank You!

By Alejandro Mata almat@ramboll.dk

https://www.linkedin.com/in/alejandro-mata-5b639343/

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