Construction Dynam(o)ite
Explode Productivity with Dynamo

Dieter Vermeulen, MSc. Str. Eng.

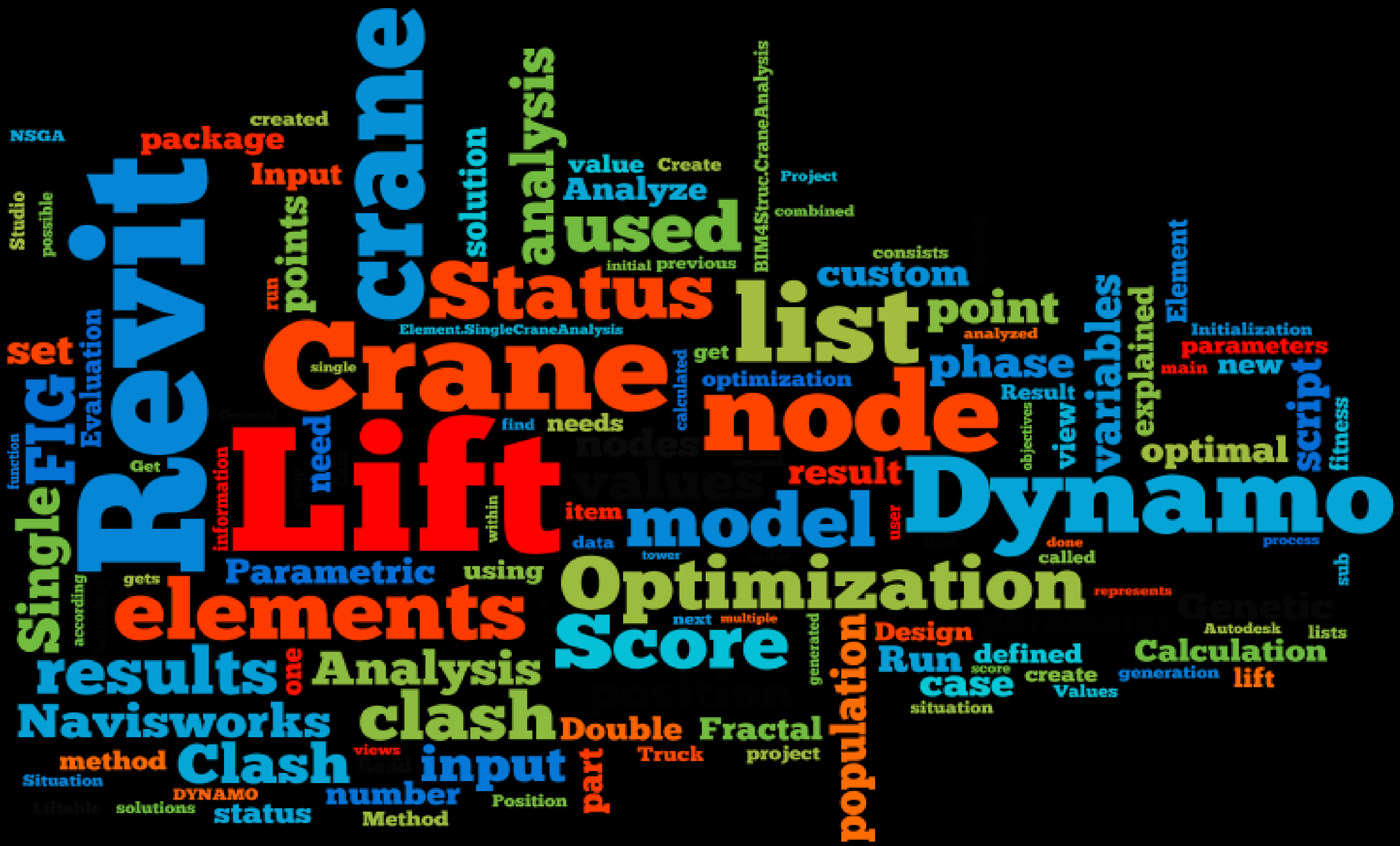
Technical Sales Specialist AEC – Computational Design & Engineering – Autodesk

@BIM4Struc

Class summary

In this class, you will learn how to use the Dynamo extension to automate all kinds of custom tasks in Revit software to make your design constructible.

You will get inspired by the wide range of possibilities the Dynamo extension offers to create your own model check and to automate the creation of construction elements.


Revit
Crane
Lift
Crane
Status
list
node
Dynamo
model
Optimization
Score
elements
results
Analysis
clash
Navisworks
Clash
input
Parametric
Run
case
Calculation
Design
Double
Fractal
Truck
project
population
number
status
Method
Position
part
DYNAMO
solutions
Situation
method
Liftable
NSGA
Studio
possible
created
package
Input
points
run
solution
analysis
value
Create
Analyze
used
Project
combined
BIM4Struc.CraneAnalysis
consists
custom
point
analyzed
phase
Result
objectives
view
variables
explained
Element
Initialization
parameters
main
new
script
fitness
optimal
result
item
data
tower
user
process
done
called
represents
sub
Genetic
Autodesk
lists
lift
Values
generation
score
create
defined
situation
generated
next
multiple
Element.SingleCraneAnalysis
get
calculated
optimization
find
needs
need
information
within
Get
gets
according
function
Single
FIG
Evaluation
set
single
Liftable
views
one
Analysis
using
Parametric
Solution
Input
Output
Get
Set
Evaluation
Element
Initialization
Parameters
Main
New
Script
Fitness
Optimal
Result
Objectives
View
Variables
Explained
Process
Done
Called
Represents
Sub
Genetic
Autodesk
Lists
Lift
Calculation
Generation
Score
Create
Values
Case
Situation
Design
Run
Defined
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Next
Multiple
Data
Tower
User
Item
Result
Optimal
Fitness
Script
New
Main
Parameters
Initialization
Element
Explained
Variables
View
Objectives
Result
Phase
Point
Analyzed
Custom
Consists
Combined
Project
BIM4Struc.CraneAnalysis
Solution
Analysis
Value
Create
Analyze
Used
Initial
Previous
Run
Points
Created
Package
Input
NSGA
Studio
Possible
Set
FIG
Single
Evaluation
Function
Get
Gets
According
Information
Need
Needs
Find
Within
Calculated
Optimization
Parametric
Using
Elements
Results
One
Analysis
Clash
Navisworks
Method
Situation
Liftable
Views
Input
Part
Number
Status
Solutions
DYNAMO
Position
Method
Double
Fractal
Truck
Project
Population
Generated
Next
Multiple
Score
Run
Case
Design
Defined
Situation
Create
Values
Generation
Score
Calculation
Lift
Autodesk
Lists
Genetic
Sub
Process
Done
Called
Represents

About me

- Technical Specialist AEC @ Autodesk, EMEA NE
- Computational Design & Engineering
- Structural Engineer based in Belgium
- +15 years experience in structural engineering



@BIM4Struc

www.linkedin.com/in/dietervermeulen

www.youtube.com/user/RevitbeyondBIM

www.revitbeyondbim.wordpress.com

www.autodesk.typepad.com/bimtoolbox/

What is generative design ?

THE OLD WAY

Designer/engineer uses computer as passive machine



one human

+



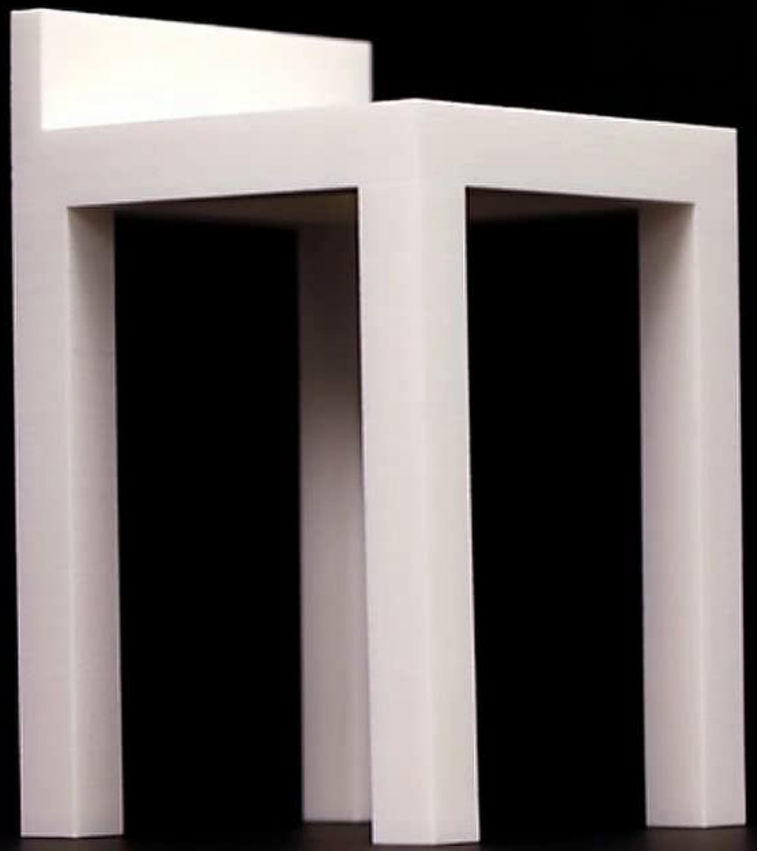
one computer

=



limited design





Support Weight:

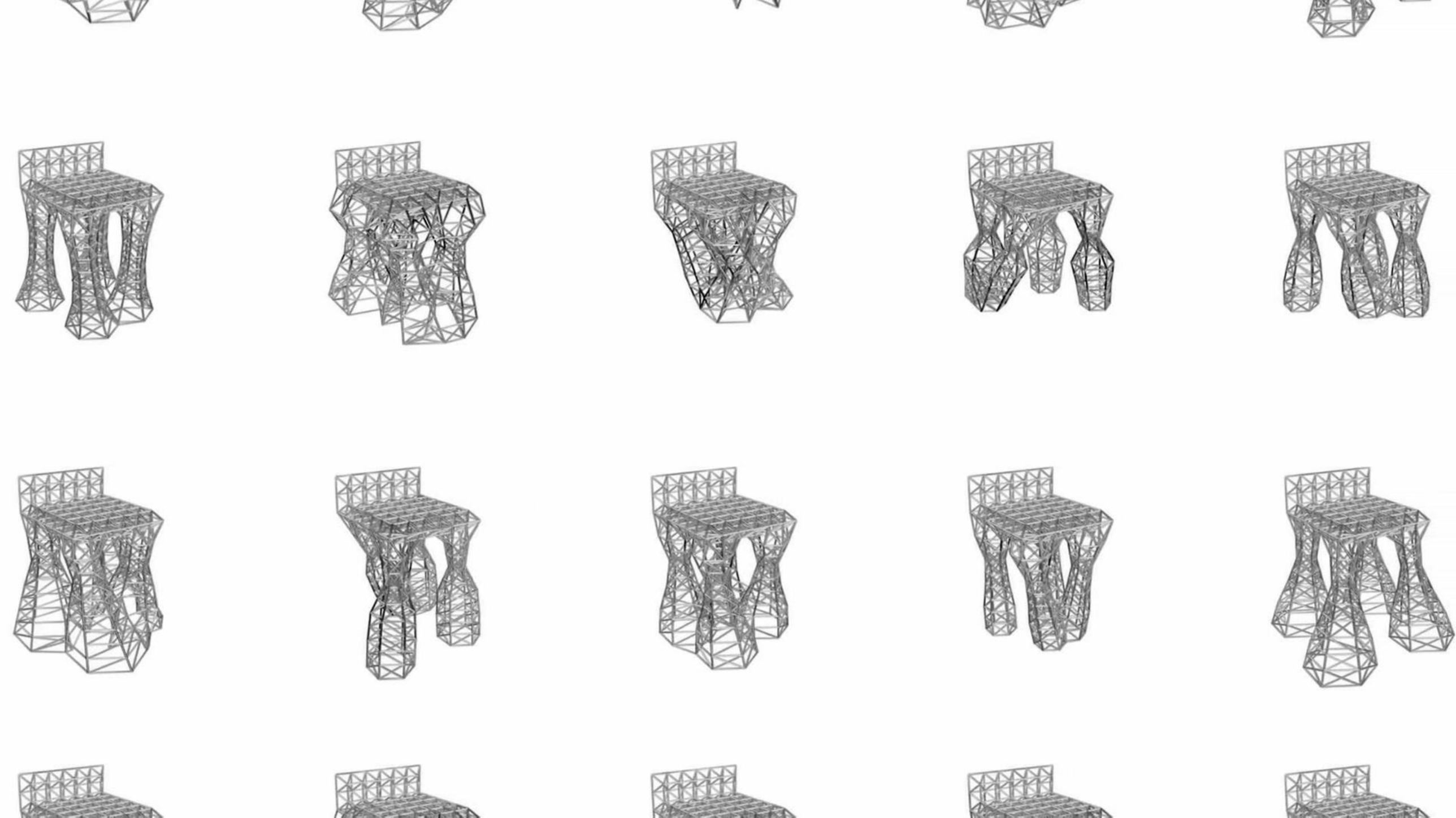
250 pounds

Chair Weight:

15 pounds

Cost:

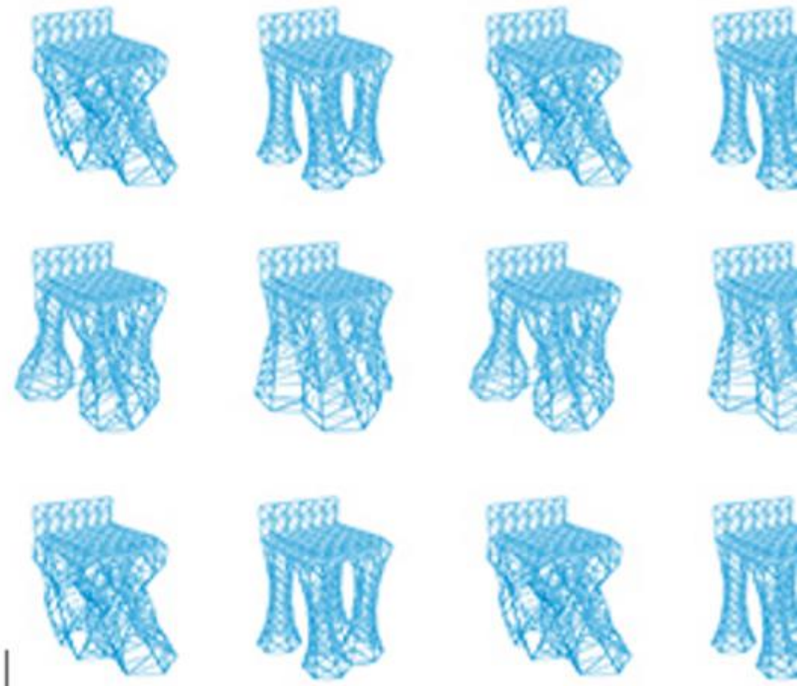
$30.00



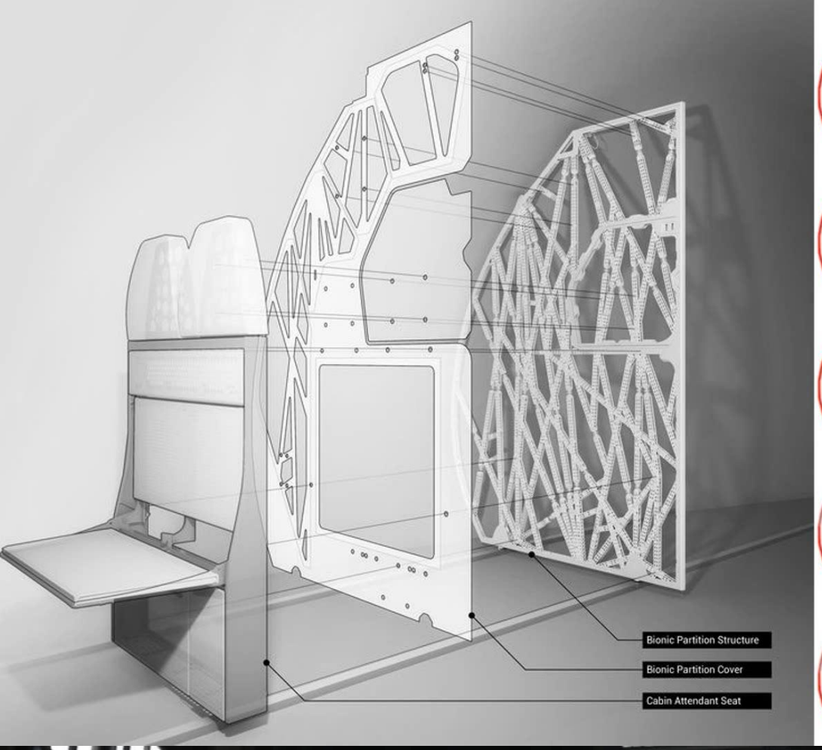
THE NEW WAY

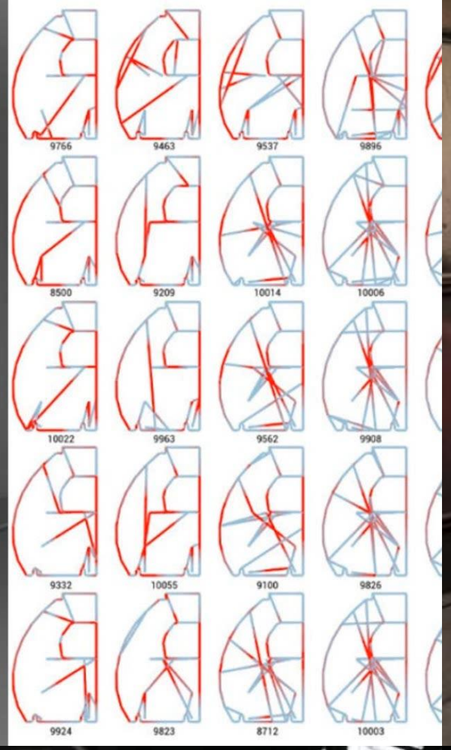
Computer and designer/engineer unite as cocreators





one human + artifical – intelligence algorithms + unlimited cloud-computing power = 100s to 1000s of design options


Bionic Partition Structure
Bionic Partition Cover
Cabin Attendant Seat


9766
9463
9537
9896
8500
9209
10014
10006
10022
9963
9562
9908
9332
10055
9100
9826
9924
9823
8712
10003




MX3D
ABB



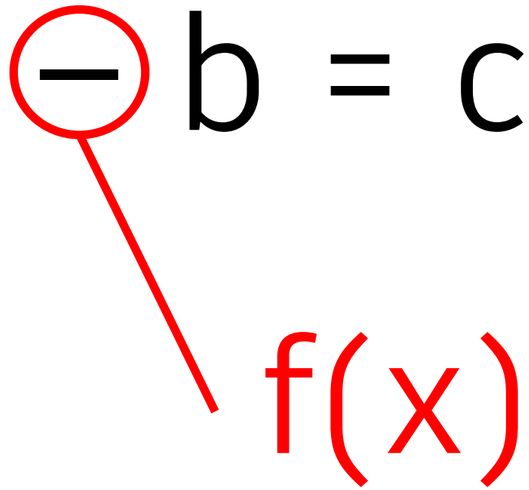
Computational Design

Parametric Design

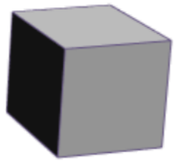
$$a = 2$$

$$b = 1$$

$$a - b = c$$



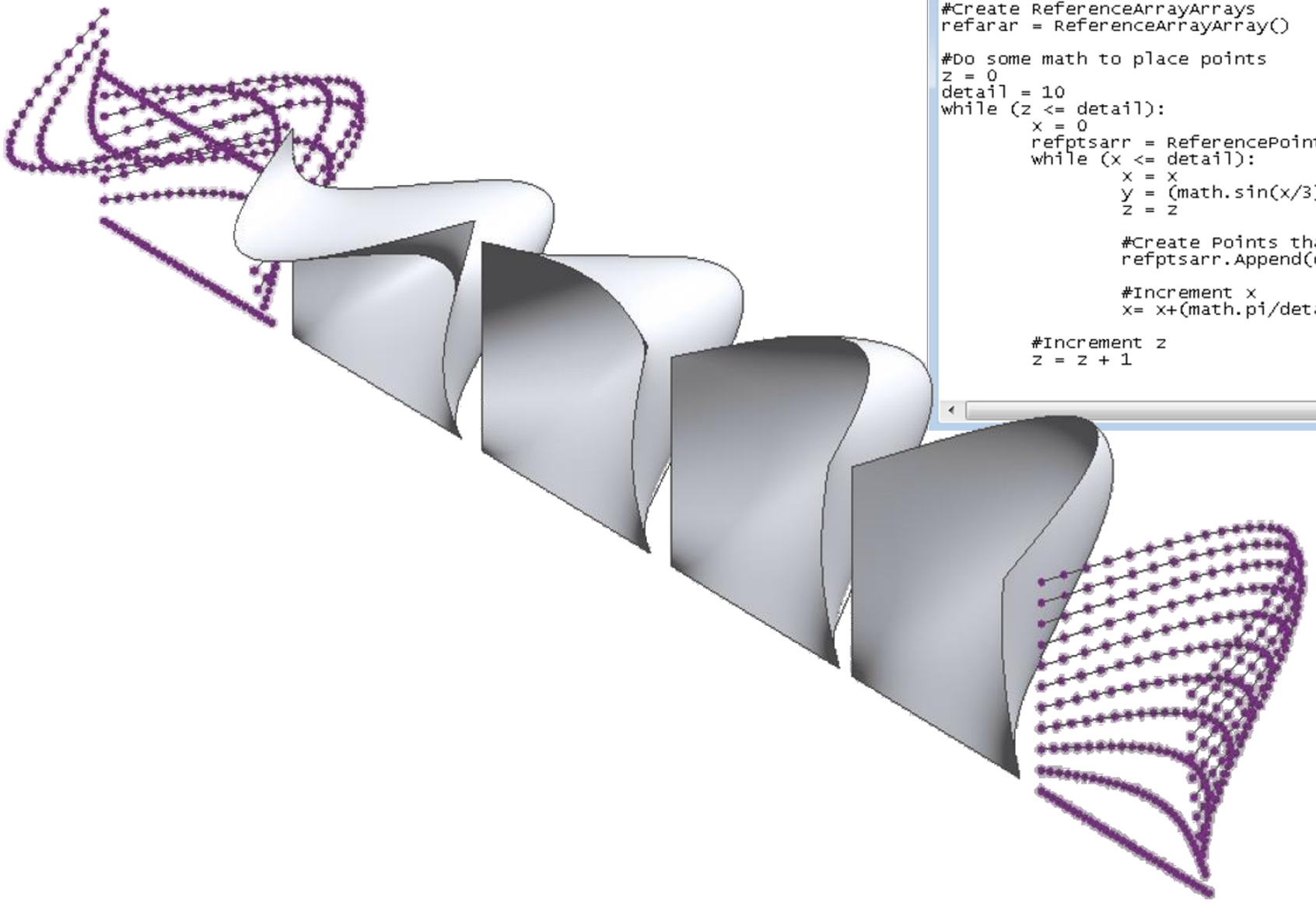
Parametric Design

a = 

b = 

a – b = 

Scripting



CreateSurface.py - Notepad

File Edit Format View Help

```
#Create ReferenceArrayArrays
refarar = ReferenceArrayArray()

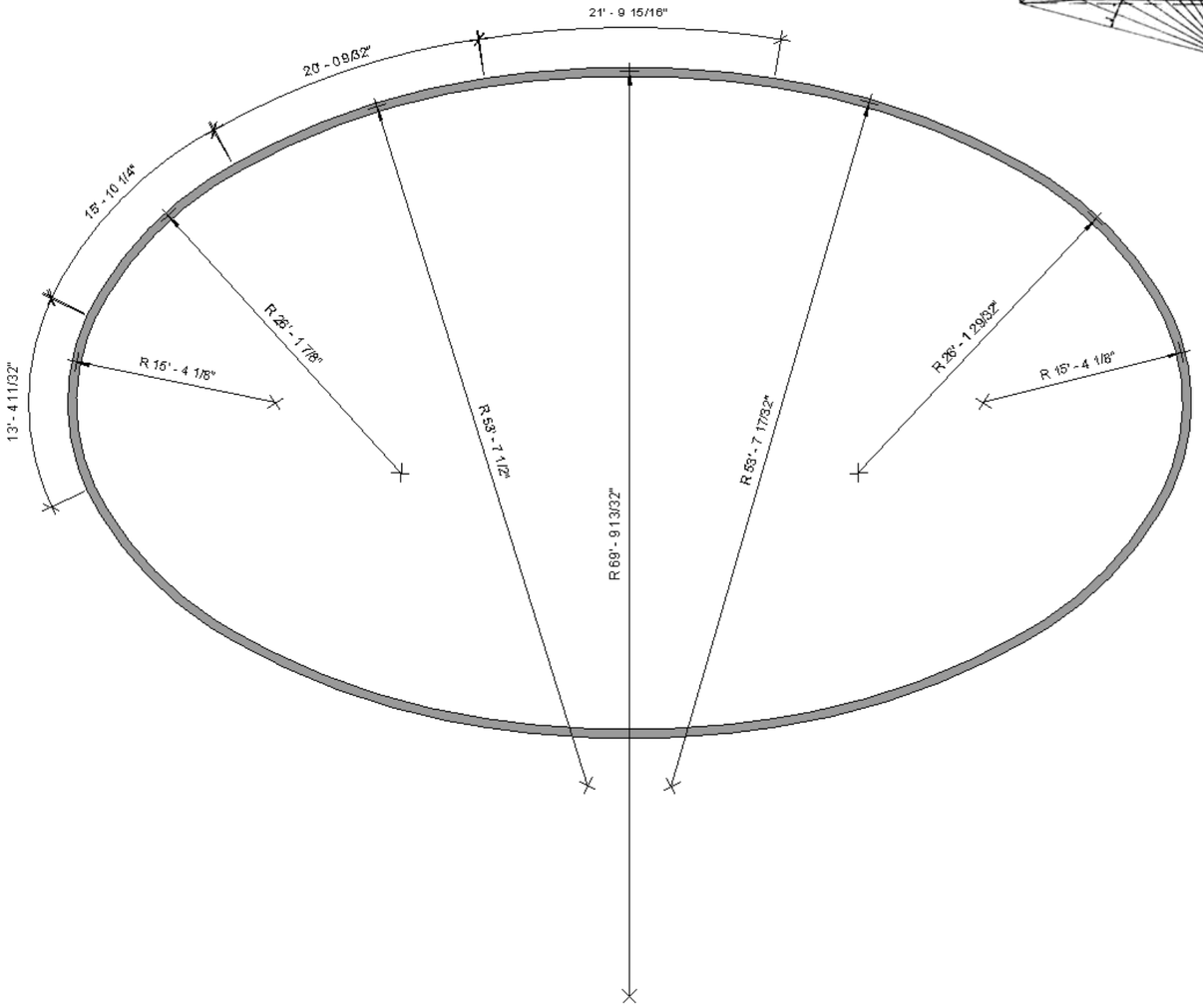
#Do some math to place points
z = 0
detail = 10
while (z <= detail):
        x = 0
        refptsarr = ReferencePointArray()
        while (x <= detail):
                x = x
                y = (math.sin(x/3)*10) * (math.sin(z*.19))
                z = z

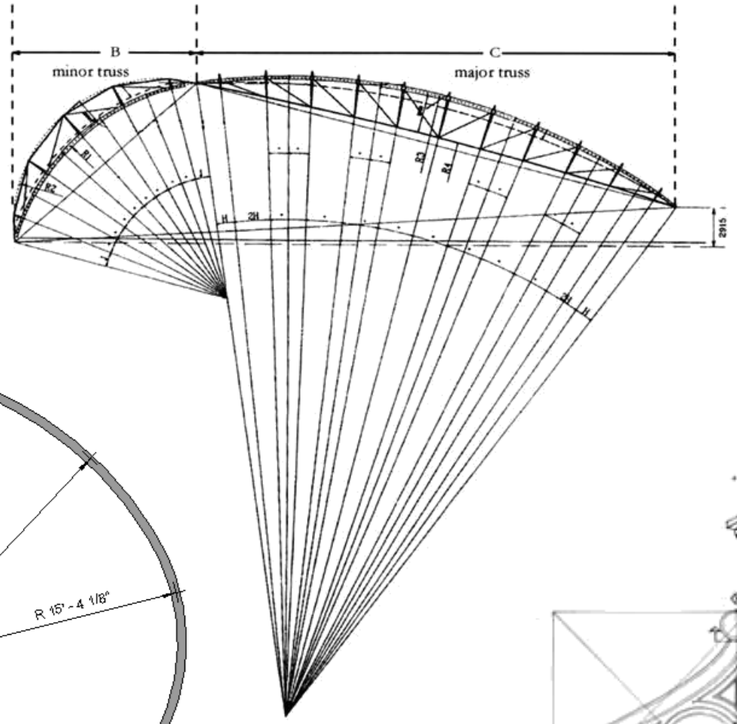
                #Create Points that are appended to an array
                refptsarr.Append(doc.FamilyCreate.NewReferencePoint(XYZ(x,y,z)))

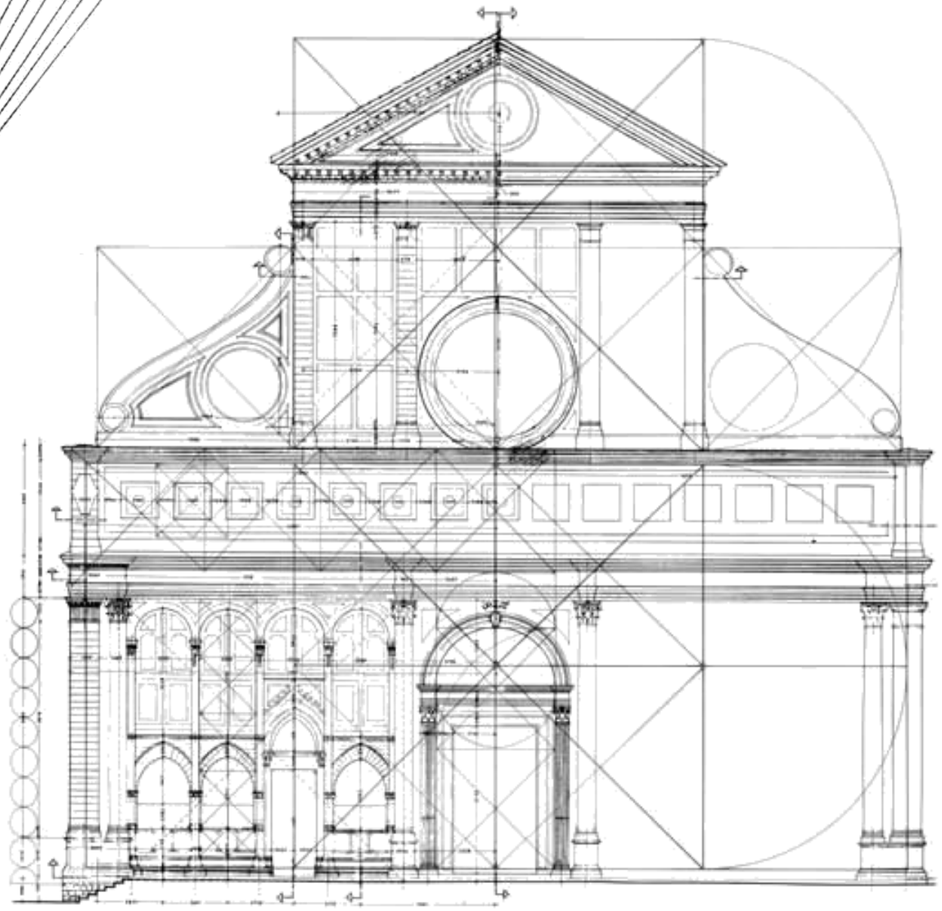
                #Increment x
                x= x+(math.pi/detail)

        #Increment z
        z = z + 1
```

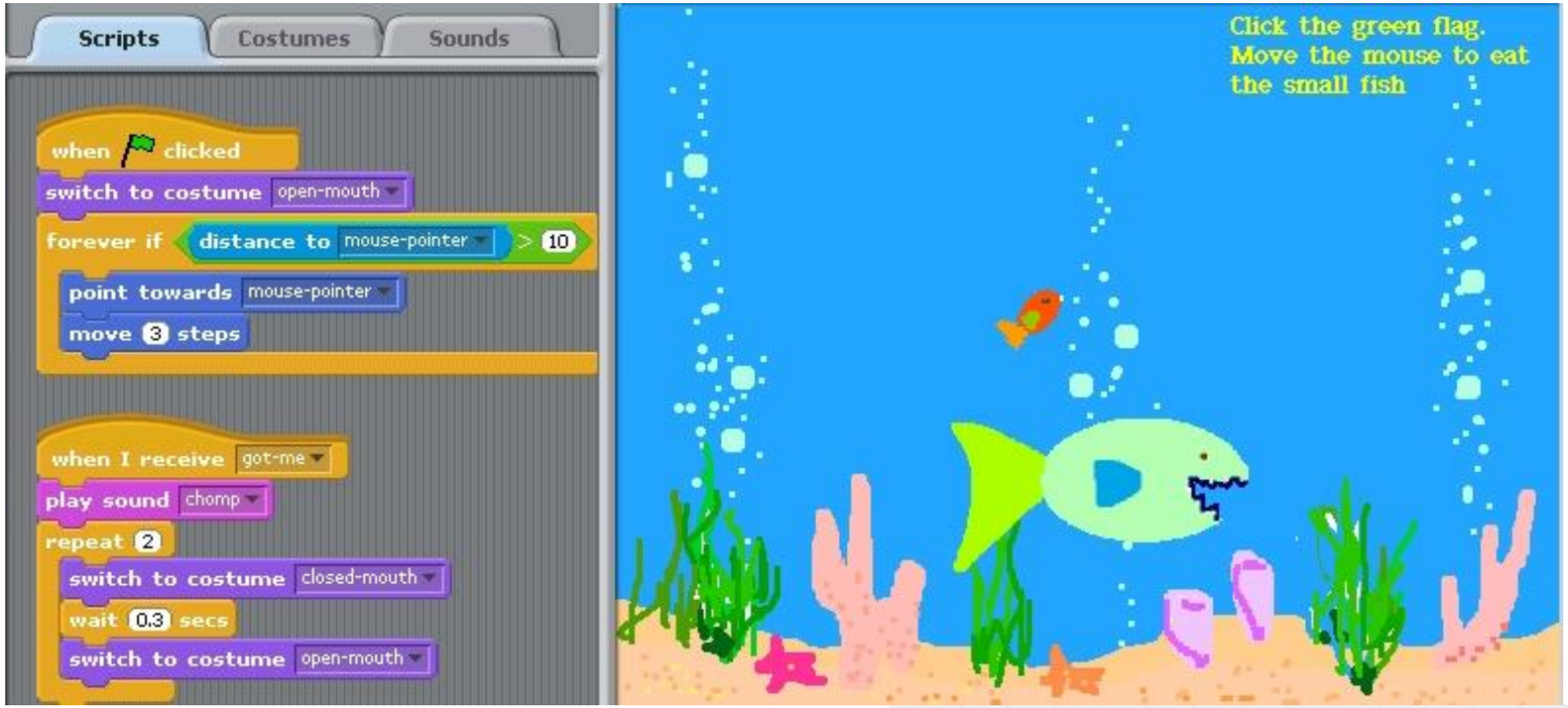
Sketching

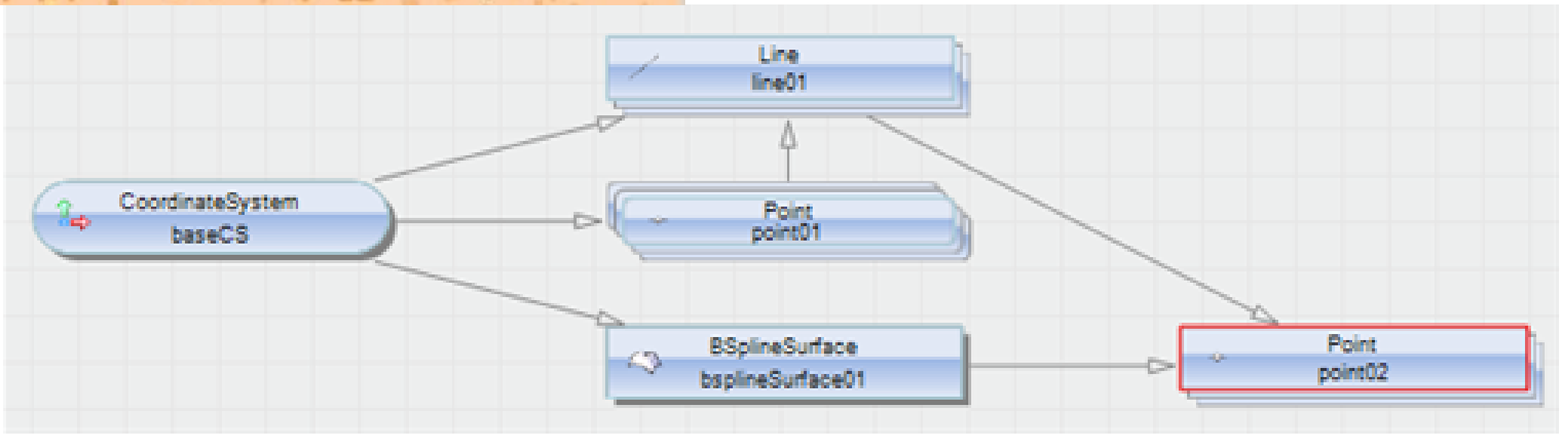

21' - 9 15/16"
20' - 0 9/32"
15' - 10 1/4"
13' - 4 11/32"
R 15' - 4 1/8"
R 26' - 1 7/8"
R 58' - 7 1/2"
R 69' - 9 13/32"
R 58' - 7 17/32"
R 26' - 1 29/32"
R 15' - 4 1/8"

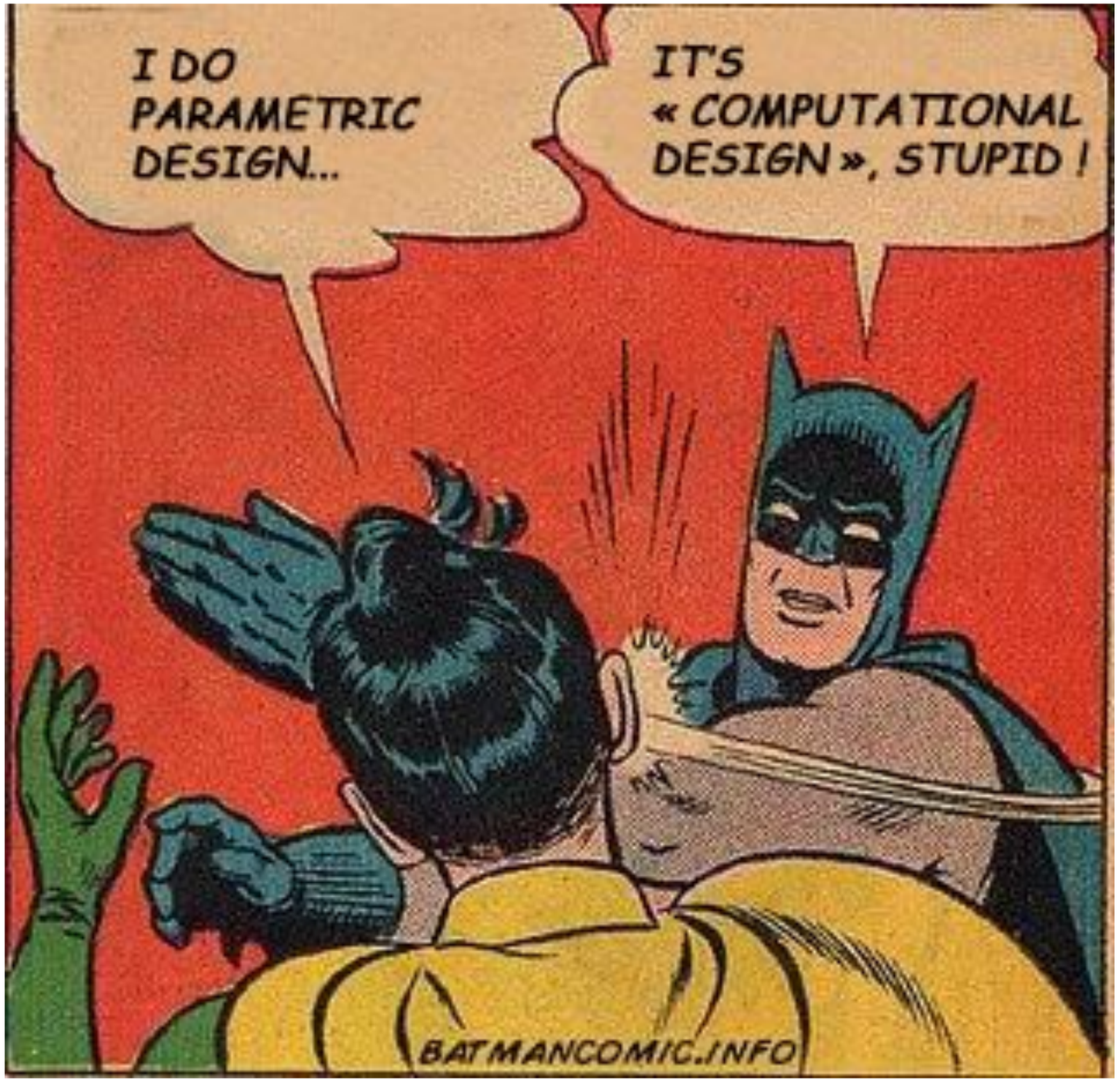

B
minor truss
C
major truss



Visual Programming





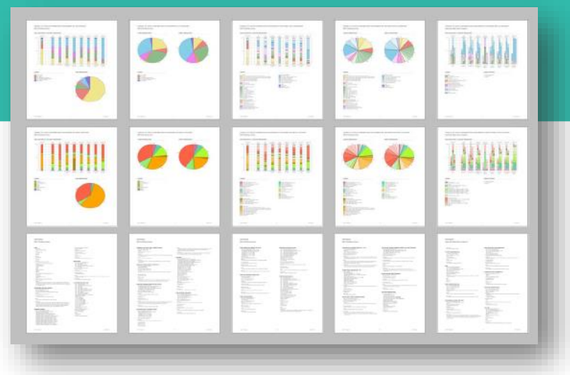

I DO PARAMETRIC DESIGN...
IT'S « COMPUTATIONAL DESIGN », STUPID !
BATMANCOMIC.INFO

So what does this mean to you?

Architects

Design Better Buildings

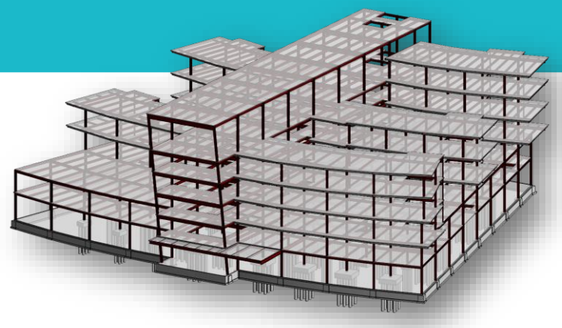
- Study more design options
- Communicate better with clients
- Understand energy design based on rules
- Design more freely
- Extend power of Revit



Engineers

Become Better Problem Solvers

- Study more design options
- Rationalize systems
- Access APIs to customize design
- Visual spreadsheet design is intuitive to engineers
- Manage risk and creativity of clients by exposing tradeoffs



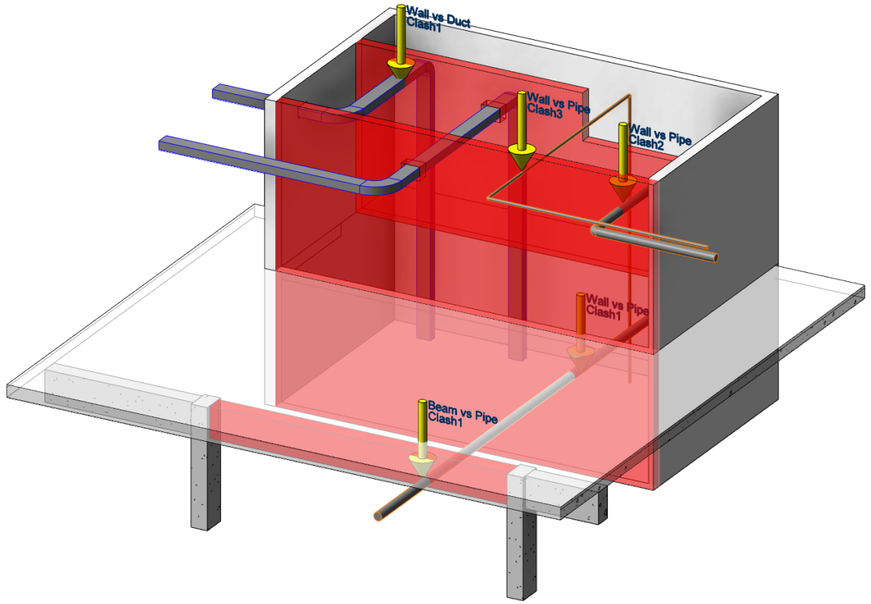
Construction

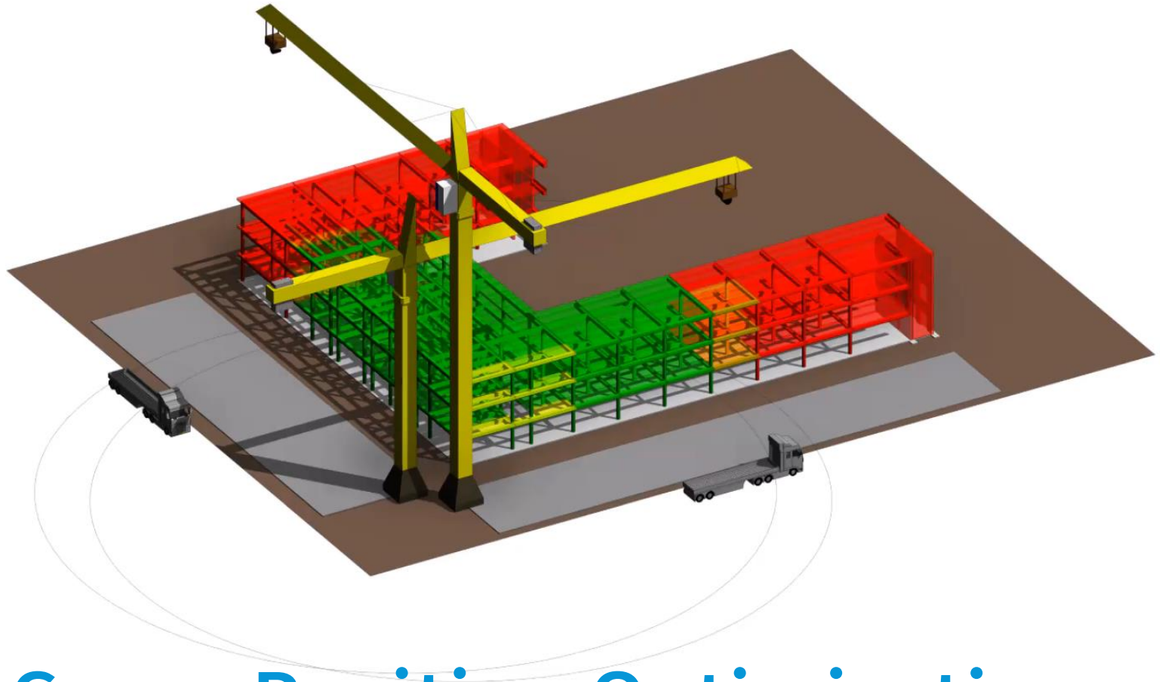
Build better Buildings

- Understand systems & connections
- Understand timeframes for construction
- Variables and alternative means & methods
- System rationalization



Dynamo Use Cases

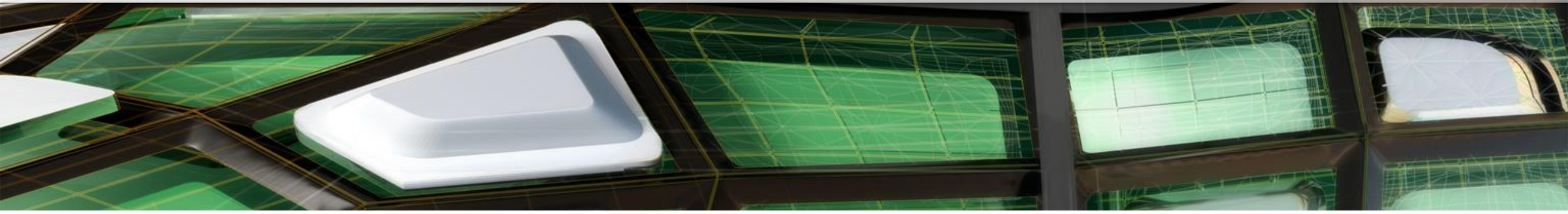




Live Design Clash Verification

Crane Position Optimization

Live Design Clash Verification

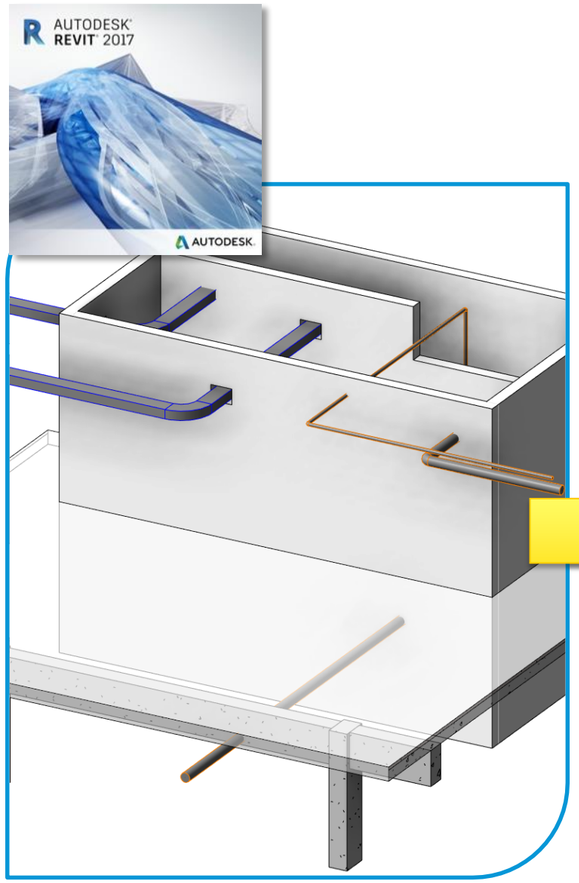




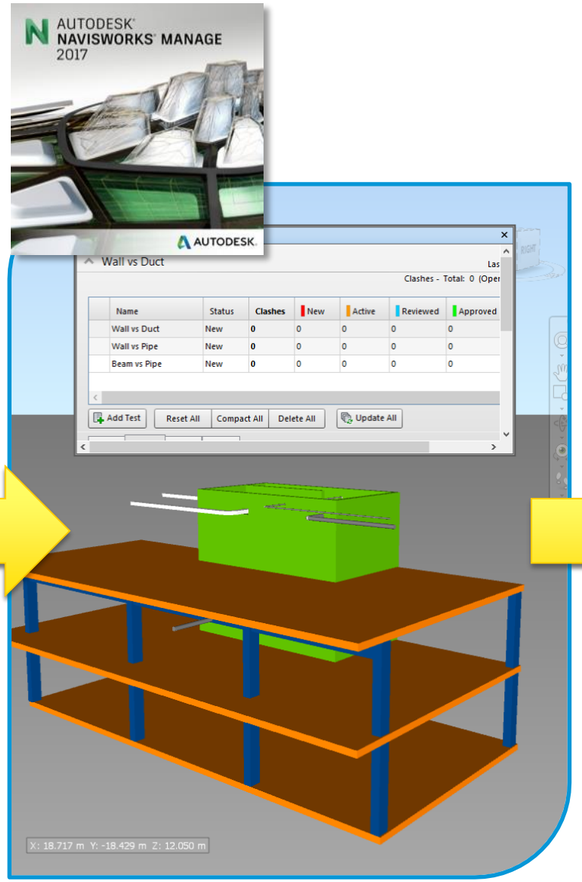




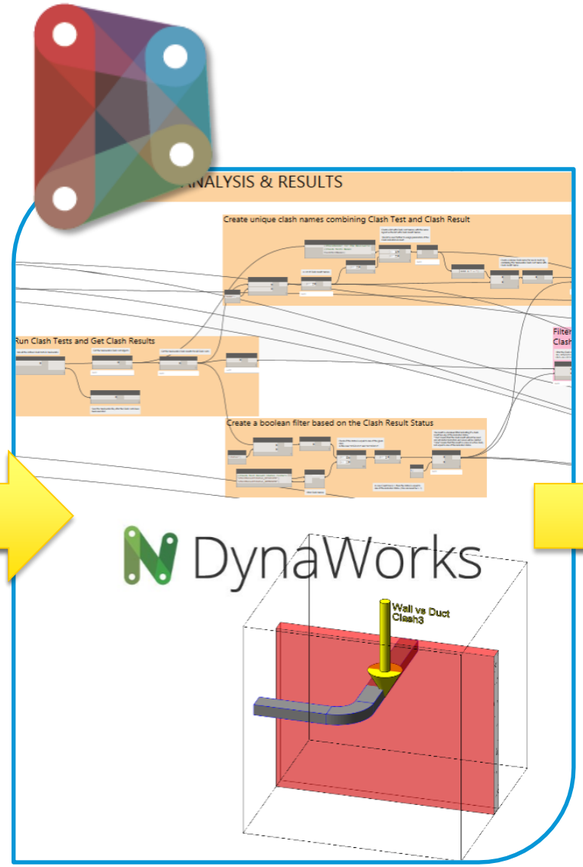
Live Design Clash Verification



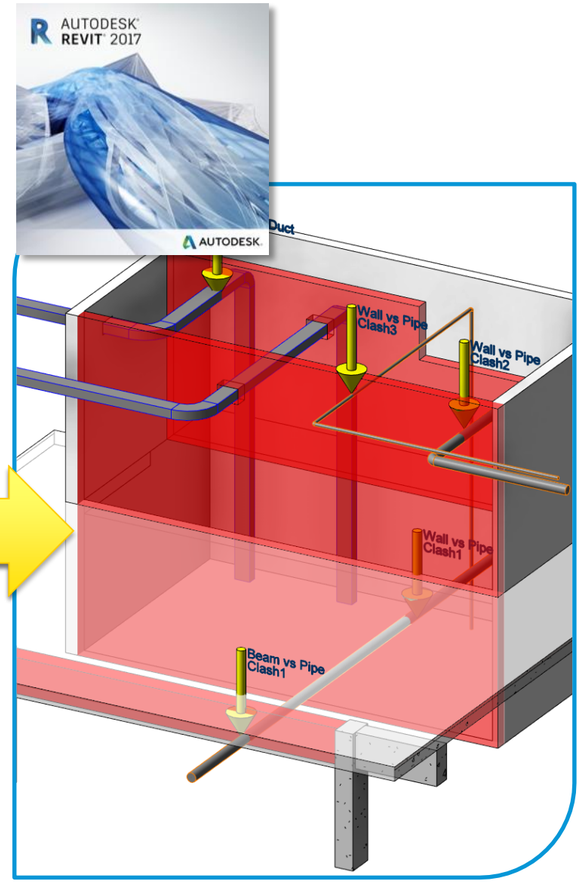
Setup Design Models



Coordination Model



Get Clash Results

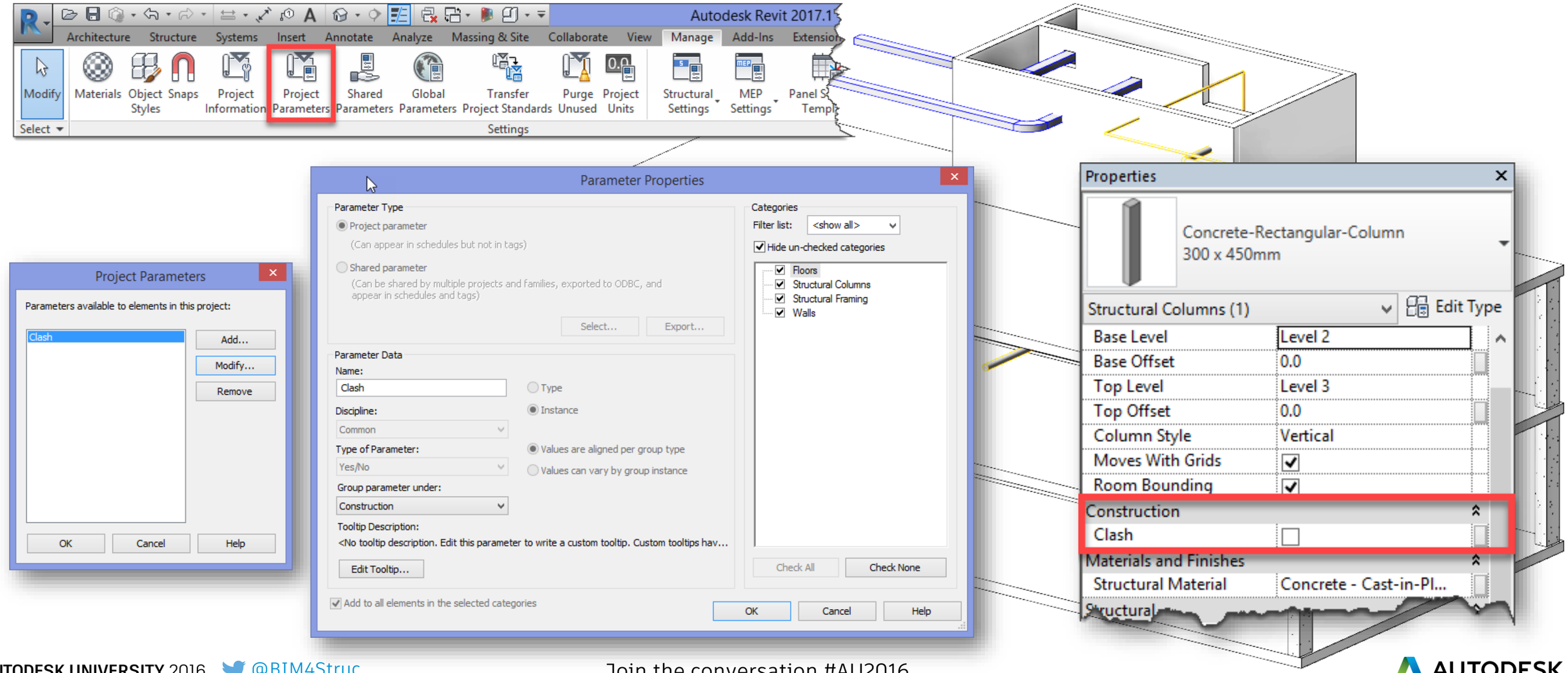


Evaluate & Modify Designs

Set up structural design model



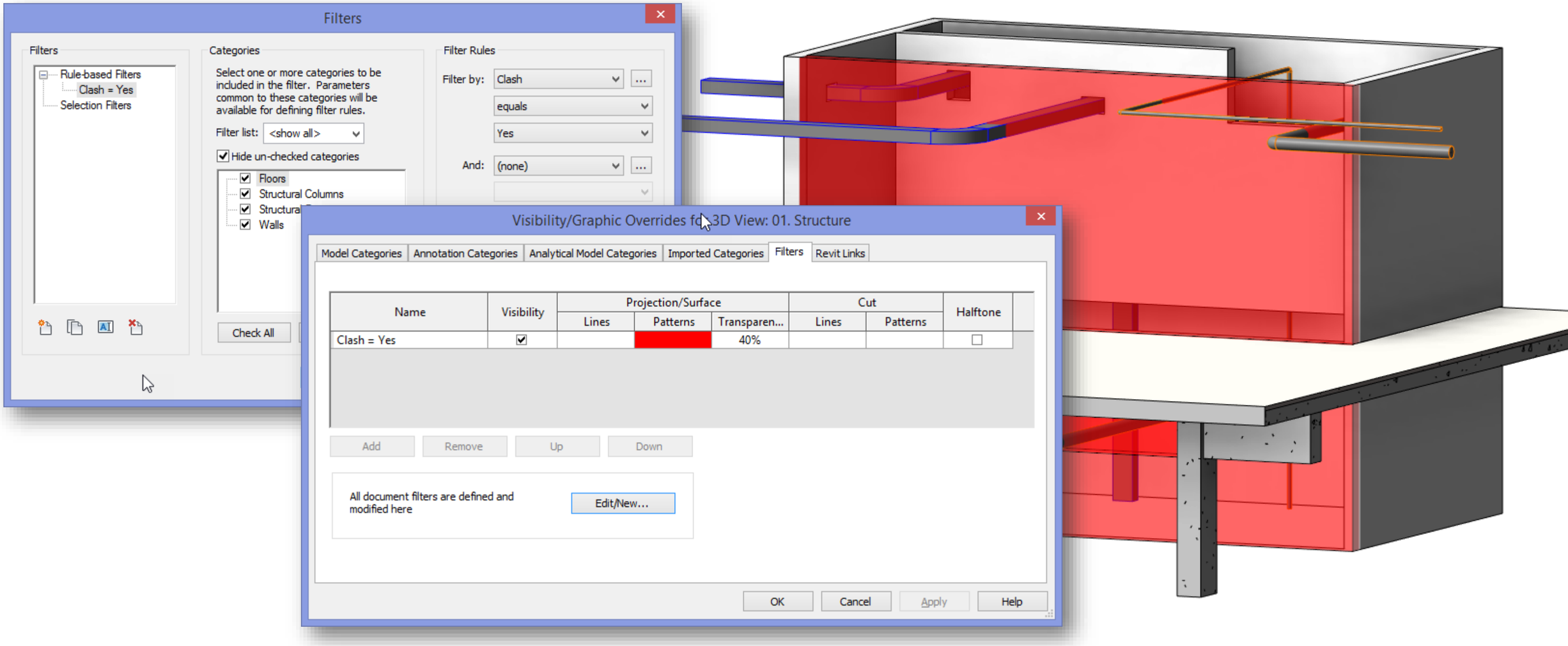
1. Add “Clash” parameter in the project



Set up structural design model



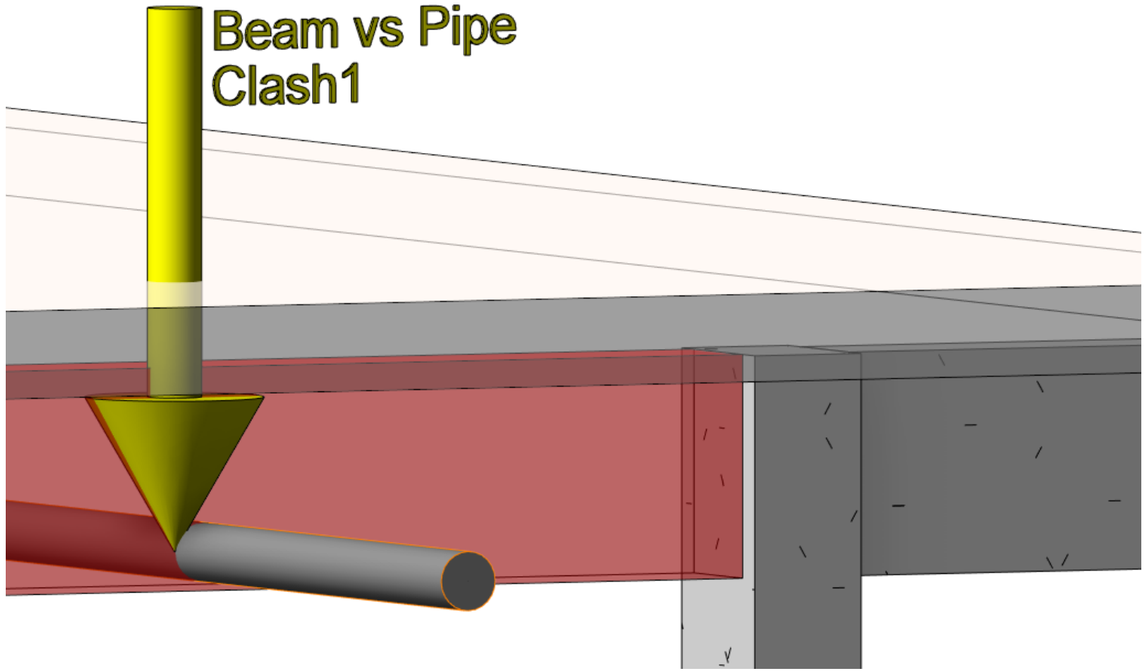
2. Create diagnostic views with Filters

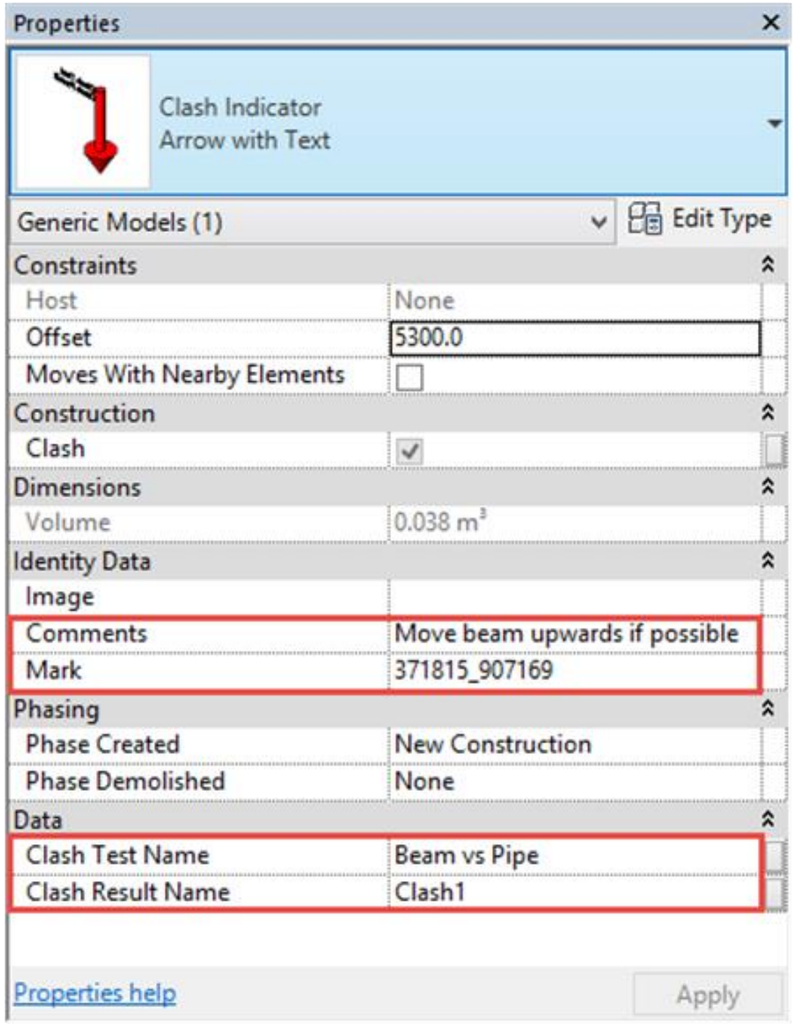


Set up structural design model



3. Create Clash Indicator family





Set up structural design model



4. Define clash schedules (optional)

Project Browser - Structural Model.rvt

- Level 3
- Level 4
- Site
- 3D Views
  - 01. Structure
  - 02. Coordination
  - 03. Sectioned
  - Beam vs Pipe - Clash1
  - Wall vs Pipe - Clash1
  - Wall vs Pipe - Clash2
- Elevations (Building Elevation)
  - East
  - North
  - South
  - West
- Legends
- Schedules/Quantities
  - Clash Indicators
  - Clash List
- Sheets (all)
- Families
- Groups
- Revit Links

Schedule: Clash Indicators - Structural ...

<Clash Indicators>

A	B	C
wt	Clash Test Name	Clash Result Name
368167_906332	Wall vs Pipe	Clash2
371815_907169	Beam vs Pipe	Clash1
371815_907169	Beam vs Pipe	Clash1
371815_907169	Beam vs Pipe	Clash1

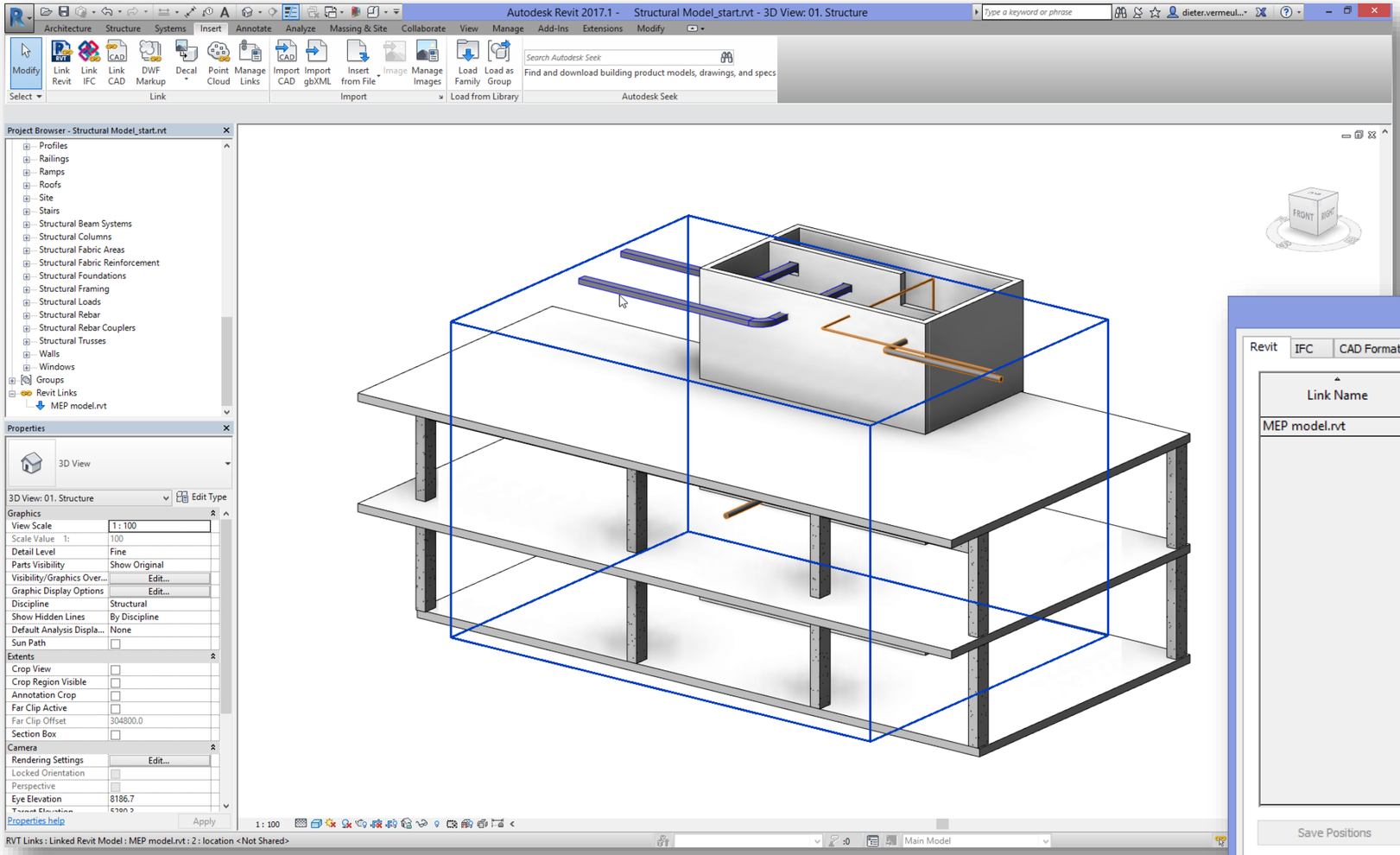
Schedule: Clash List - Structural Model....

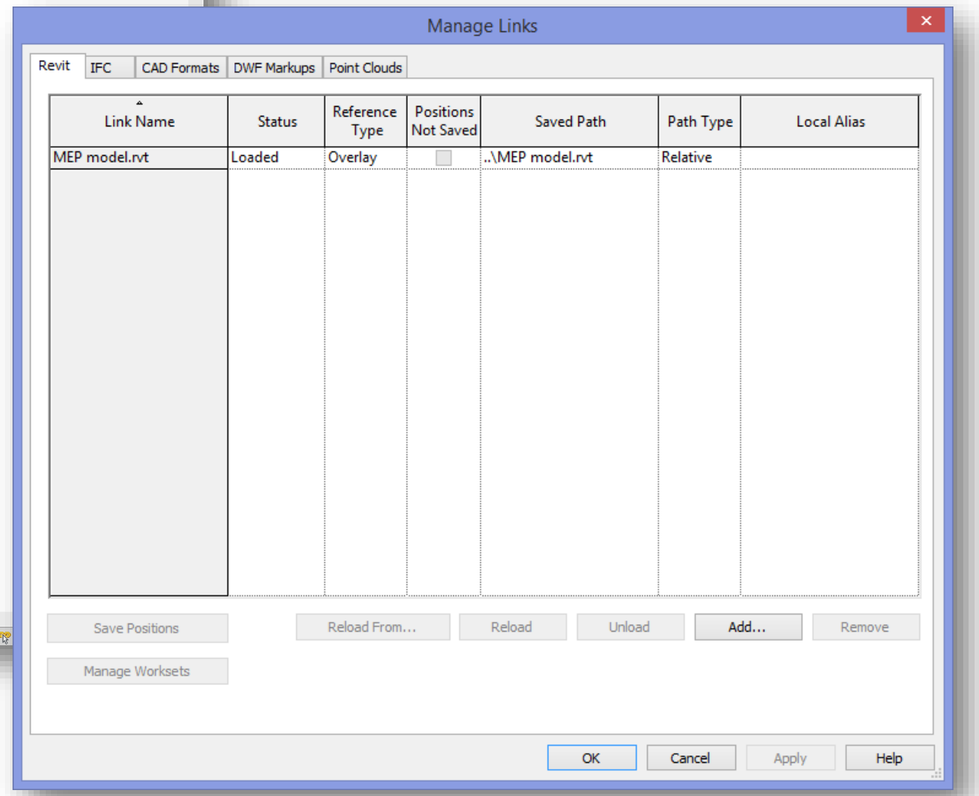
<Clash List>

A	B	C
Family	Type	Clash
Structural Framing		
Concrete-Rectang	300 x 600mm	☑
Concrete-Rectang	300 x 600mm	☑
Concrete-Rectang	300 x 600mm	☑
Walls		
Basic Wall	Concrete 200 mm	☑
Basic Wall	Concrete 200 mm	☑

Optional: Link the MEP model



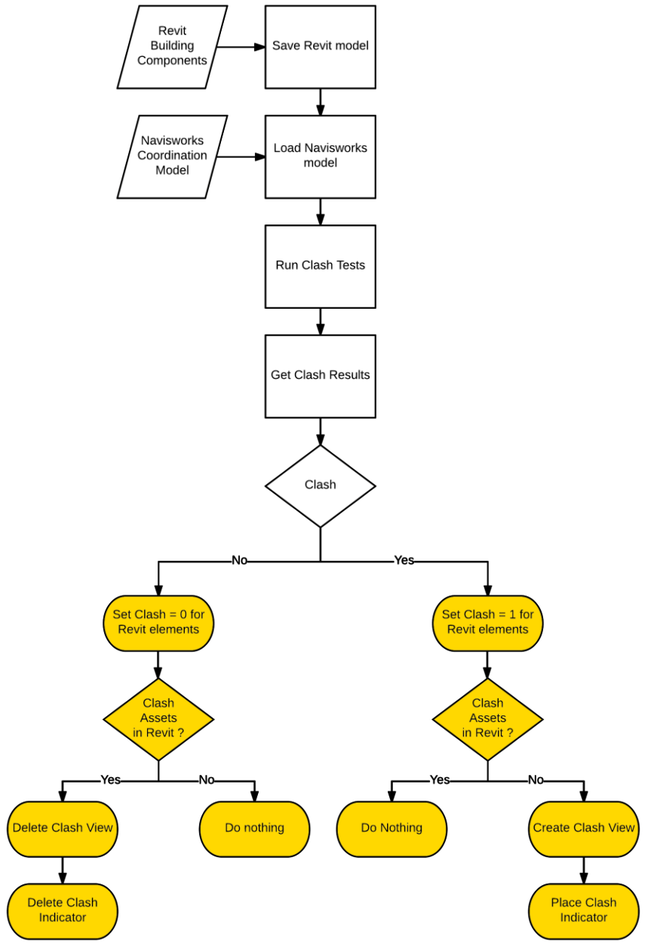


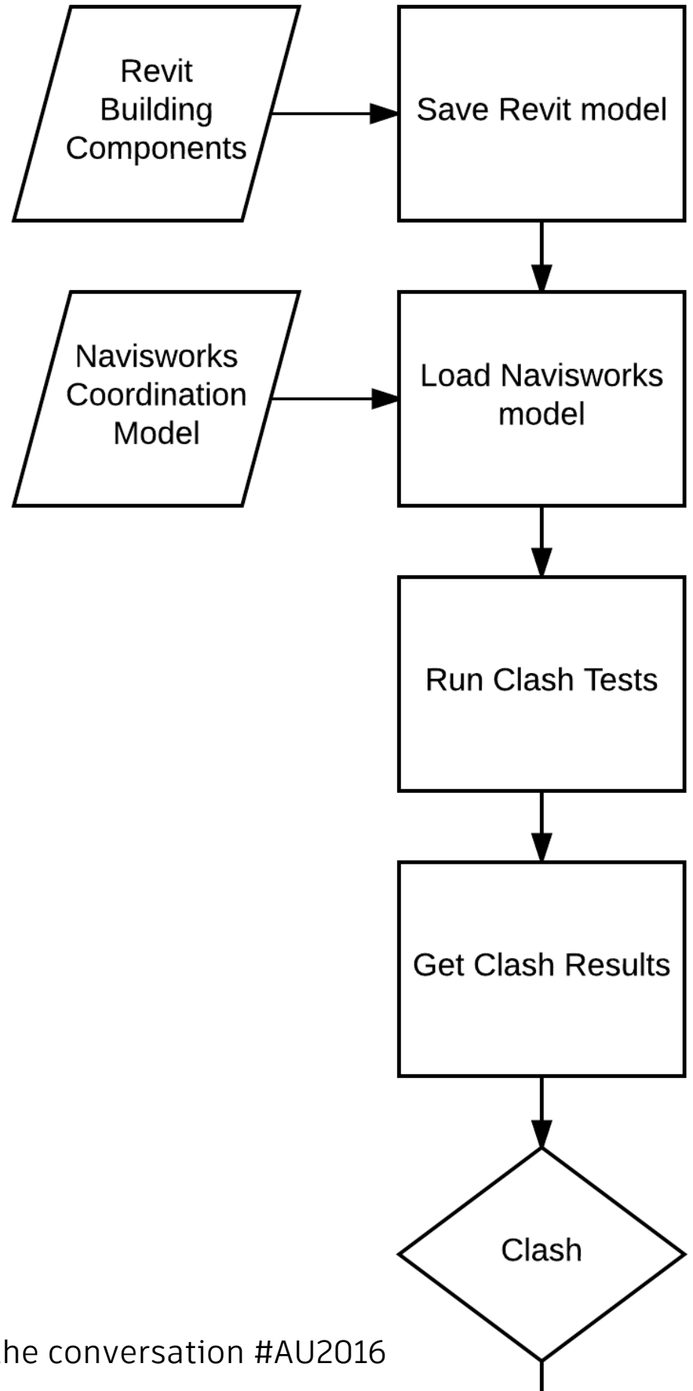


Define Clash Rules in Coordination Model



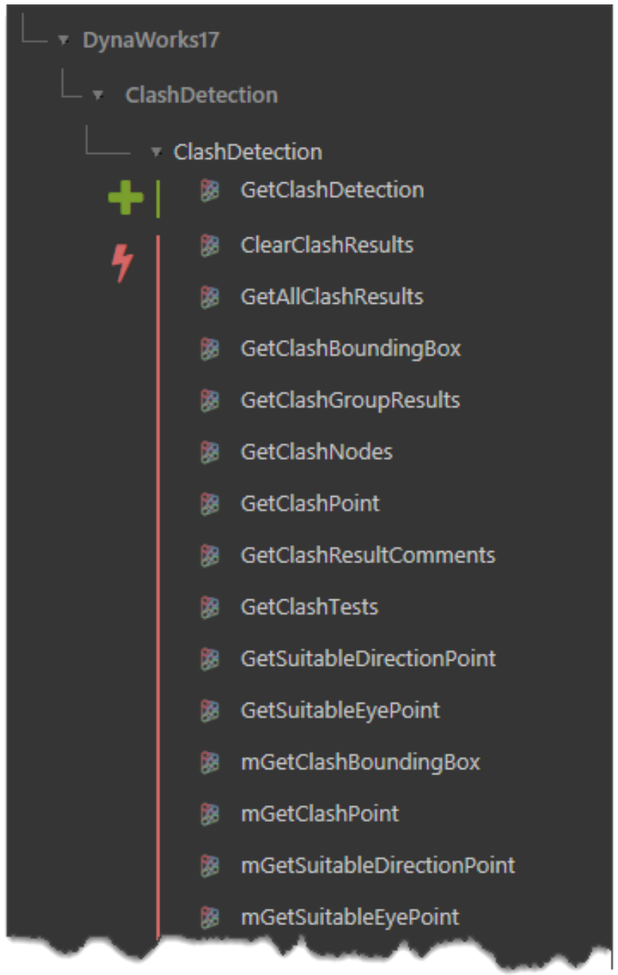
Dynamo Flowchart





DynaWorks 17 package

- Dynamo Library for Navisworks
- Read from coordination model
- Automate clash detection
- Get Revit data from Navisworks

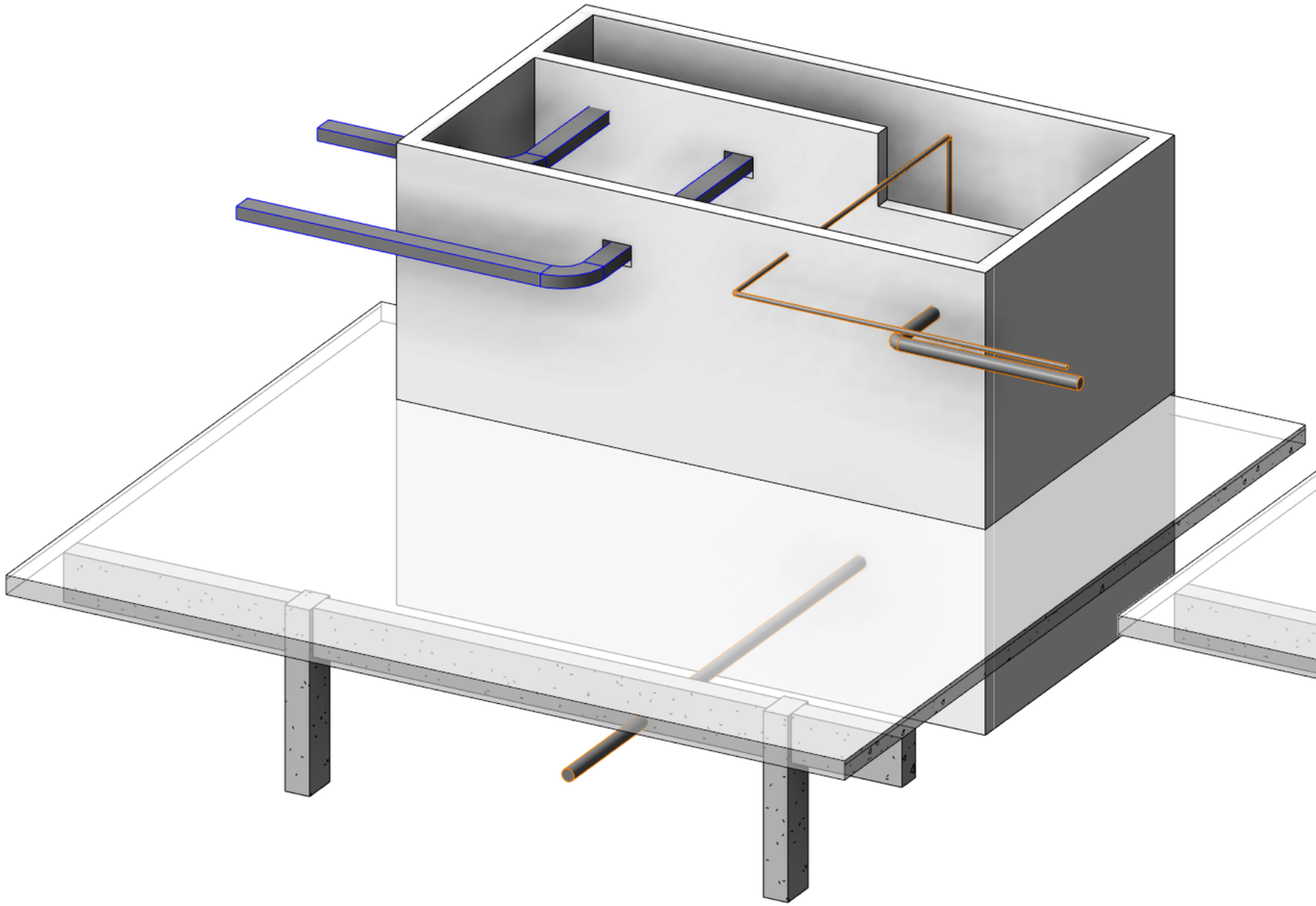


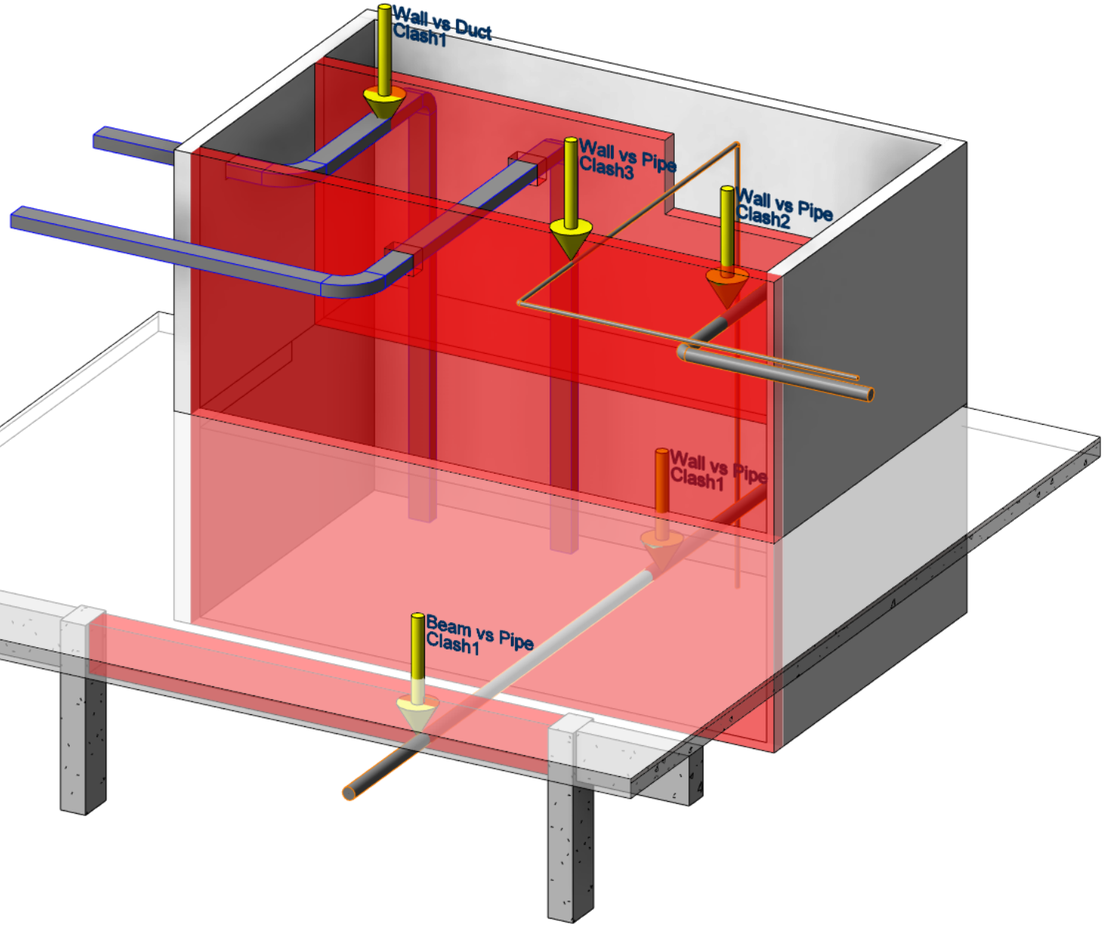
DynaWorks

Authored by Adam Sheather
@Gytaco

Stream clash results to Revit

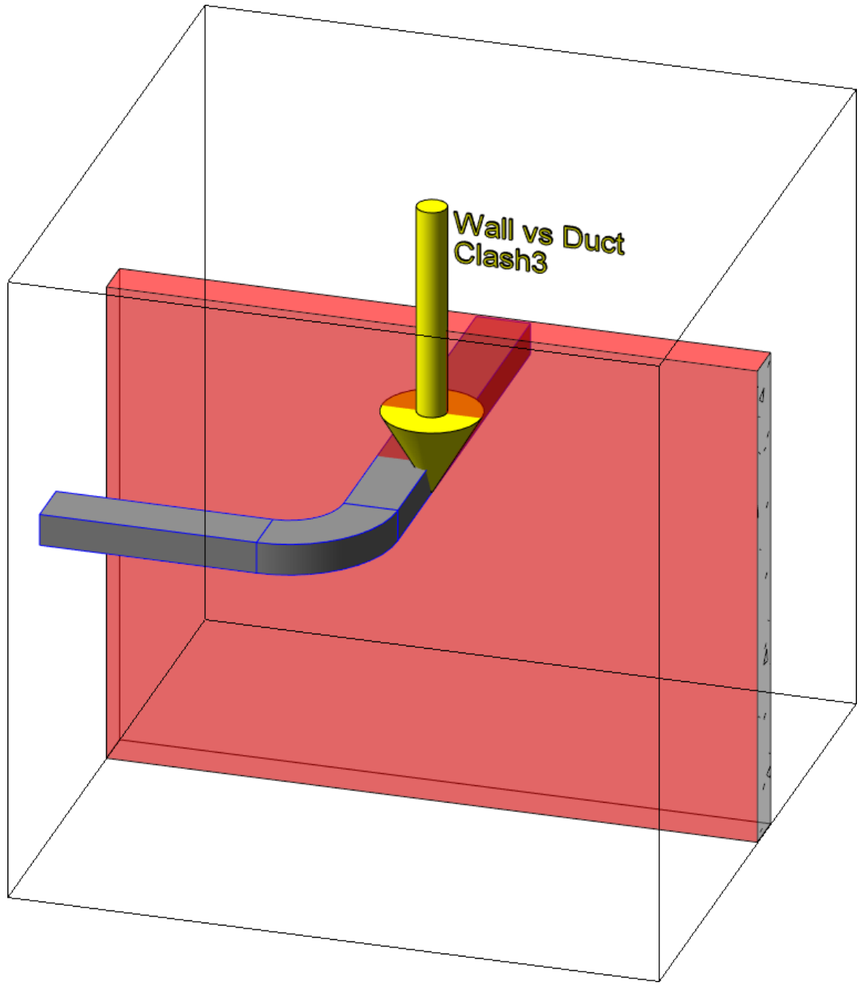


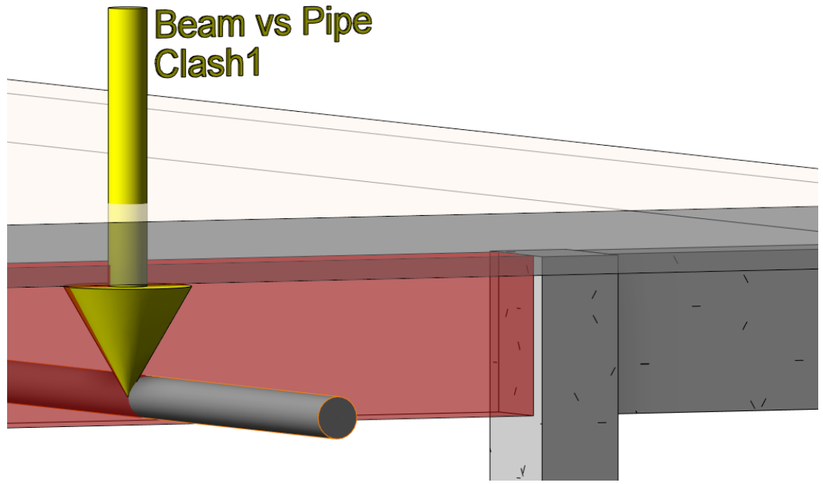




Place indicators and create clash views







Properties

Clash Indicator
Arrow with Text

Generic Models (1) | Edit Type

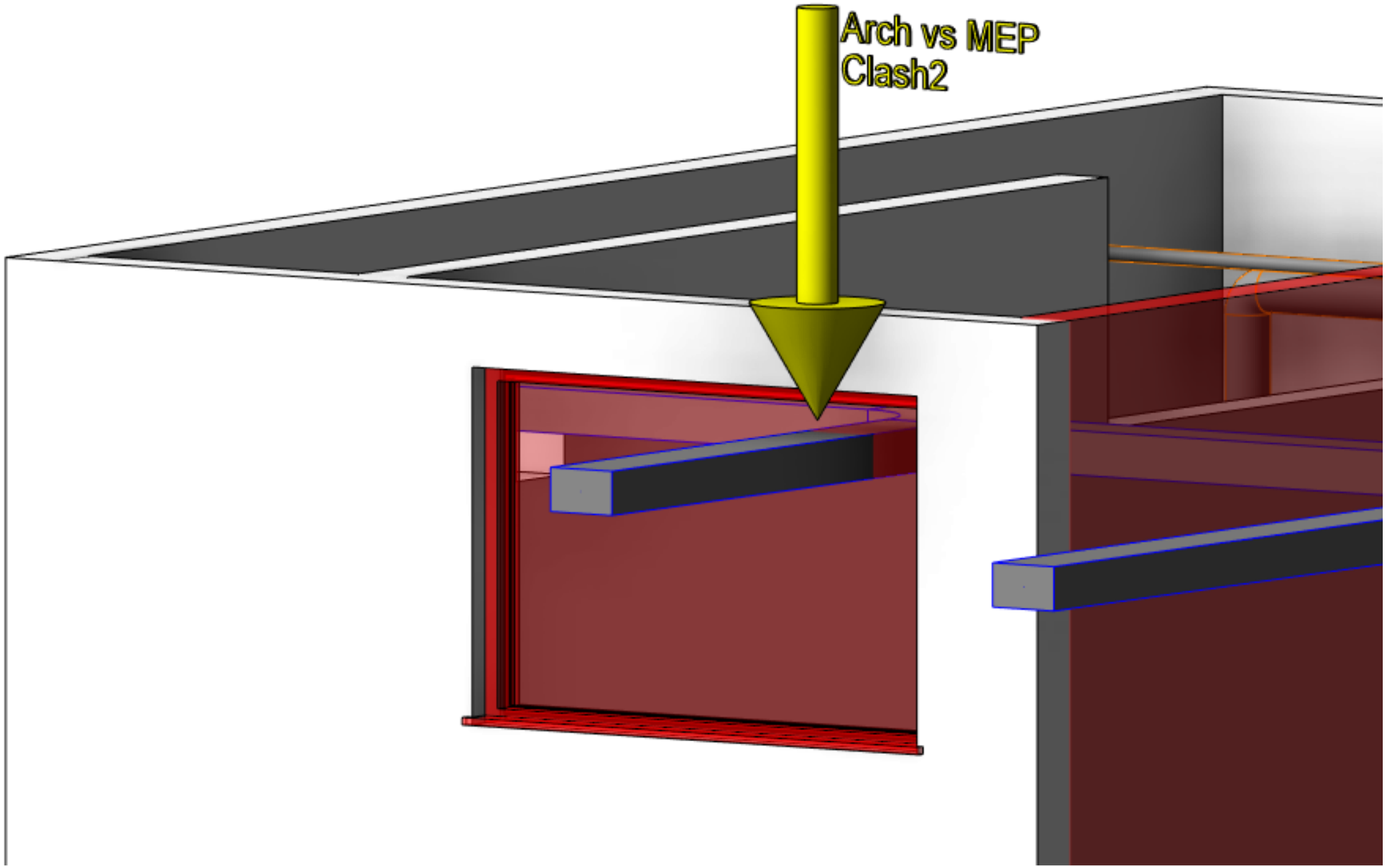
Constraints	
Host	None
Offset	5300.0
Moves With Nearby Elements	☐
Construction	
Clash	☑
Dimensions	
Volume	0.038 m³
Identity Data	
Image	
Comments	Move beam upwards if possible
Mark	371815_907169
Phasing	
Phase Created	New Construction
Phase Demolished	None
Data	
Clash Test Name	Beam vs Pipe
Clash Result Name	Clash1

Properties help | Apply

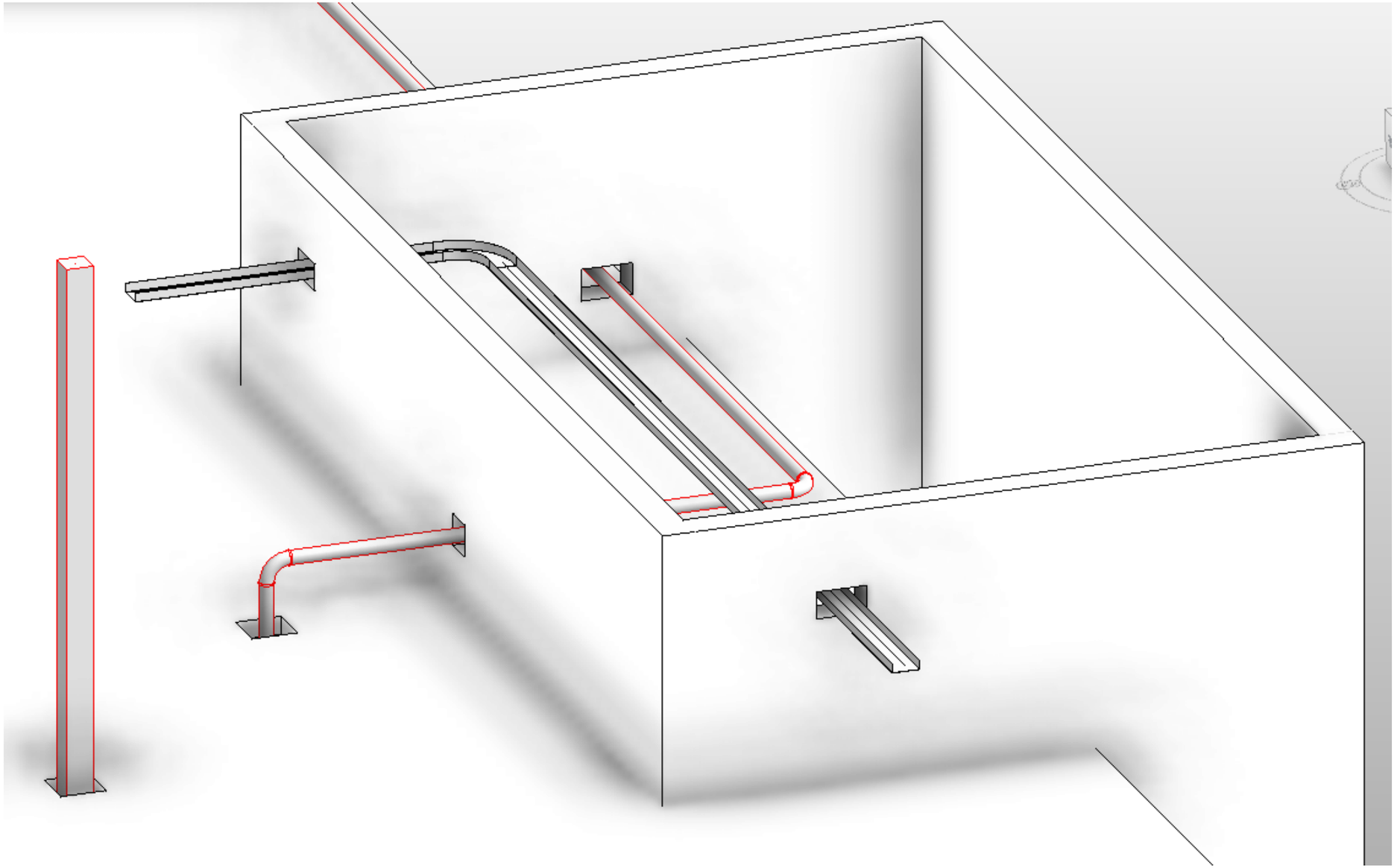
LIVE DEMO !



Similar with Architecture



Automate Wall Opening Creation



Crane Positioning Optimization



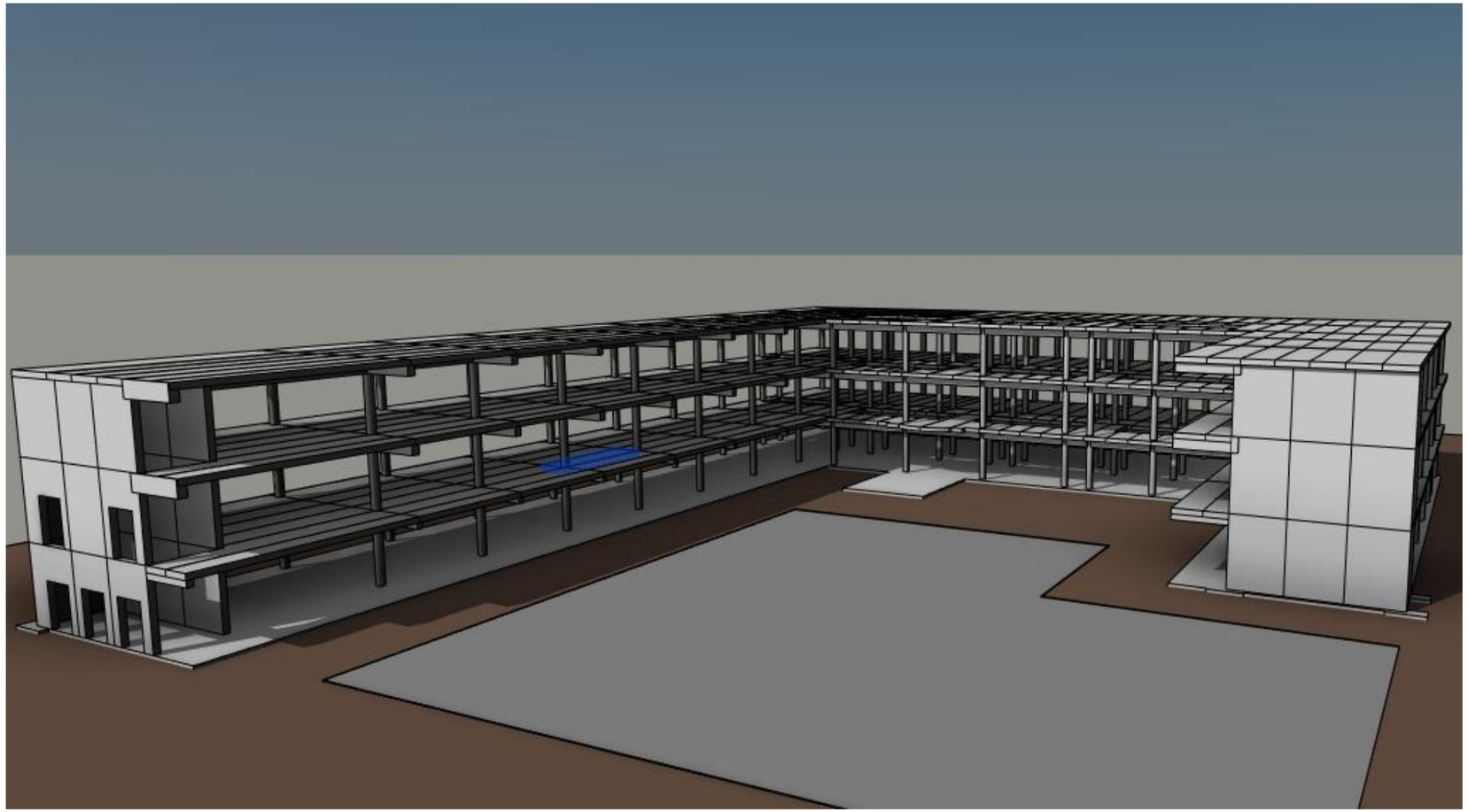

P3
P2

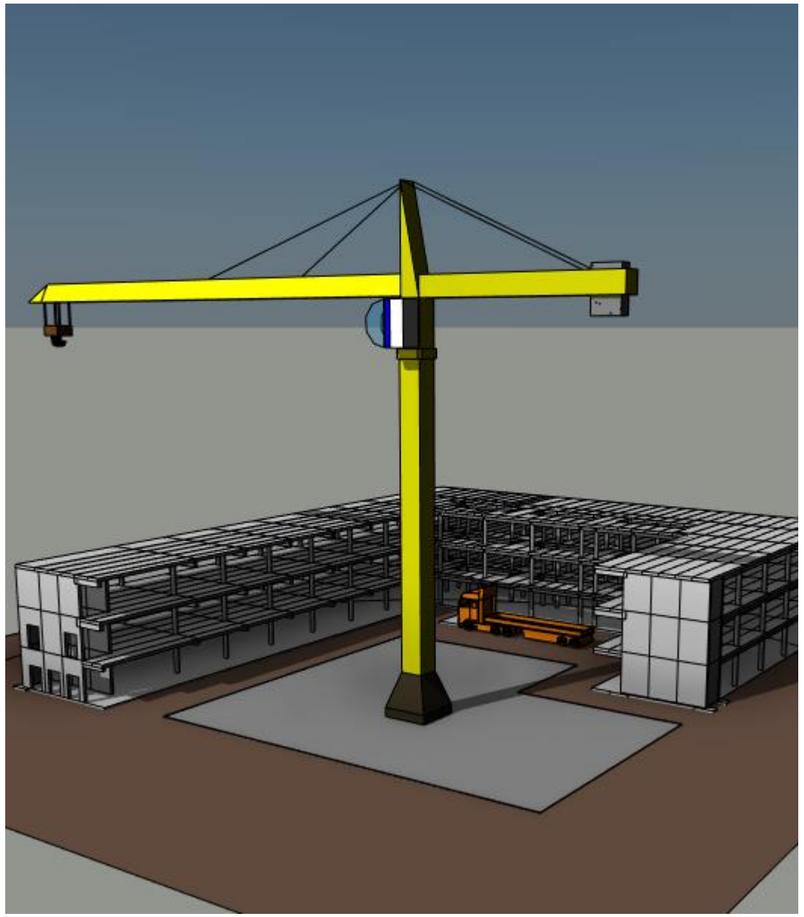
Why Optimize Crane Position?

- Define optimal number and location
- Avoid conflicts between cranes
- Detect possible hoisting problems
- Save time & cost
- Avoid overload of cranes on site
- Site planning



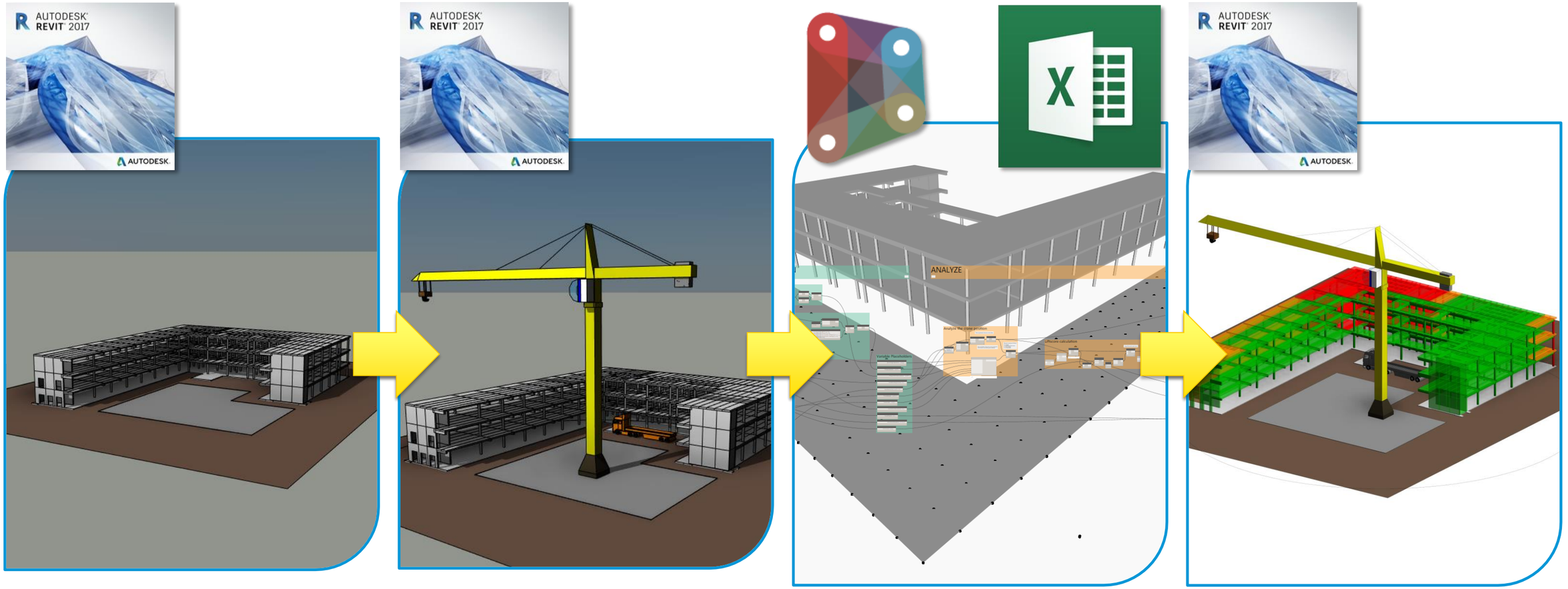
Project Description





Case inspiration by Jesper Wallaert from MTHøjgaard (Denmark)
@Jwallaert

Crane Position Analysis



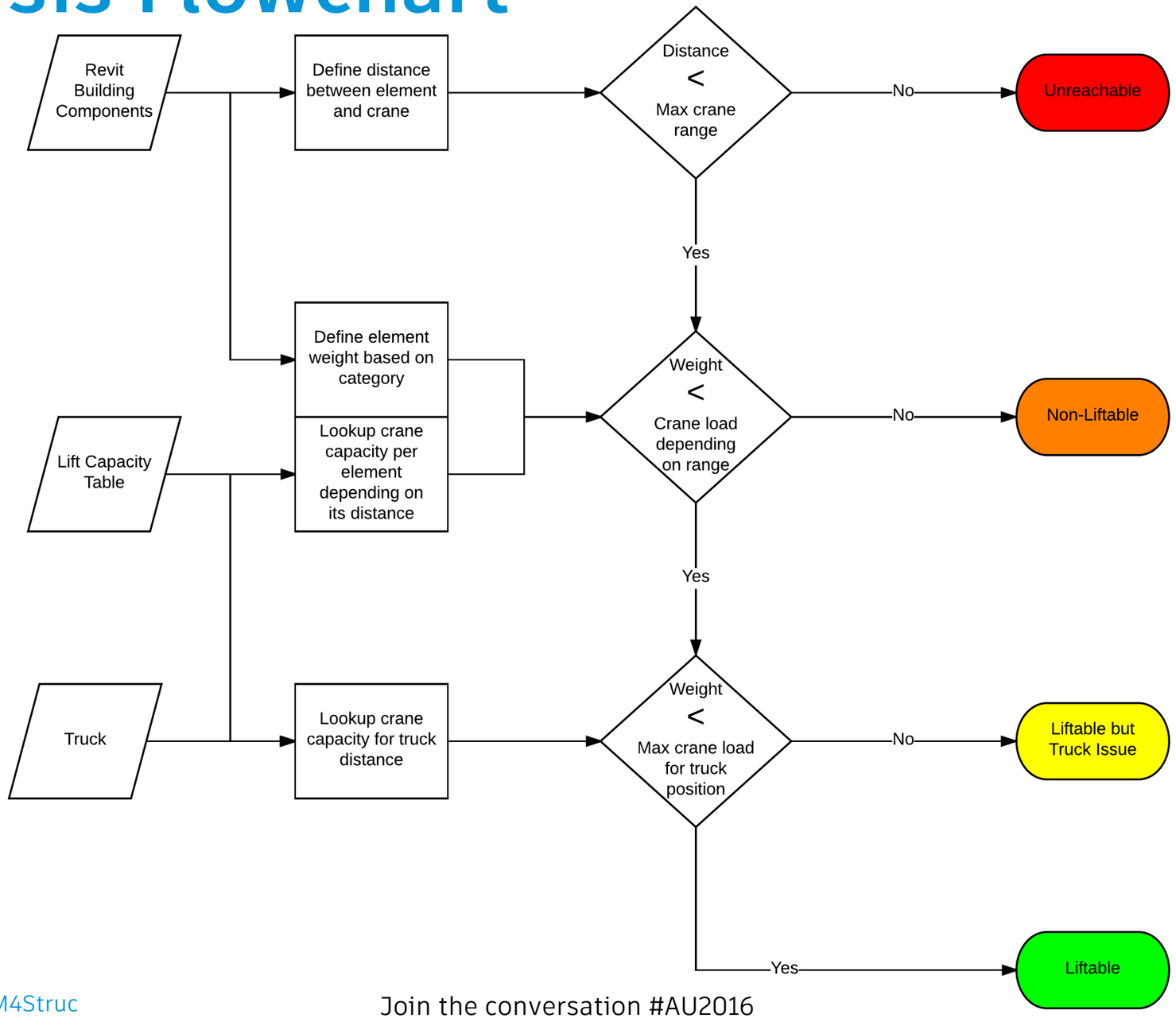
Create Design Model

Supply & Delivery Initialization

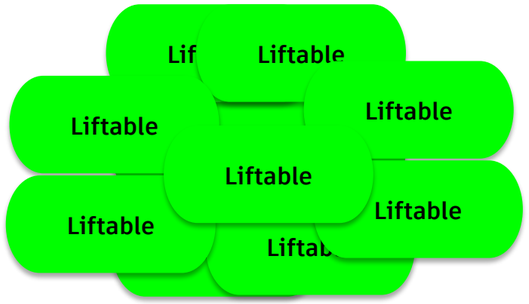
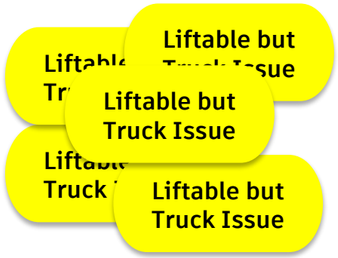
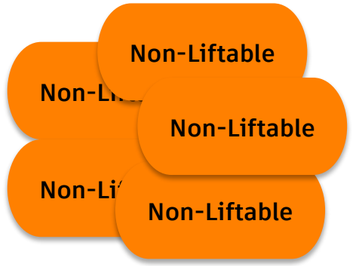
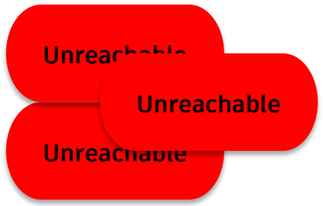
Crane Position Analysis

Evaluation of Results

Lift Analysis Flowchart



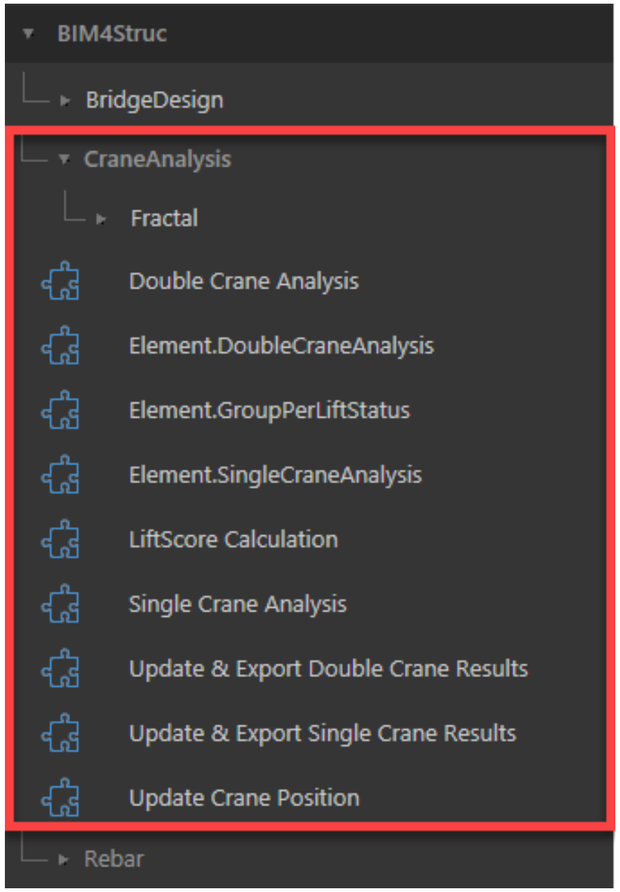
Lift Status Evaluation

	Elements	Status Score	Total Lift Score
	600	0	0
	15	5	75
	20	20	400
	50	100	5000

LiftScore = 5475

BIM4Struc.CraneAnalysis package

- Crane Position analysis nodes
- Single & Double cranes
- Lift score calculations
- Ready for Genetic Optimization
- Compatible with Dynamo Studio

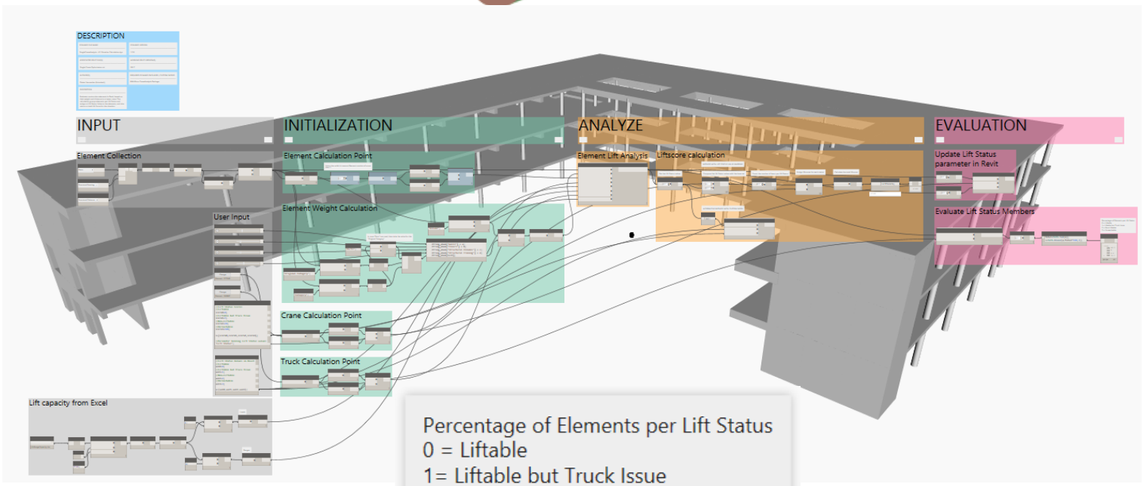


Approaches for Crane Position Analysis

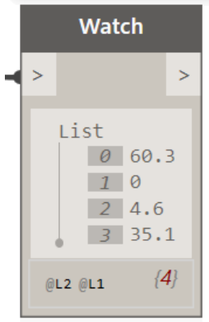
- Single Situation Calculation
- Crane Position Analysis with Parametric Run
- Crane Position Genetic Optimization
- Crane Layout Exploration with Fractal

Single Situation Calculation

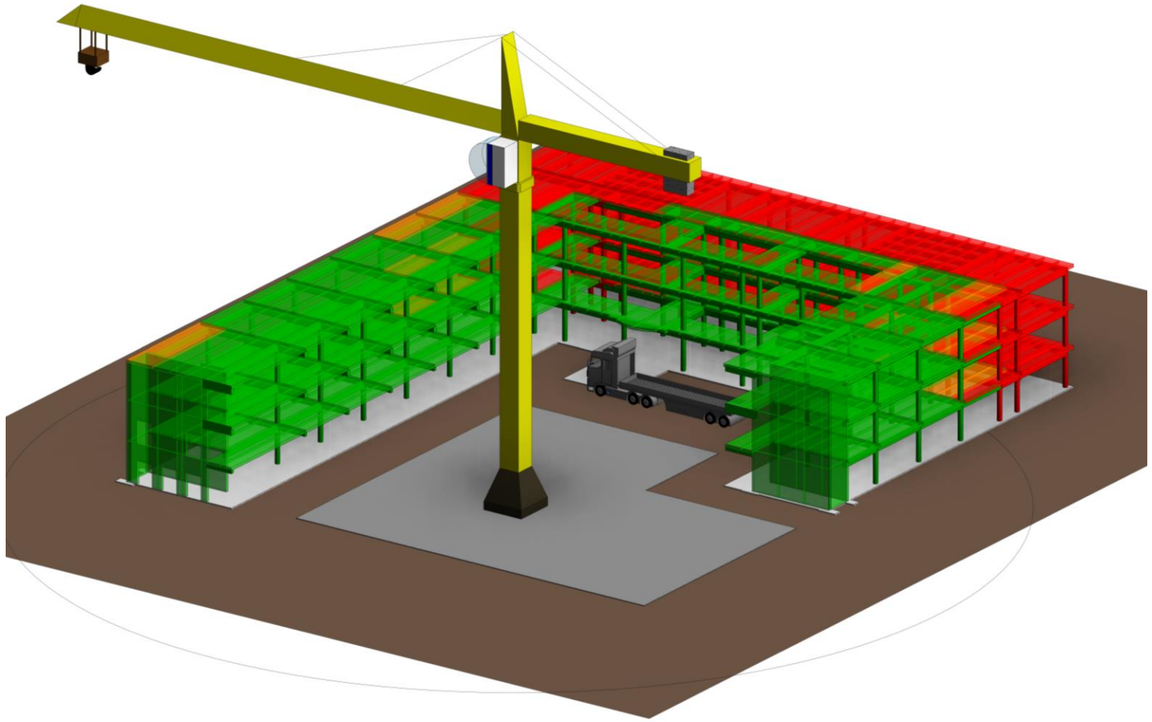
Single Situation Calculation



Percentage of Elements per Lift Status
0 = Liftable
1= Liftable but Truck Issue
2 = Non-Liftable
3 = Unreachable





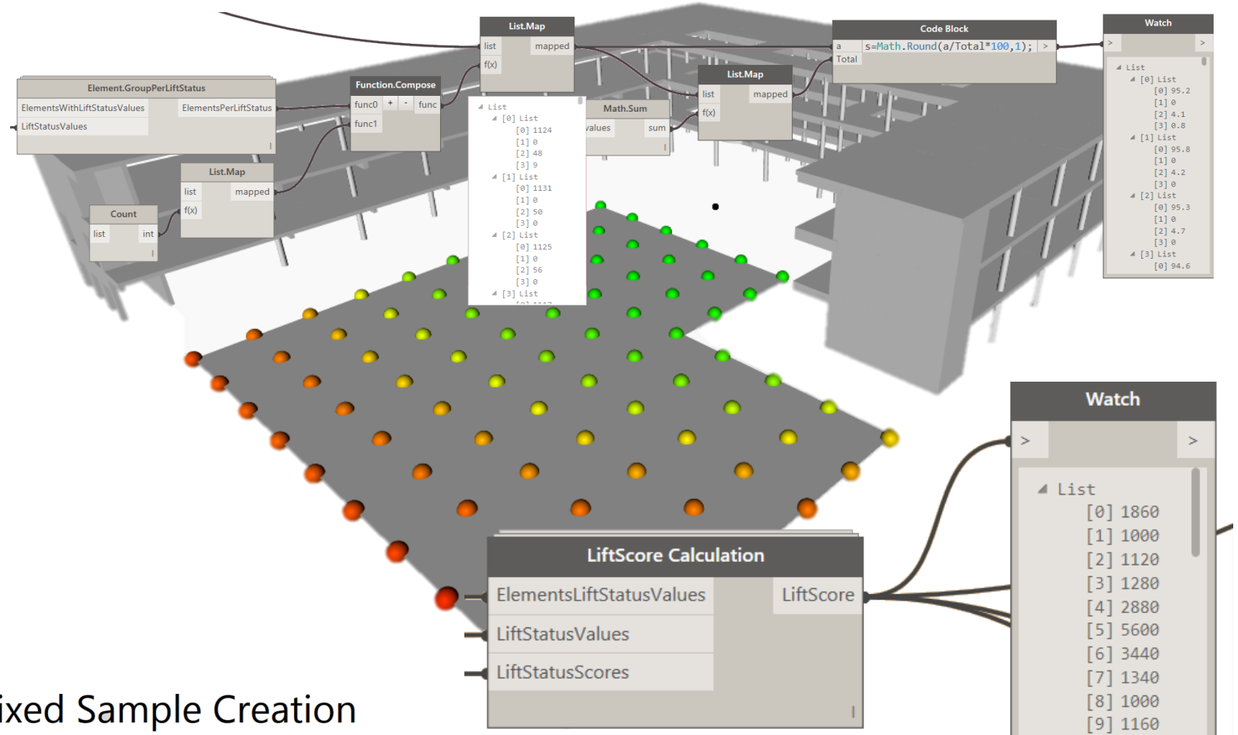


LIVE DEMO !

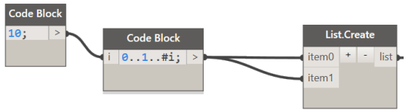

EVALUATION
Visualize the analysis results in Dynamo
Position the crane in Revit to the position with the minimal liftscore
Evaluate Lift Status Members

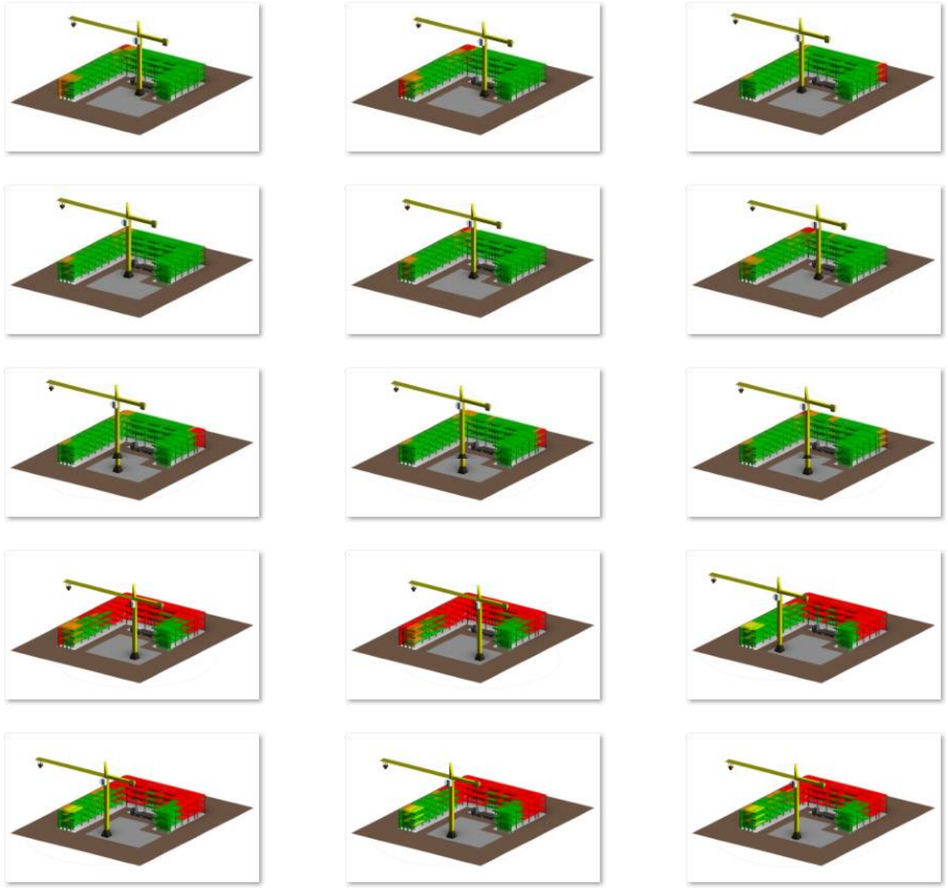
Parametric Run

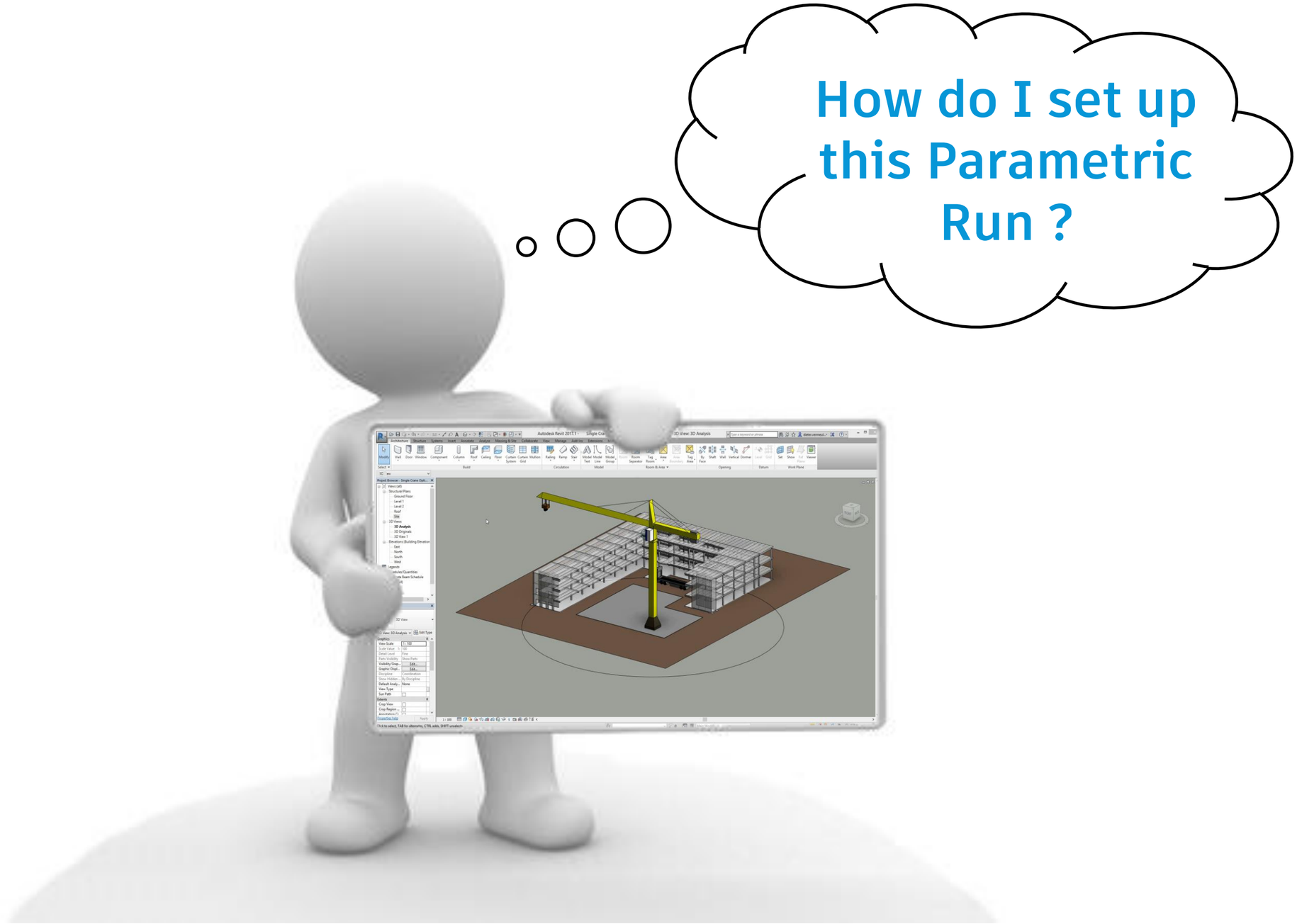
Crane Position Analysis with Parametric Run

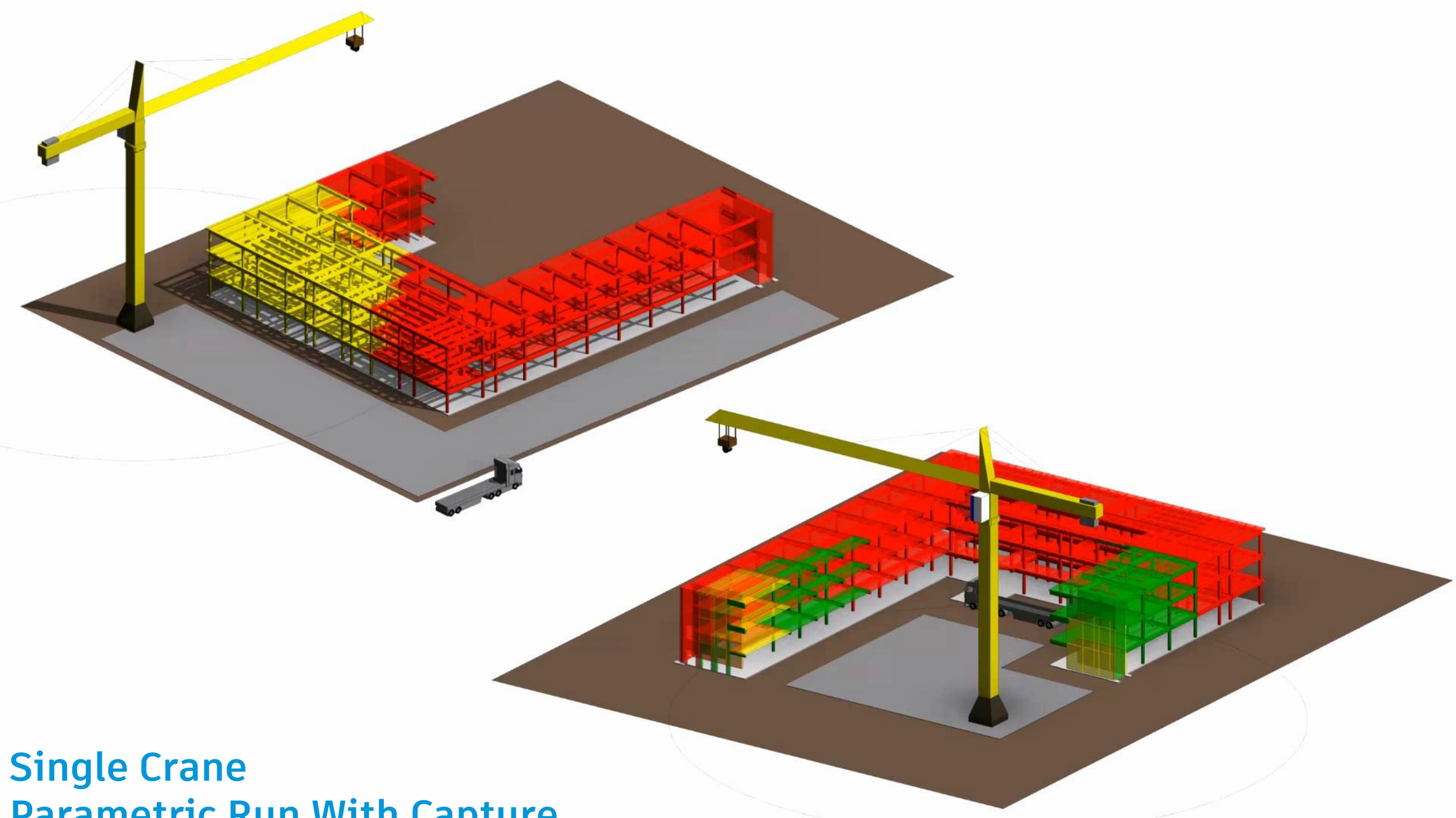


Fixed Sample Creation



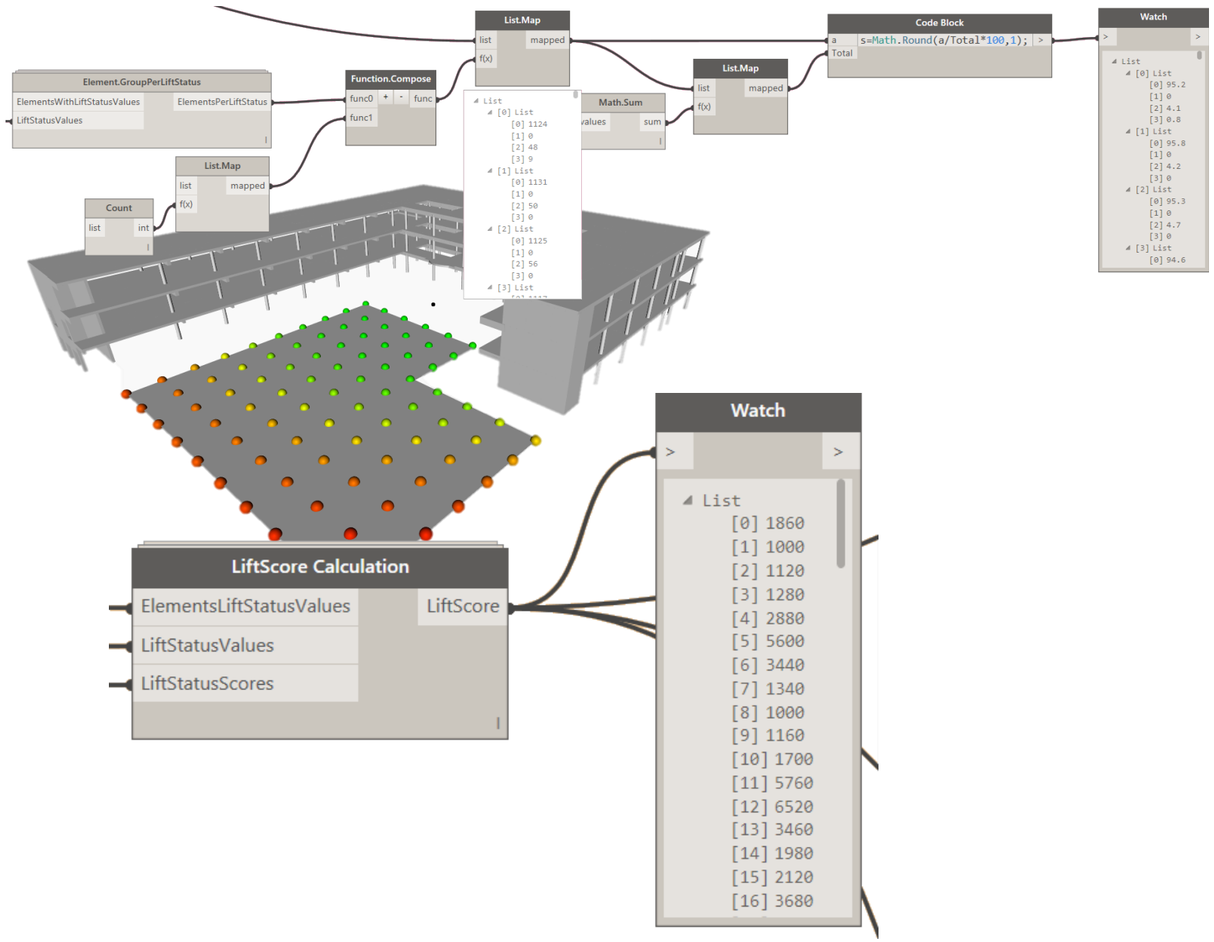


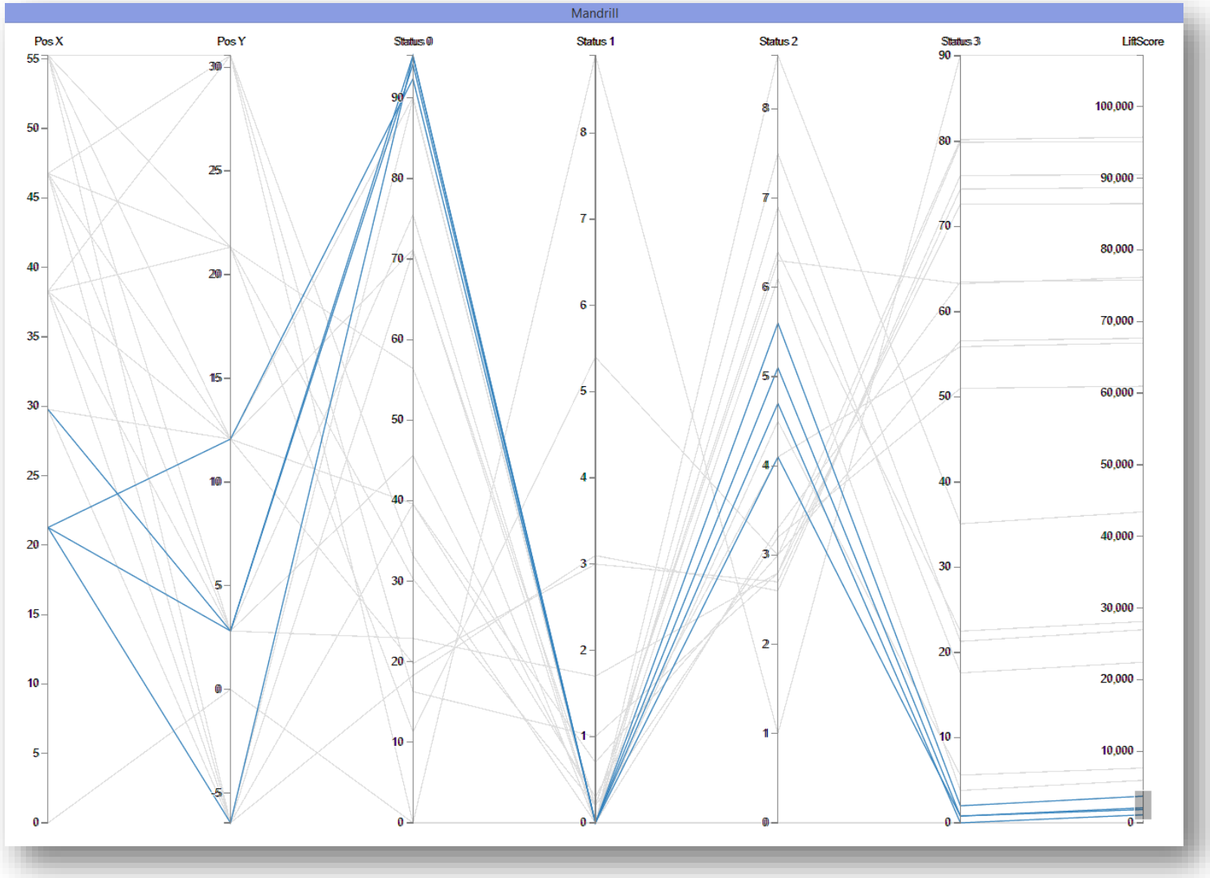

How do I set up this Parametric Run ?



Single Crane
Parametric Run With Capture

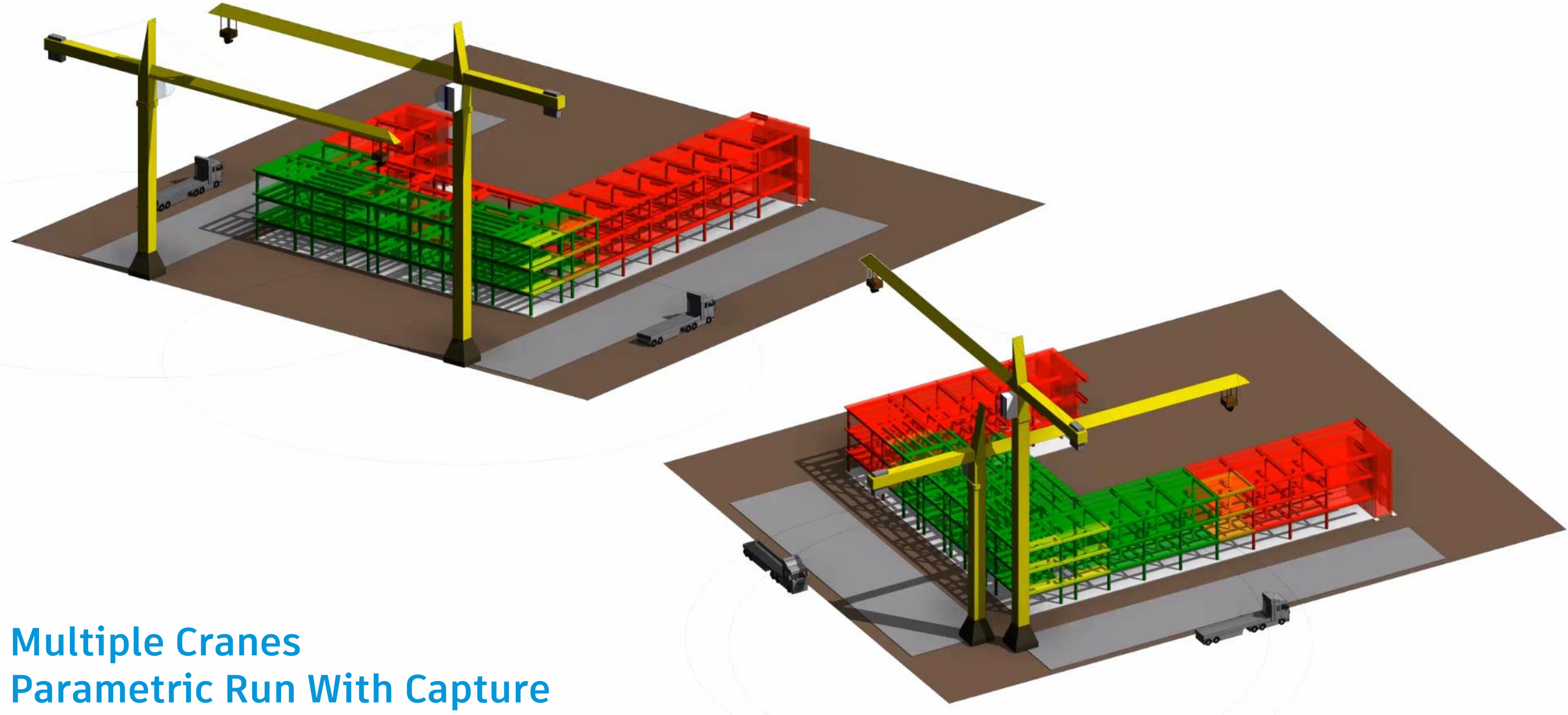
Single Crane Parametric Run Reporting





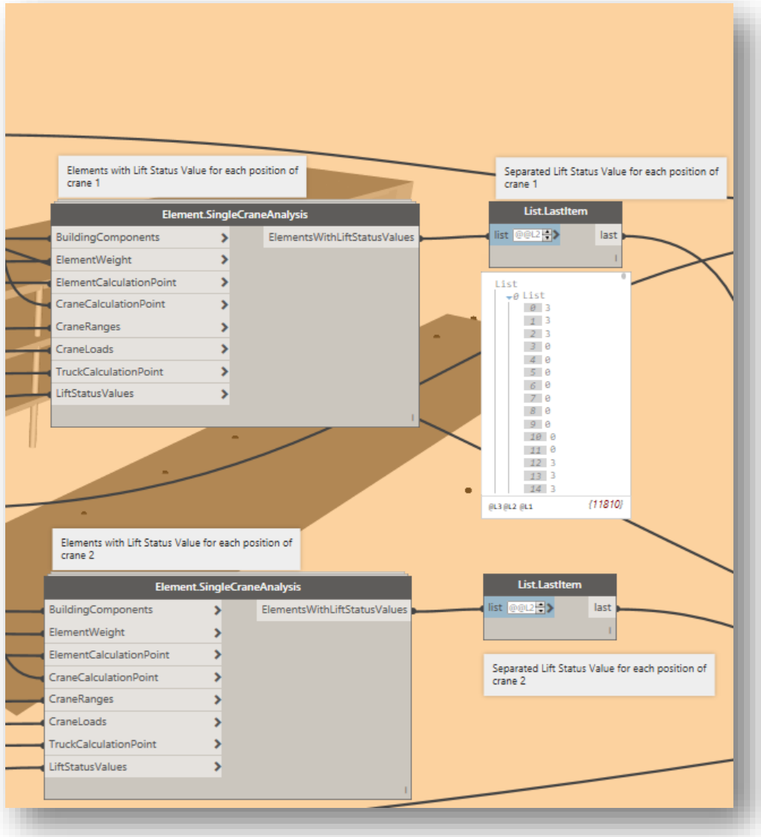
Parallel Coordinates Diagram
with **Archi-Lab Mandrill** package
(by Konrad Sobon - @arch_laboratory)

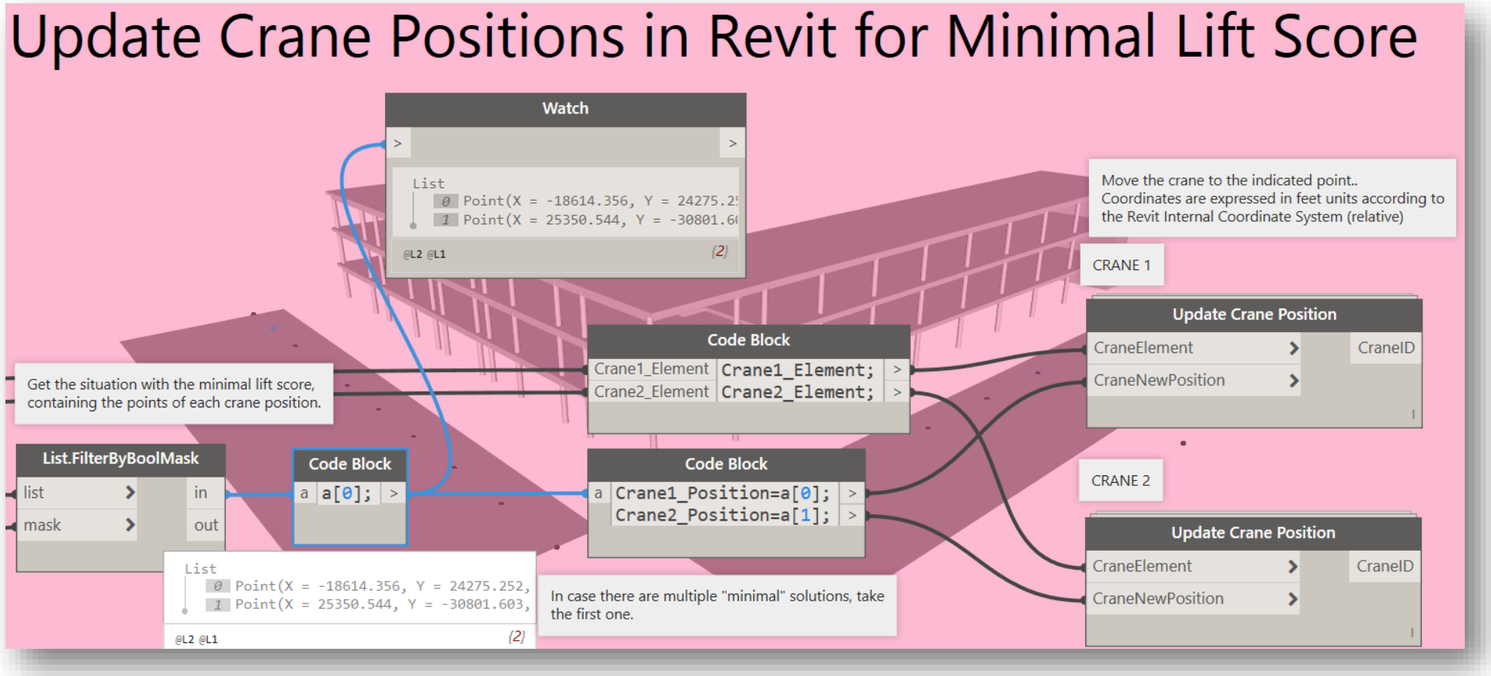

Is there another way to evaluate the results?

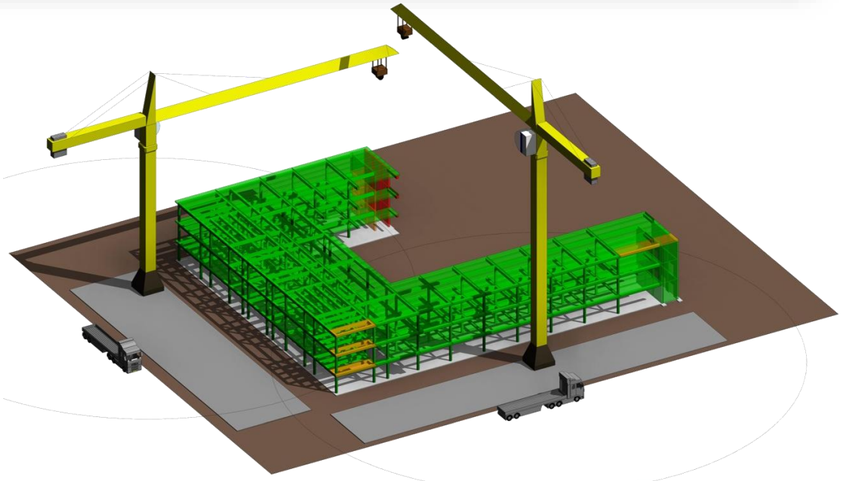


Multiple Cranes
Parametric Run With Capture

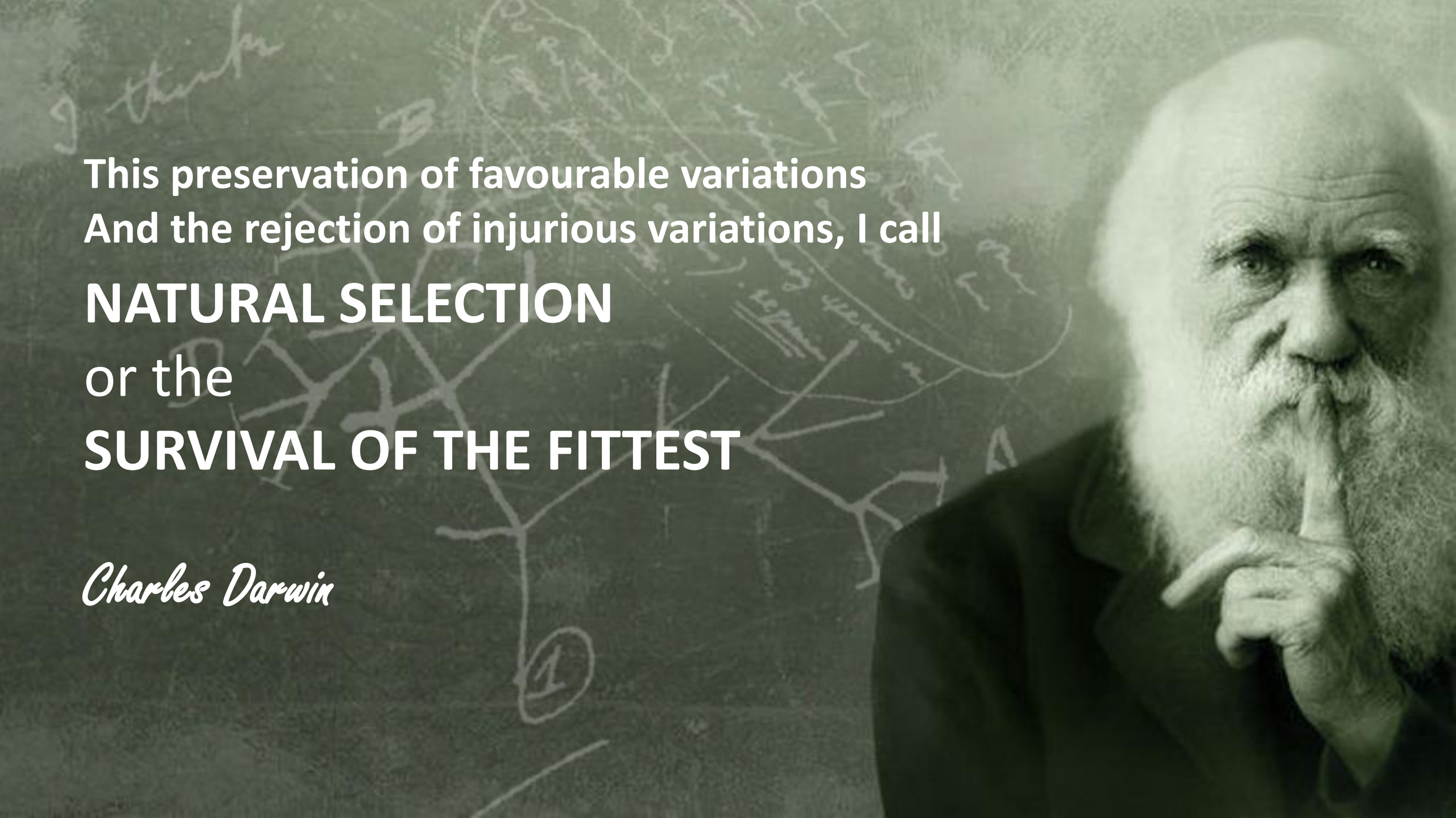
Multiple Cranes – Minimal Lift Score Solution





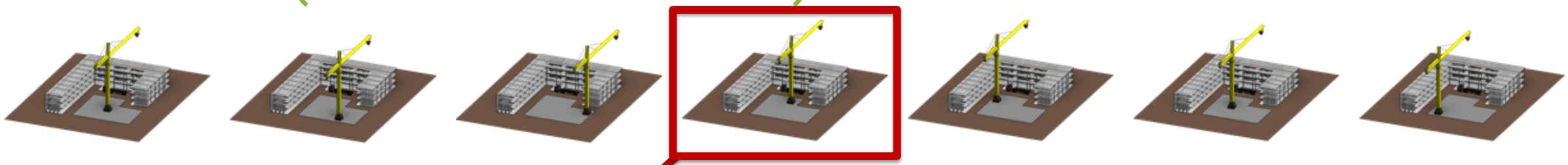


Genetic Optimization

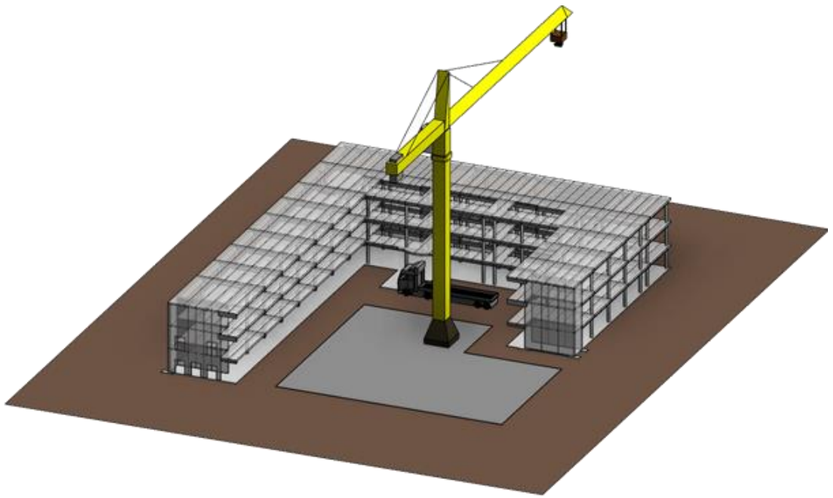

This preservation of favourable variations
And the rejection of injurious variations, I call
NATURAL SELECTION
or the
SURVIVAL OF THE FITTEST
Charles Darwin

Genetic Optimization of Crane Positions

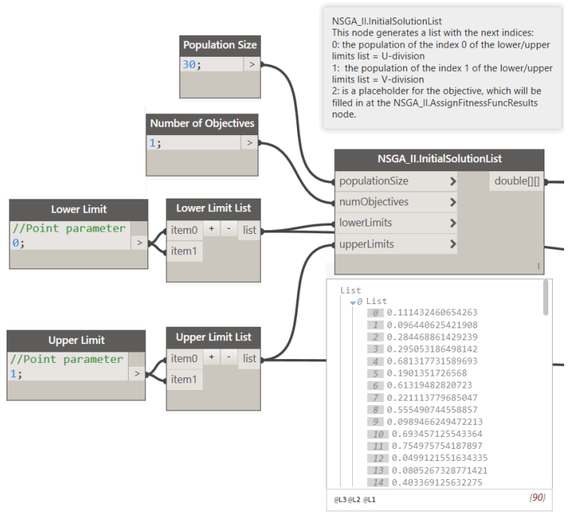
POPULATION (= initial set of solutions)



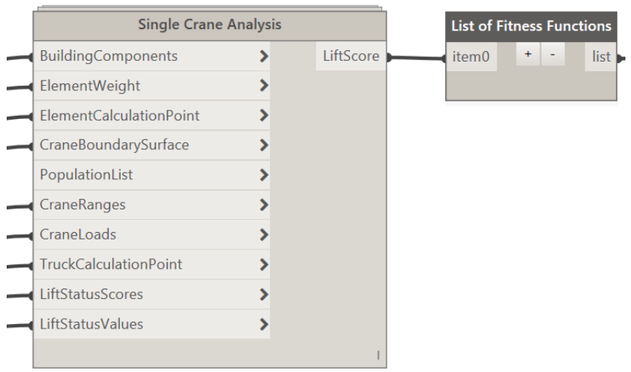
PHENOTYPE



GENOTYPE



FITNESS FUNCTION



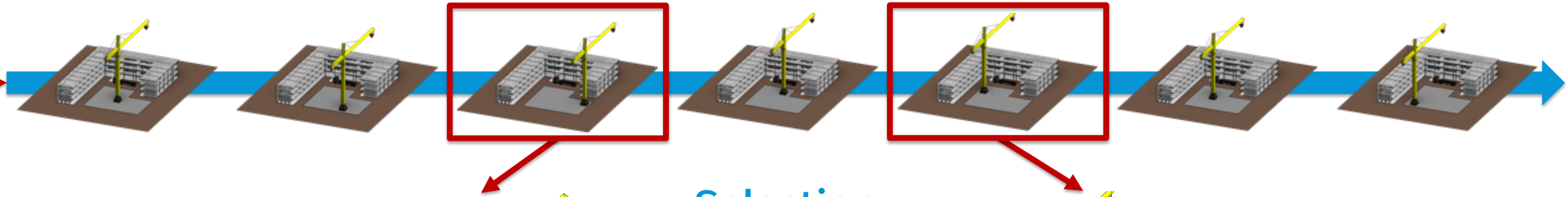
Situation Shape

Parameters

Evaluation

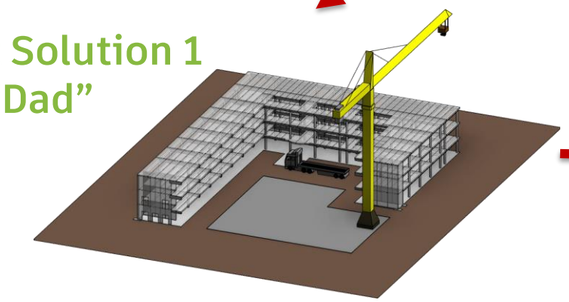
Genetic Optimization of Crane Positions

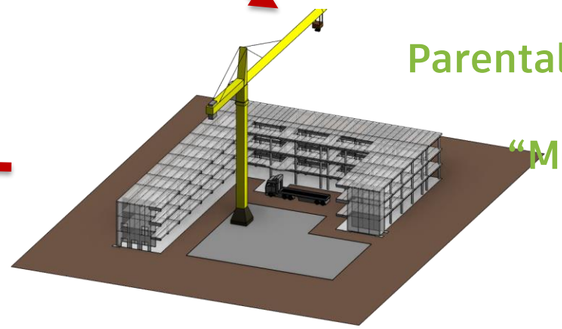
EVOLUTION



Parent Solution 1
"Dad"

Selection

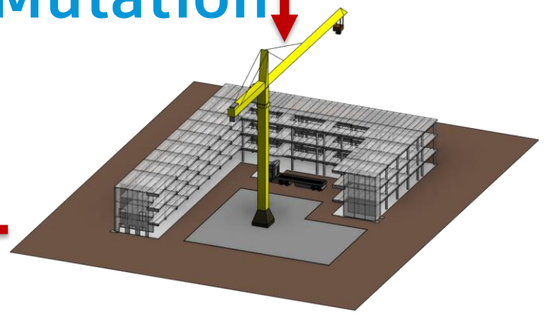




Parental Solution
2
"Mom"

Iterate
Generations

Cross Over
Mutation



Child Solution
"Baby"

Evaluation
Insert to the
population

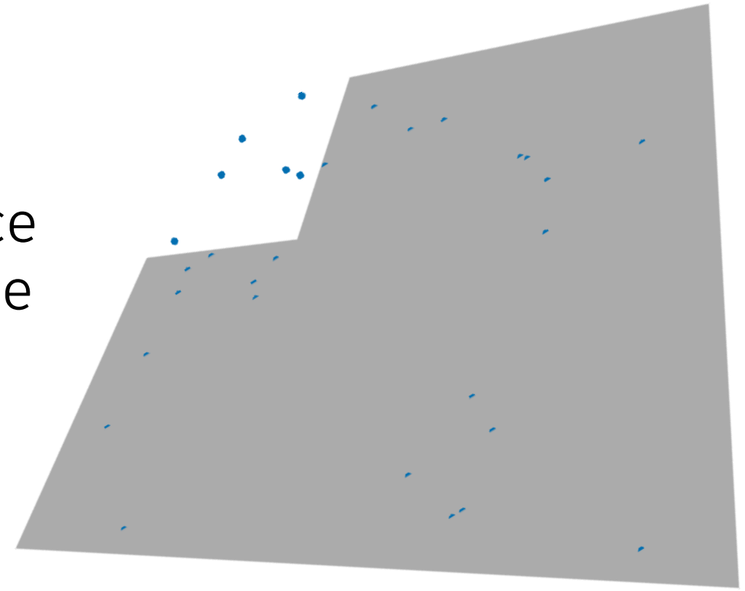
Representation of Optimization Problem

Objective:

- Minimal Lift Score

Design Variables:

- U-parameter for point at surface
- V-parameter for point at surface



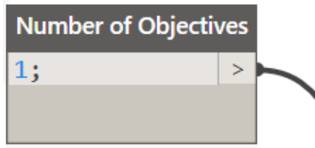
Design Variable Domain :

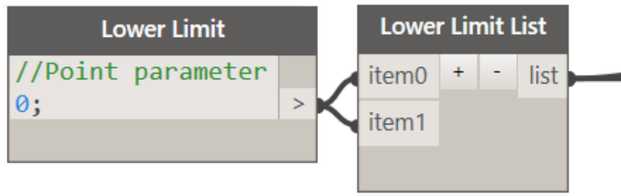
- $0 \leq U \leq 1$
- $0 \leq V \leq 1$

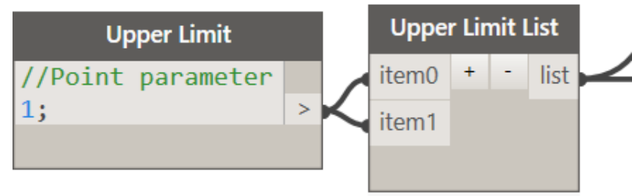
Constraints:

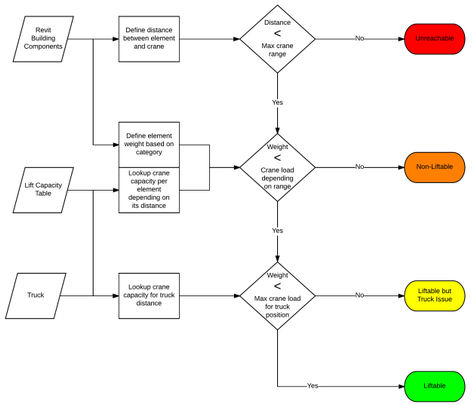
- Defined by the Crane Analysis Flowchart





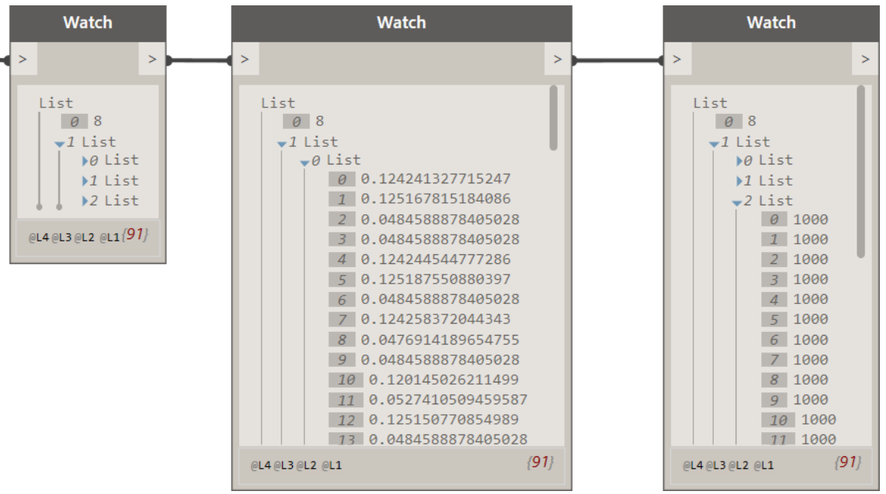


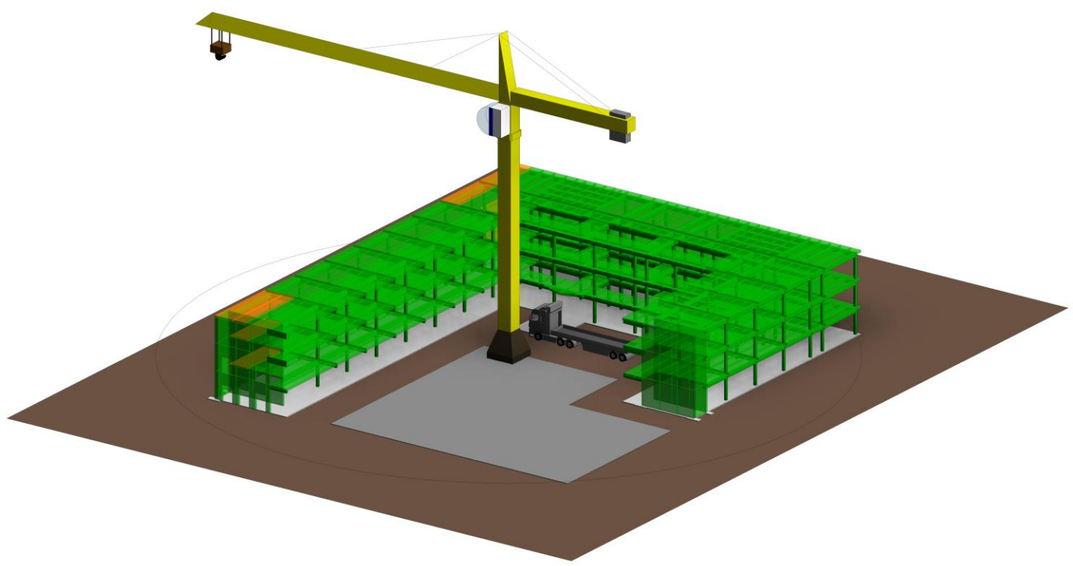


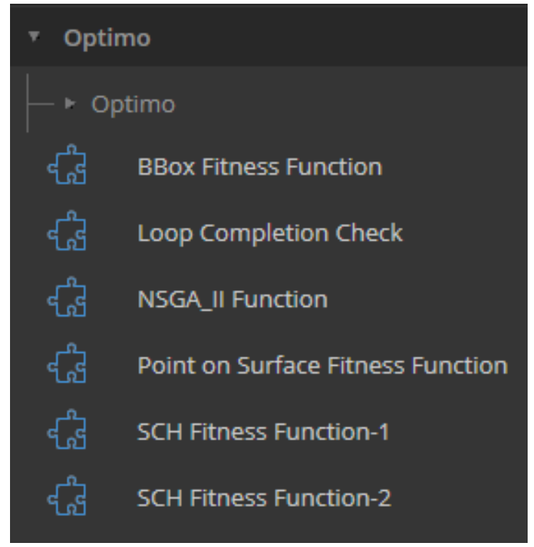


Genetic Optimization of Single Crane Position

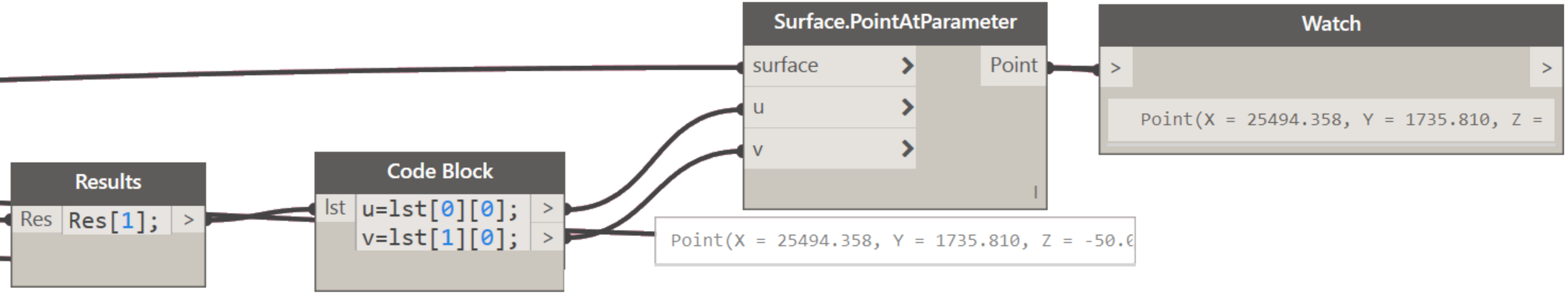
PARETO OPTIMAL

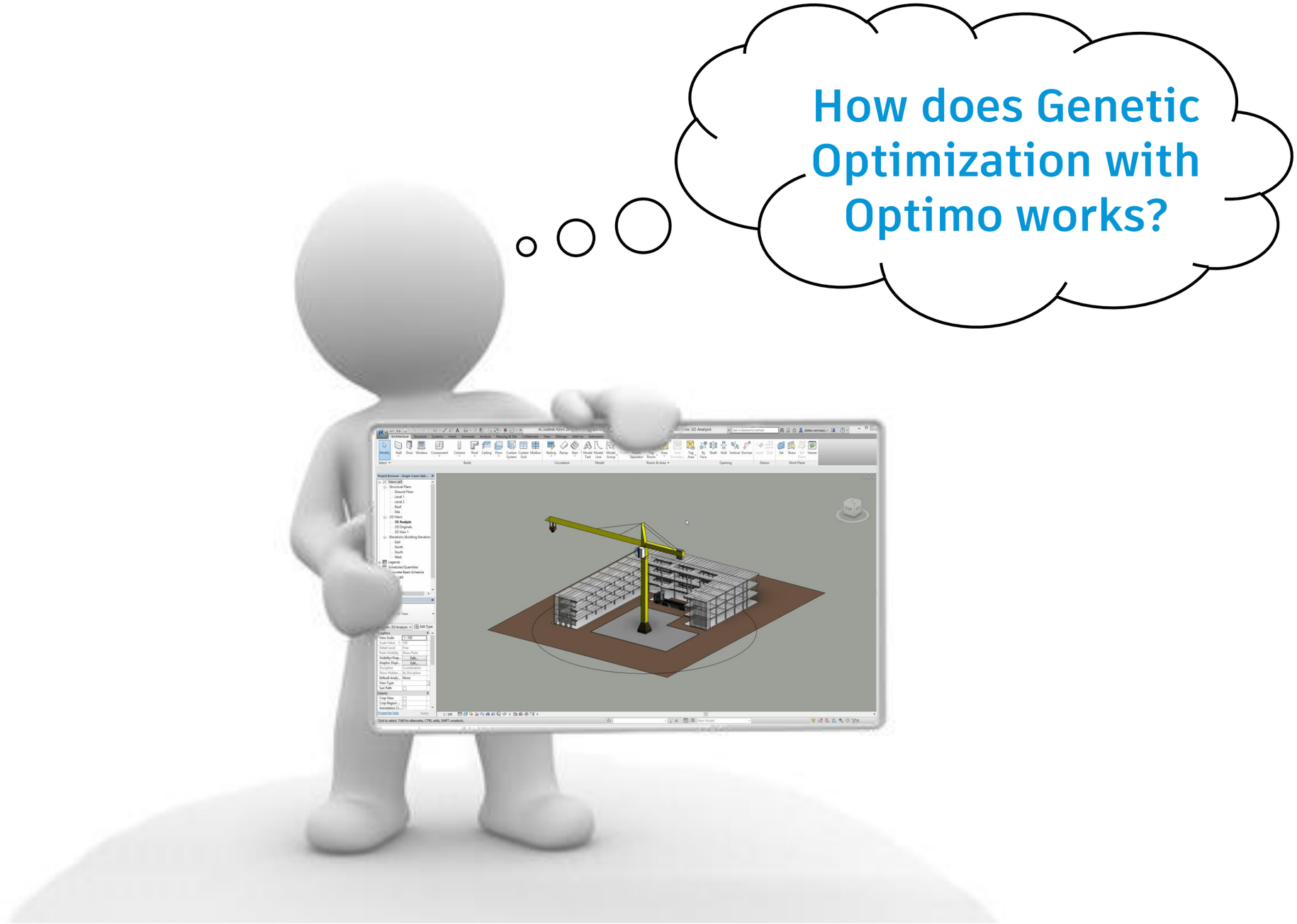






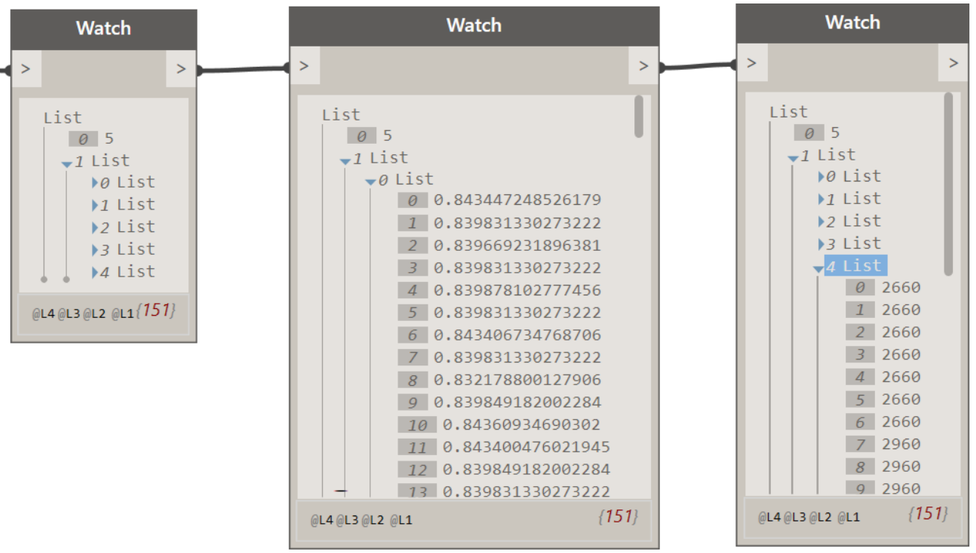
NSGA-II technology with **Optimo** package

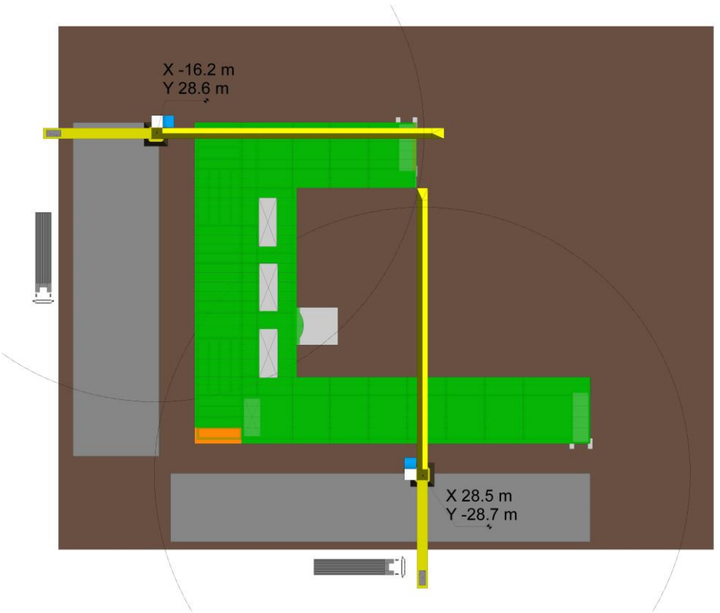


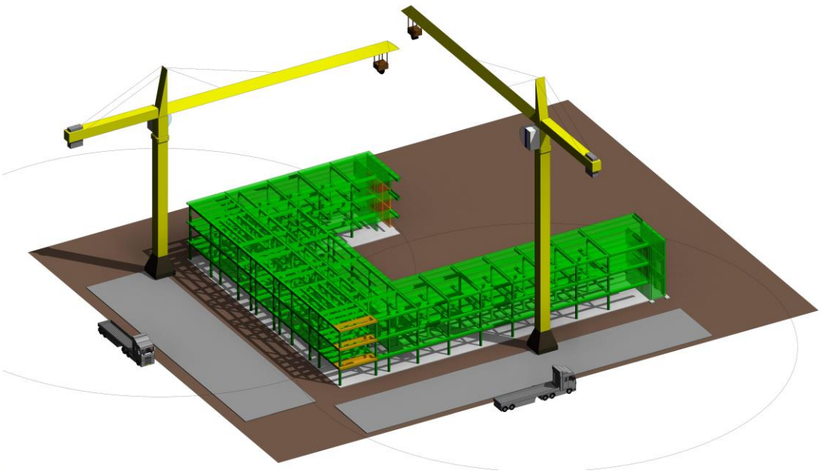

How does Genetic Optimization with Optimo works?

Genetic Optimization of Double Crane Position

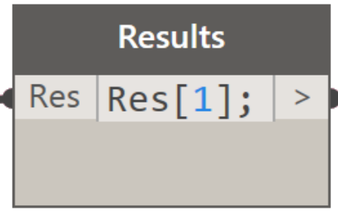
PARETO OPTIMAL



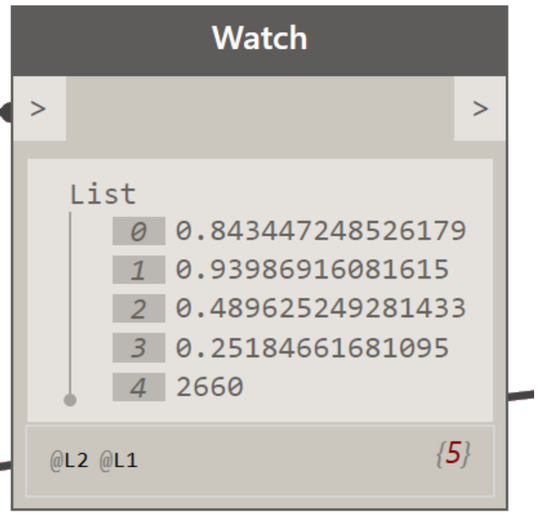




As all results are practically the same, take index [0];



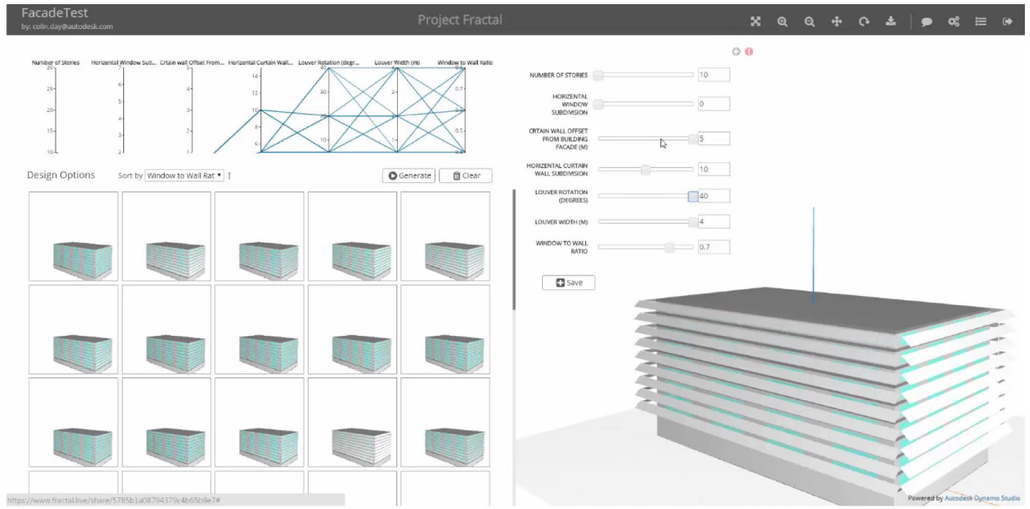




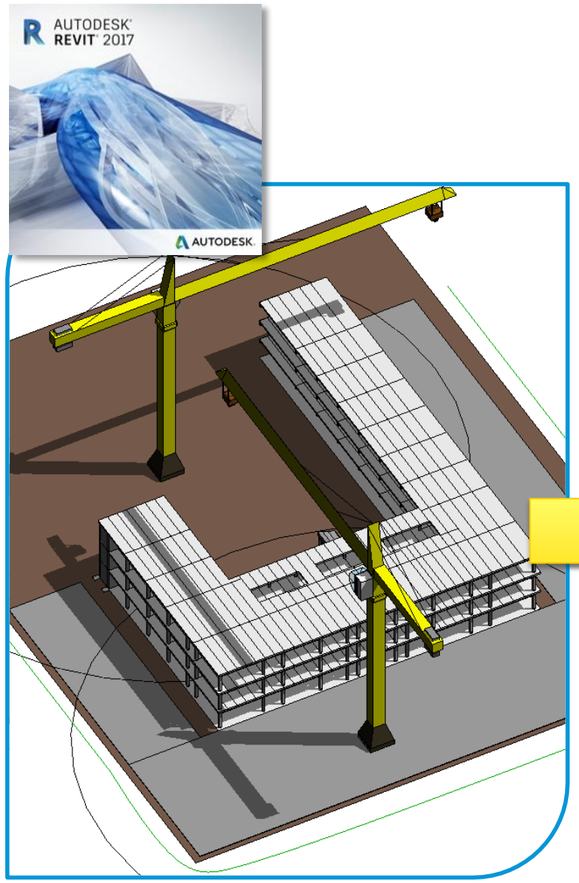
Crane Layout Exploration with Project Fractal

What is Project Fractal

- Alpha version of computational design in cloud
- Explore the parametric design space
- Reads from Dynamo **Studio**
- Automatic generation of samples
- Extension of “Project Akaba”
- Follow us on @Fractal_live

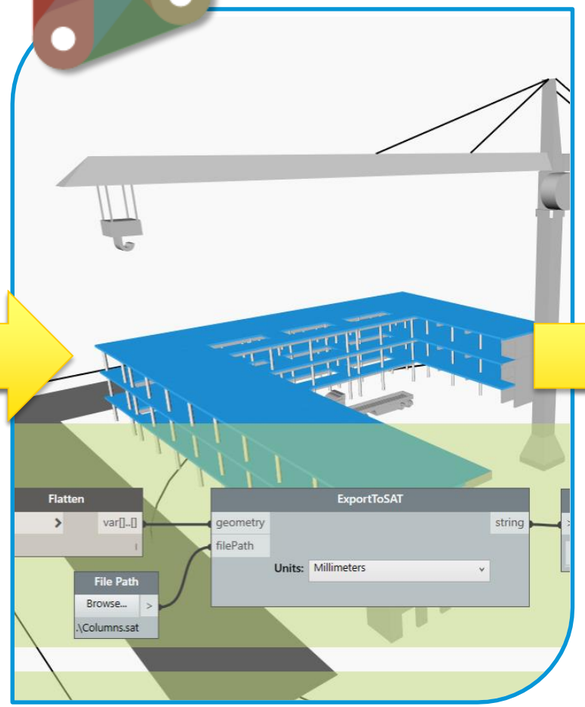


Crane Optimization with Fractal



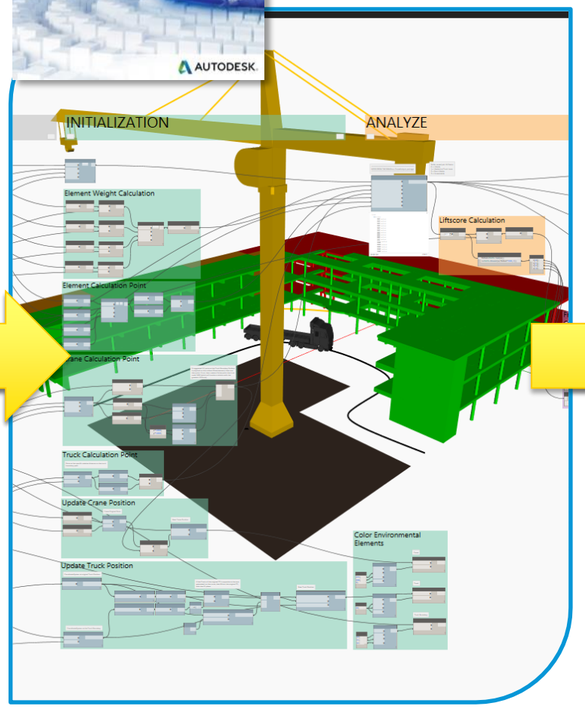
Create model with crane & truck





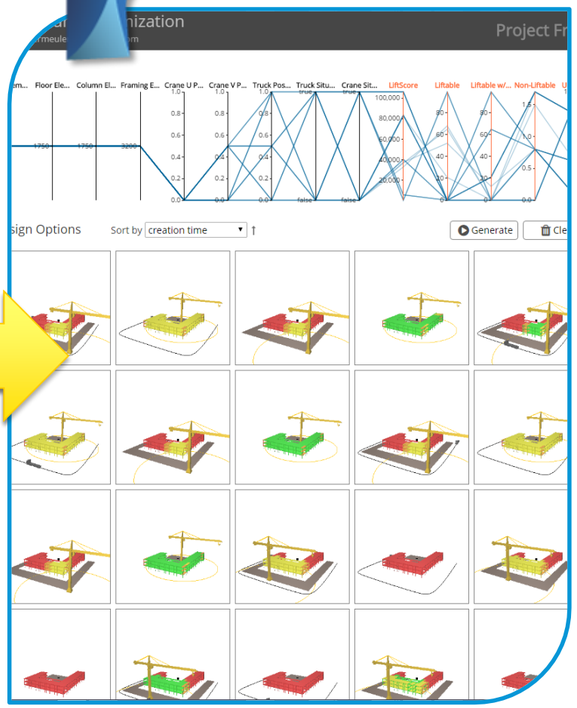
Export to separate SAT files





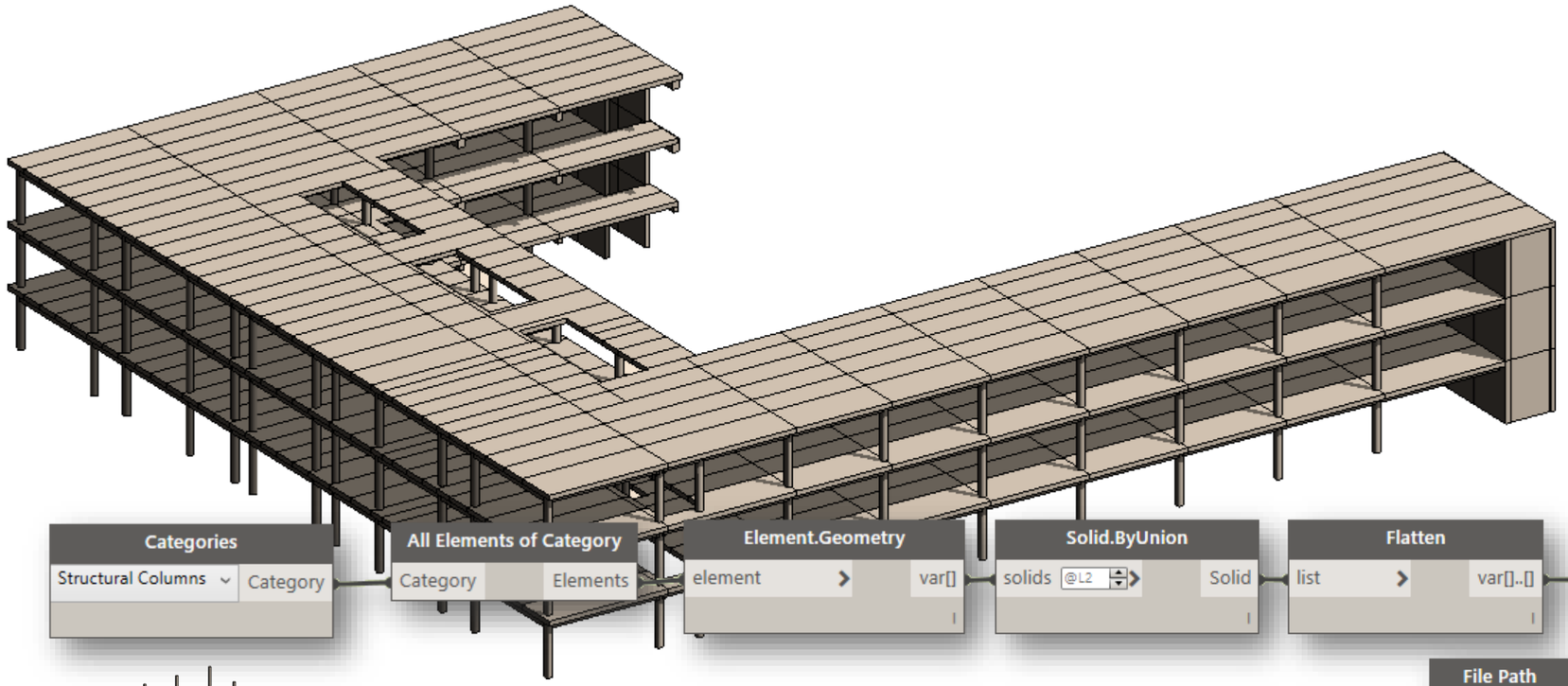
Import geometry Crane Analysis

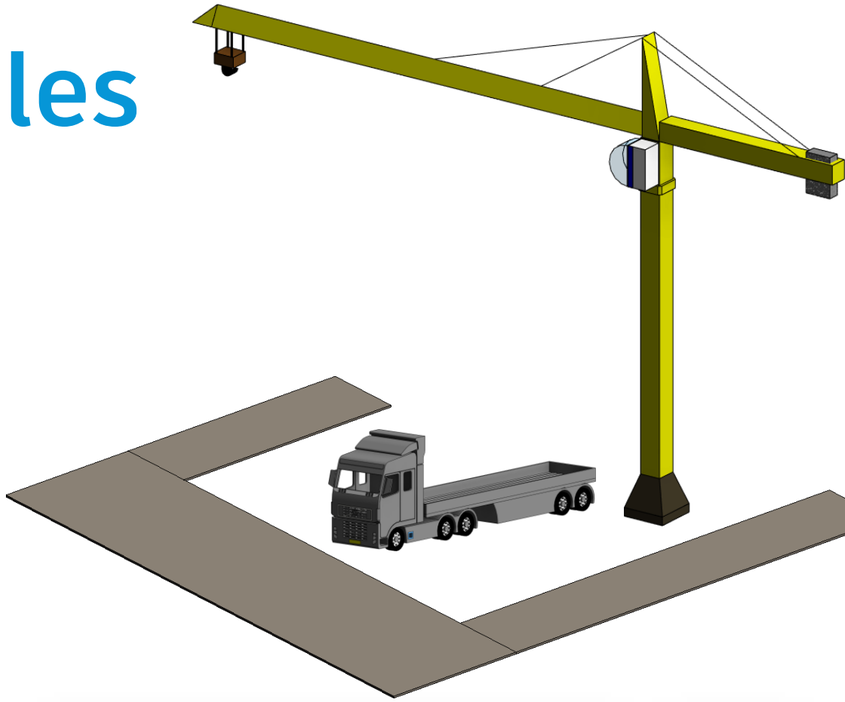


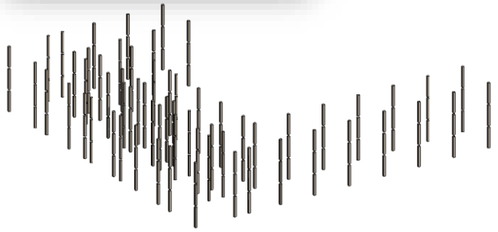


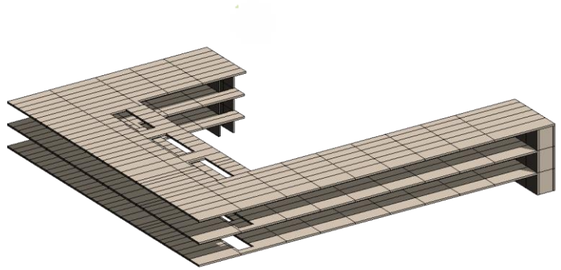
Optimize analysis

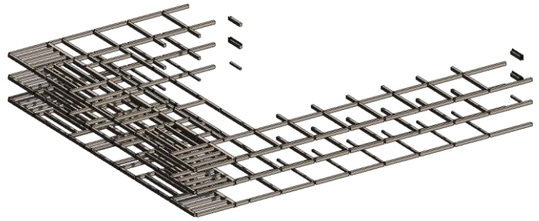
Break up model in separate SAT files

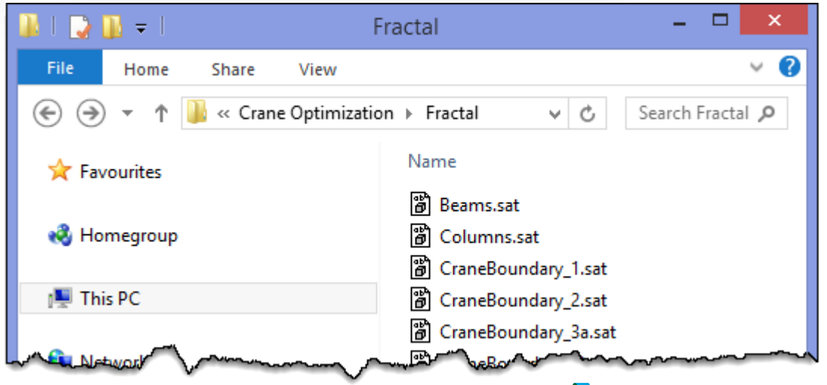








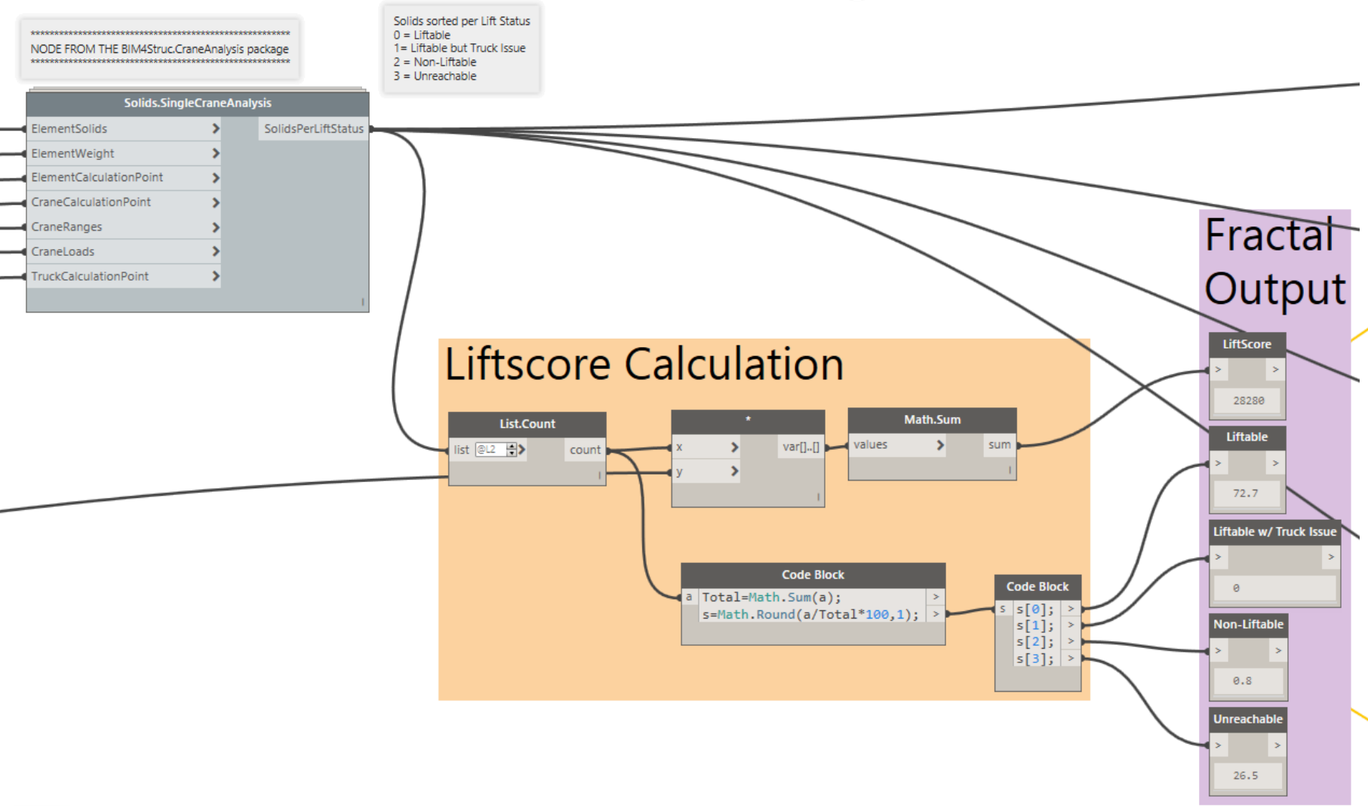


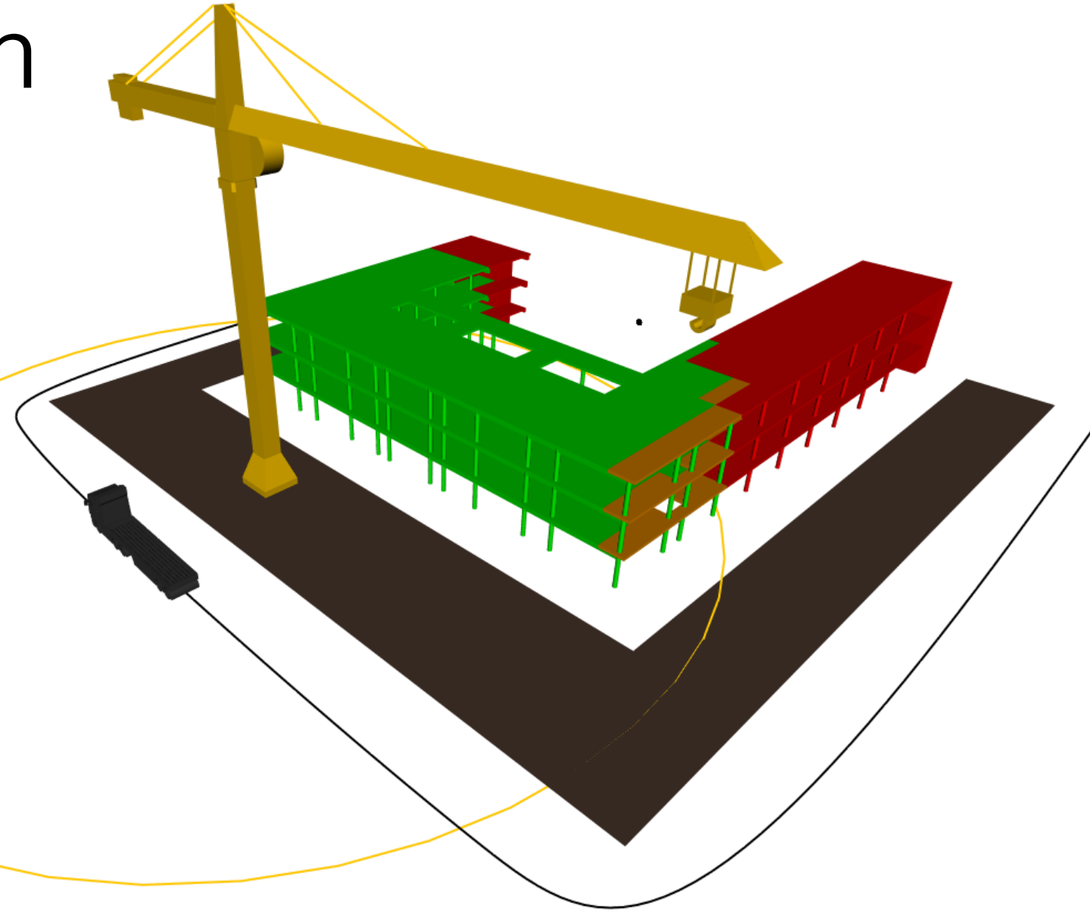


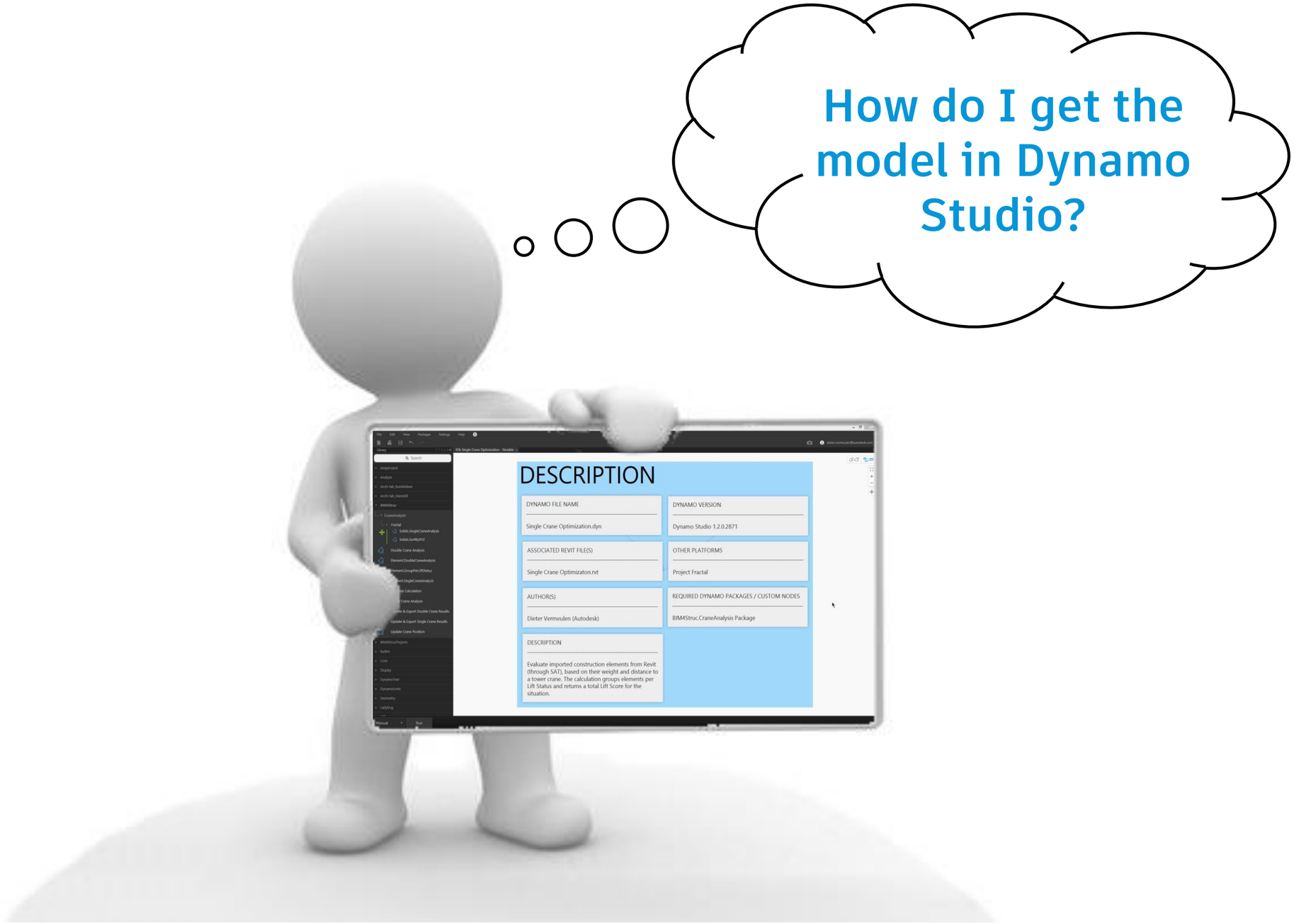
Dynamo Studio 2017



- Stand-alone environment
- Manual design exploration

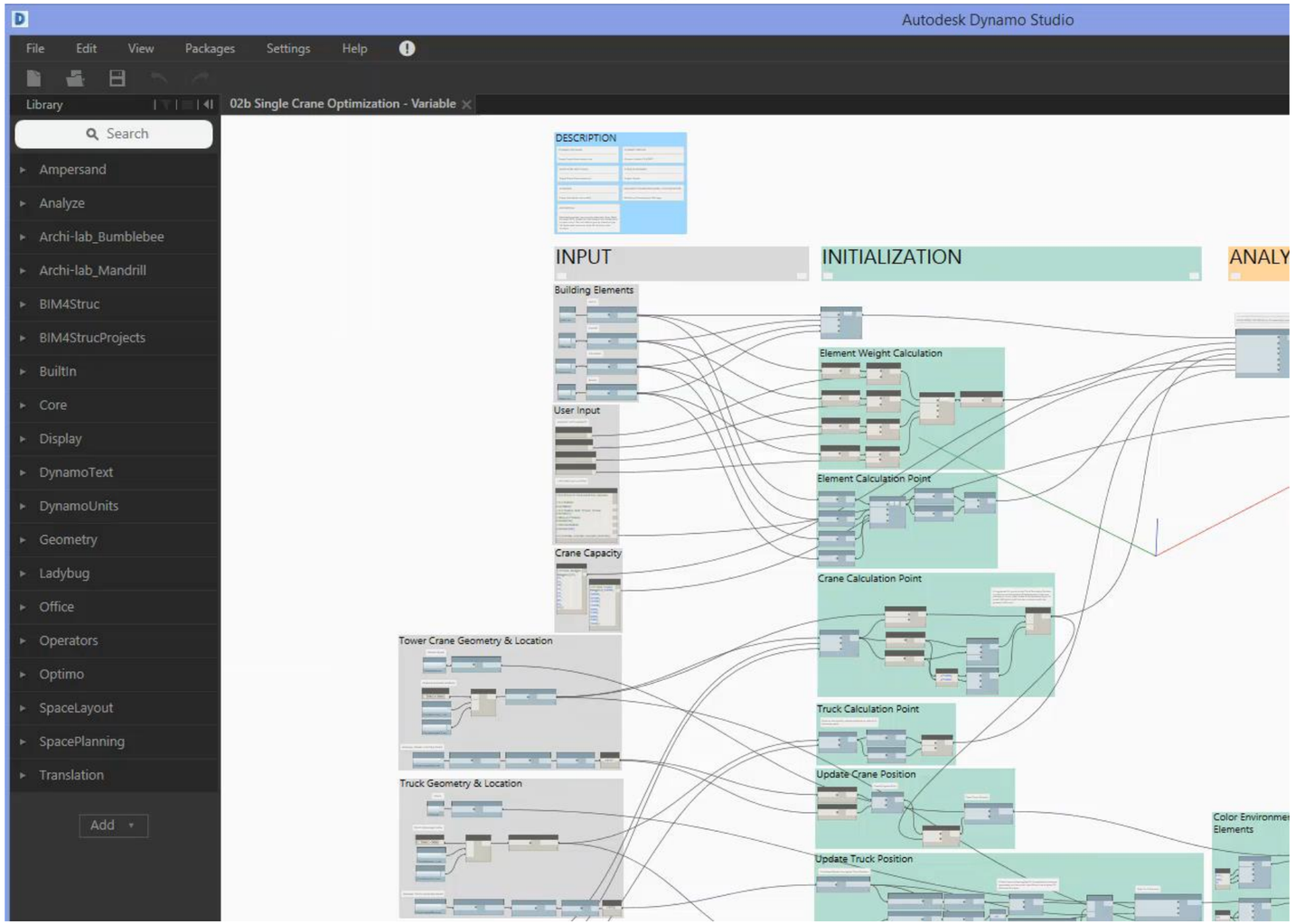


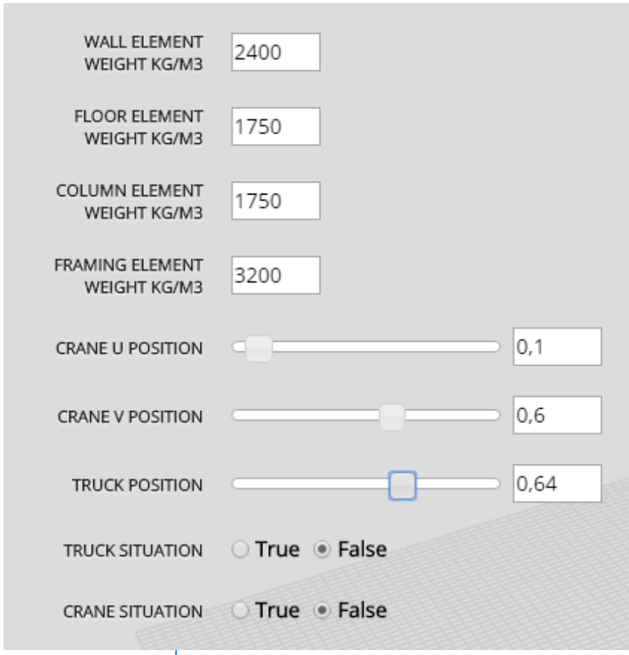


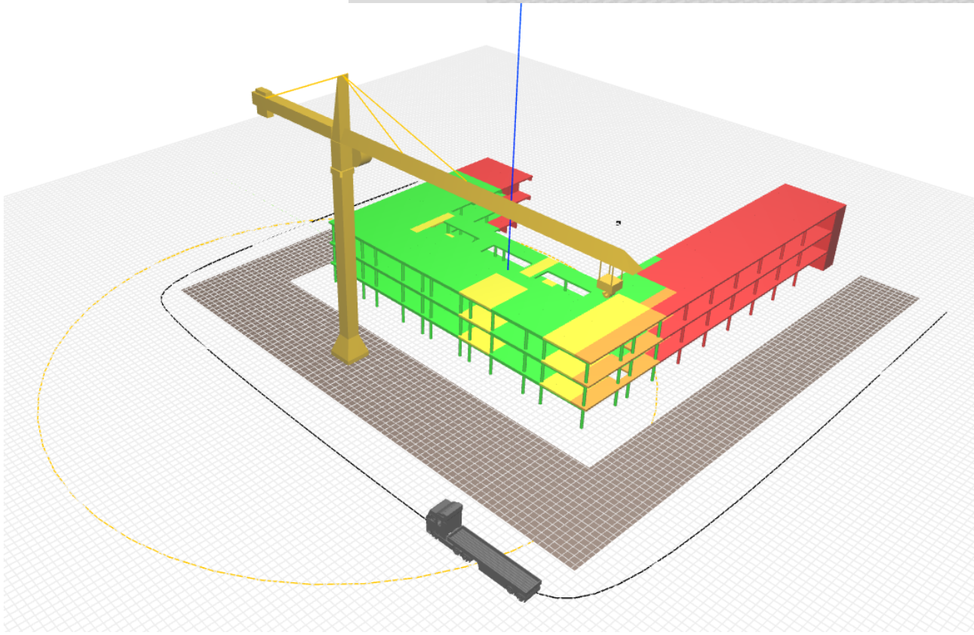

How do I get the model in Dynamo Studio?
DESCRIPTION
DYNAMO FILE NAME
Single Crane Optimization.dyn
DYNAMO VERSION
Dynamo Studio 1.2.0.2871
ASSOCIATED REVIT FILE(S)
Single Crane Optimizaton.rvt
OTHER PLATFORMS
Project Fractal
AUTHOR(S)
Dieter Vermeulen (Autodesk)
REQUIRED DYNAMO PACKAGES / CUSTOM NODES
BIM4Struc.CraneAnalysis Package
DESCRIPTION
Evaluate imported construction elements from Revit (through SAT), based on their weight and distance to a tower crane. The calculation groups elements per Lift Status and returns a total Lift Score for the situation.

Dynamo Customizer

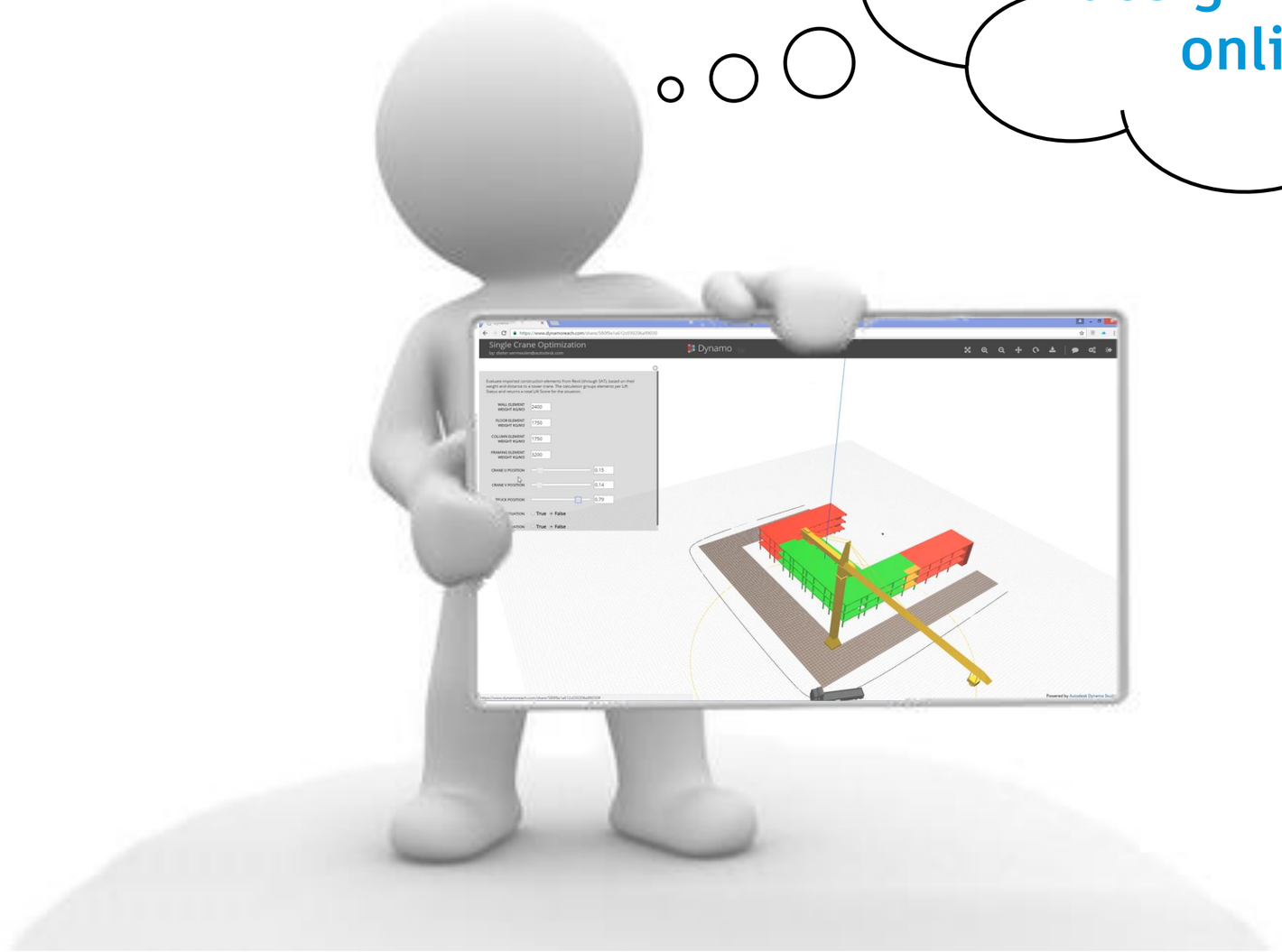
- Explore design on web platform





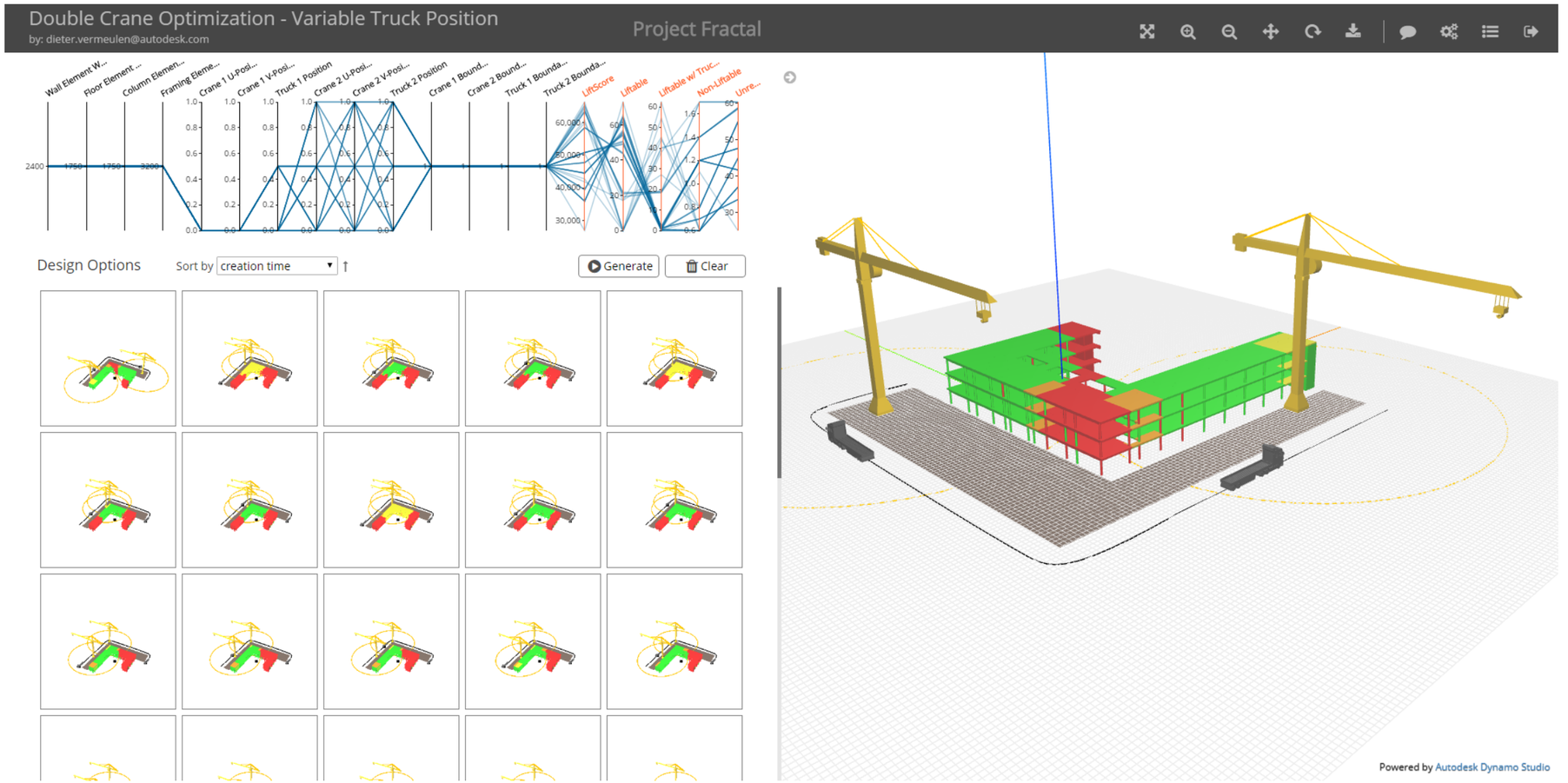


How can I explore design options online?



Project Fractal

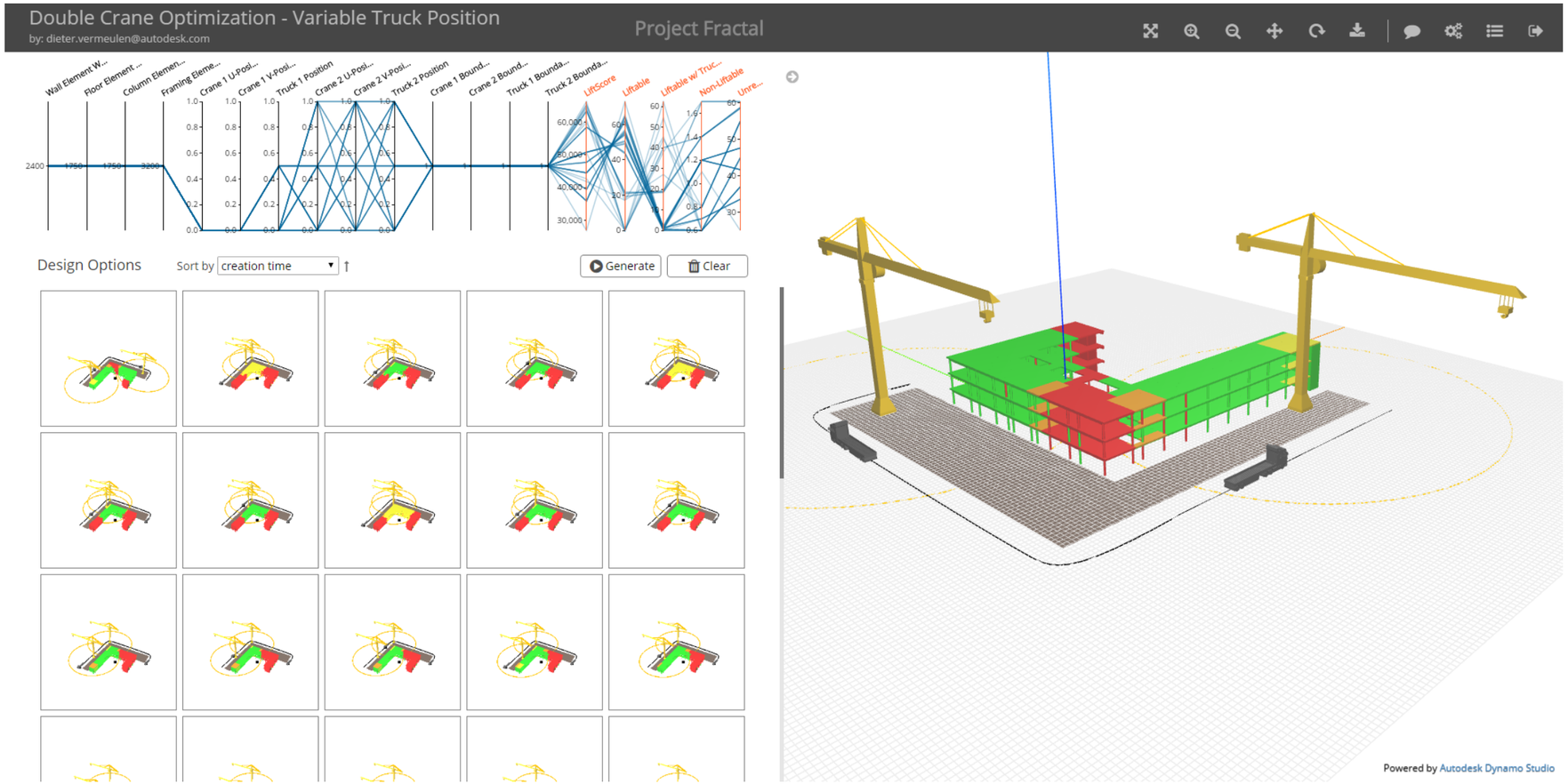
- Generate wide range of design options




Let’s explore the design variations!
Single Crane Optimization
Project Fractal
Design Options

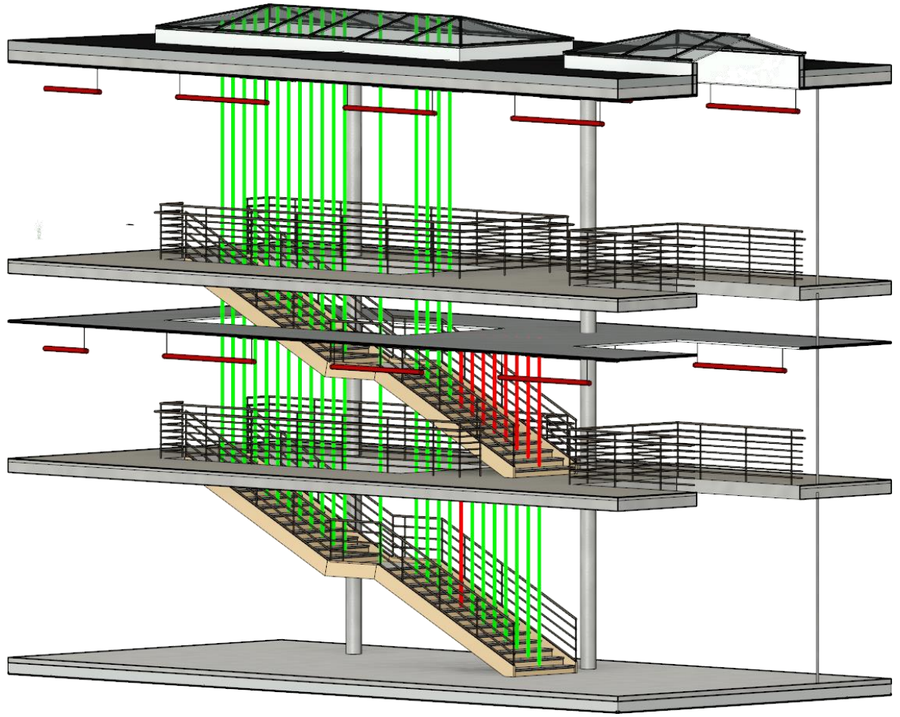
Other variations

- Variable Truck Position
- Variable Boundary Choices



Other Examples

Design Check & Automation

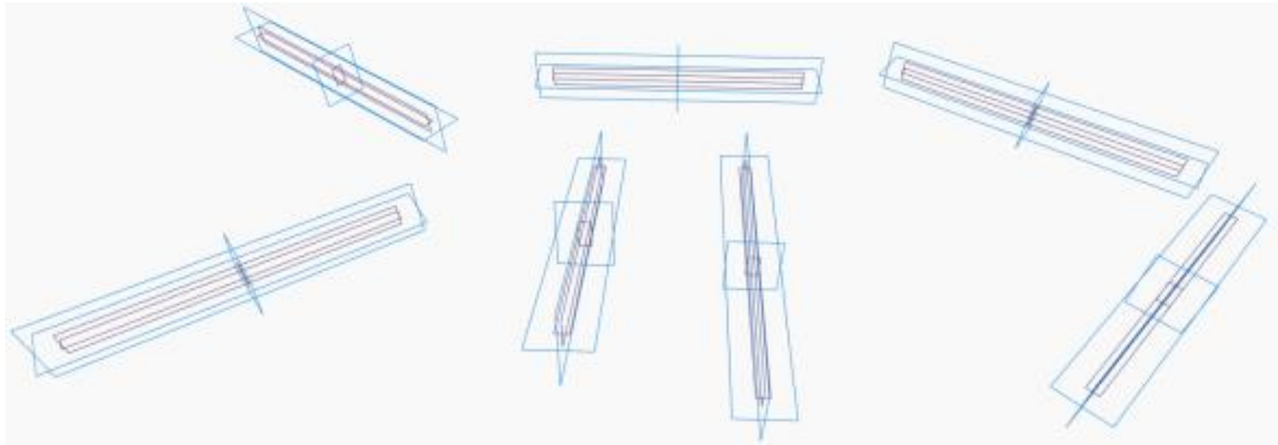


- Clearance Height on Stairs

  https://revitbeyondbim.wordpress.com/2016/05/26/clearance-height-on-stairs-watch-your-head/

- Automatic Element View Generation

  https://revitbeyondbim.wordpress.com/2015/10/15/automatic-element-view-generation-in-revit-with-dynamo-3/

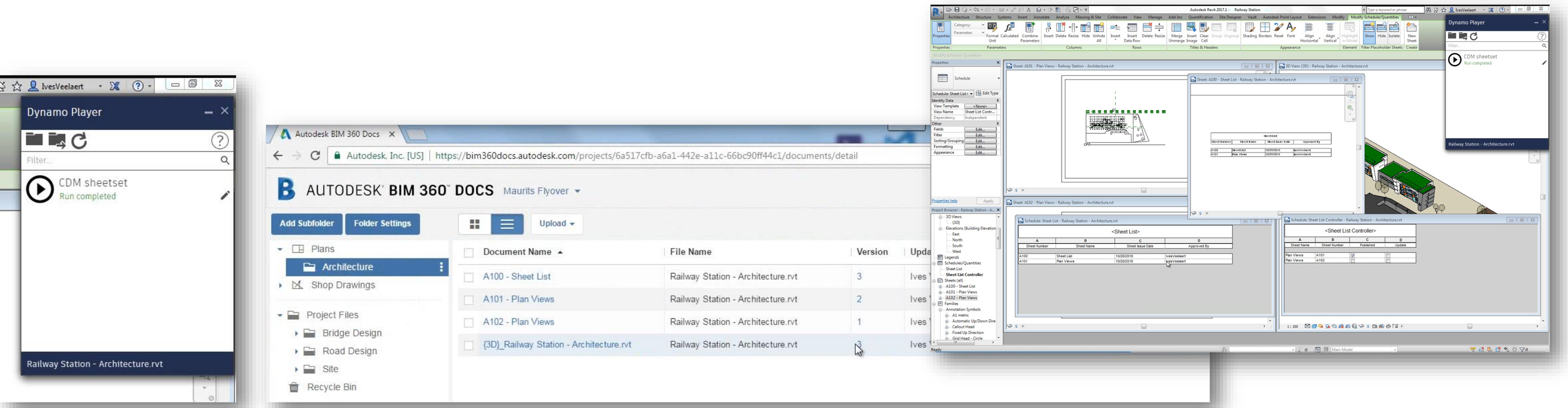


Concluding

Other classes with Dynamo & Construction

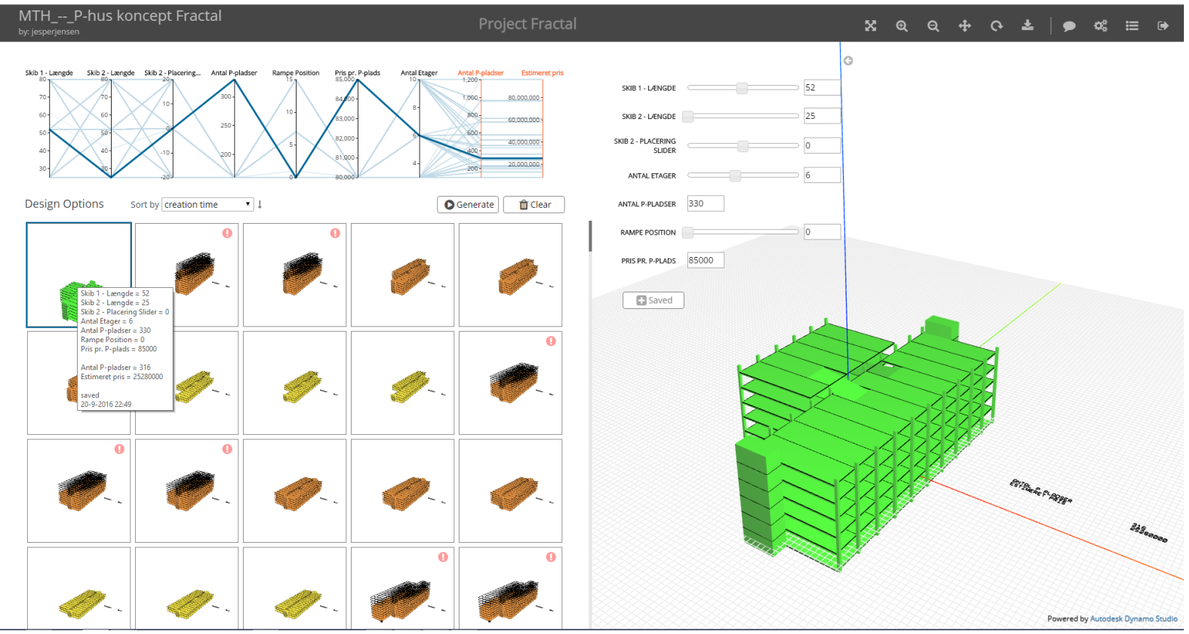
- CS21165 - Honey, Have You Seen My Construction Documents?

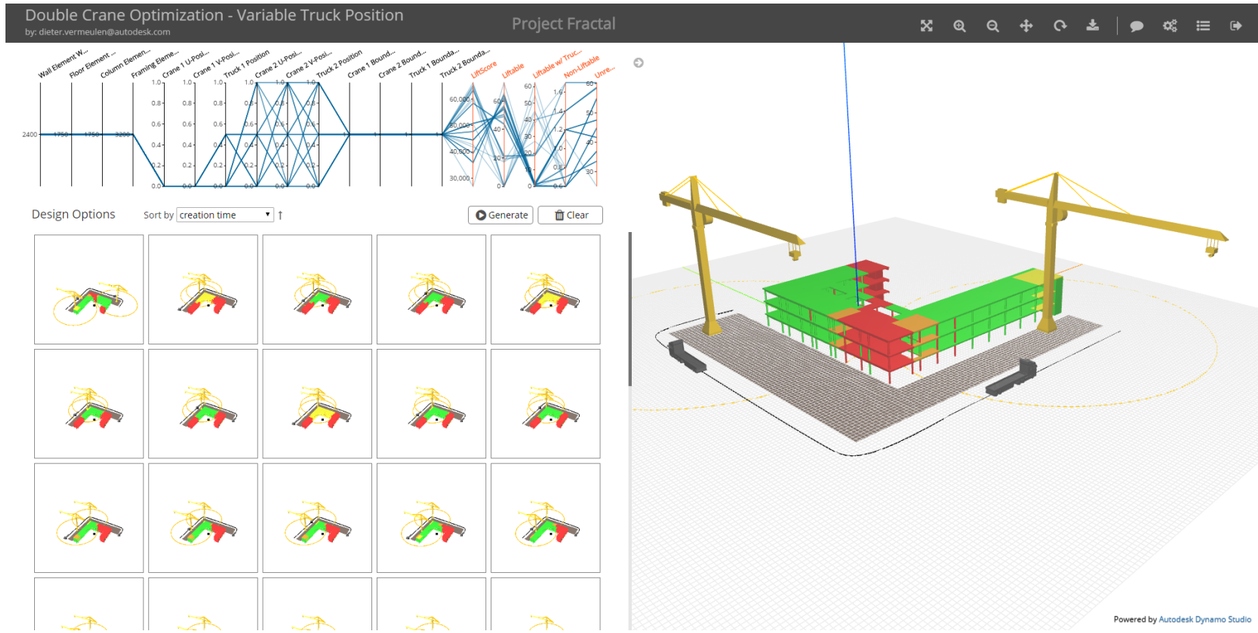
Wed 16th November : 3pm – 4pm



Project Fractal @ AEC Booth

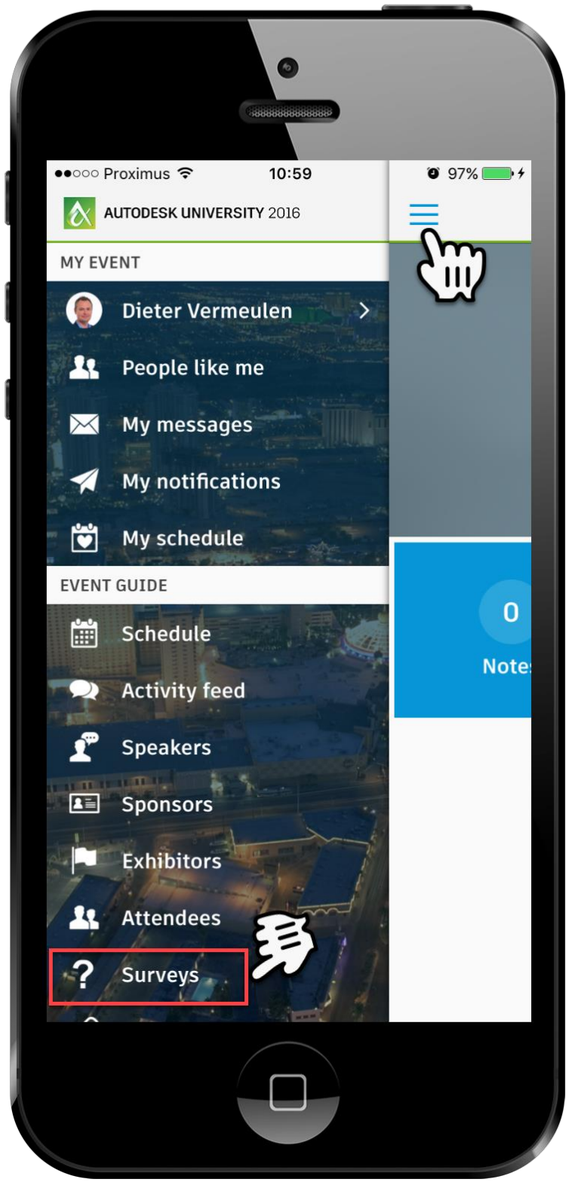
- See Fractal in action @ AEC Booth
- Hall B, Level 2 Exhibit Hall, Booth 1990
- **Thu 11:30am-1:00pm**





How did I do?

- Your class feedback is critical.
  Fill out a **class survey** now.
- Use the AU mobile app or fill out a class survey online.
- Give feedback after each session.
- AU speakers will get feedback in real-time.
- **Your feedback results in better classes and a better AU experience.**







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