From Design Automation to Generative Design in AEC

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AUTODESK UNIVERSITY

@BIM4Struc

About me

- Computational Design & Engineering
- Passionate about Generative Design in AEC
- +5 years at Autodesk
- Previous experience in structural engineering
- DJ QuSe @ Autodesk Events ☺ www.facebook.com/quse.dj

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www.linkedin.com/in/dietervermeulen

www.youtube.com/user/RevitbeyondBIM

www.revitbeyondbim.wordpress.com

www.autodesk.typepad.com/bimtoolbox/

AU Online Profile

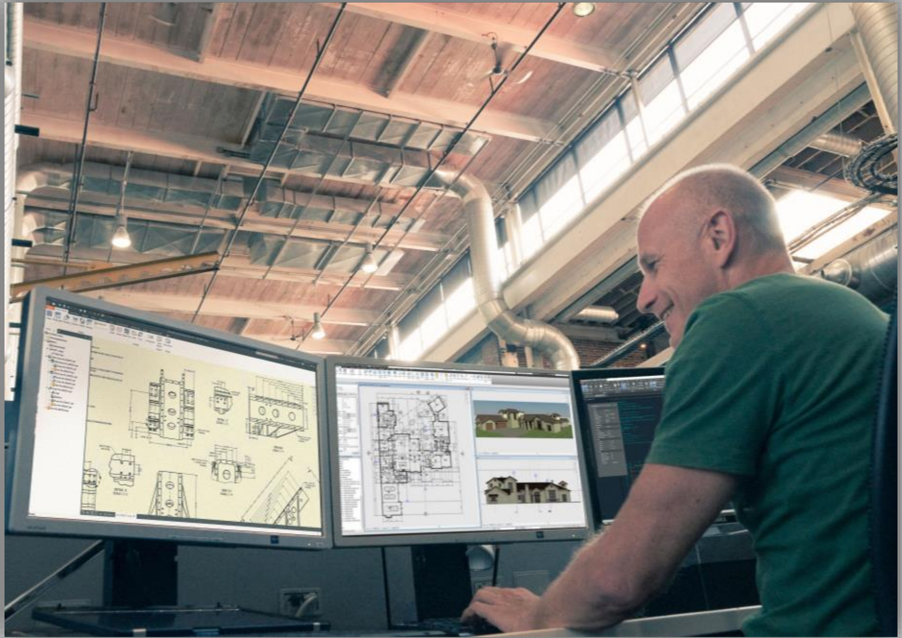
DEMOGRAPHIC CHANGES

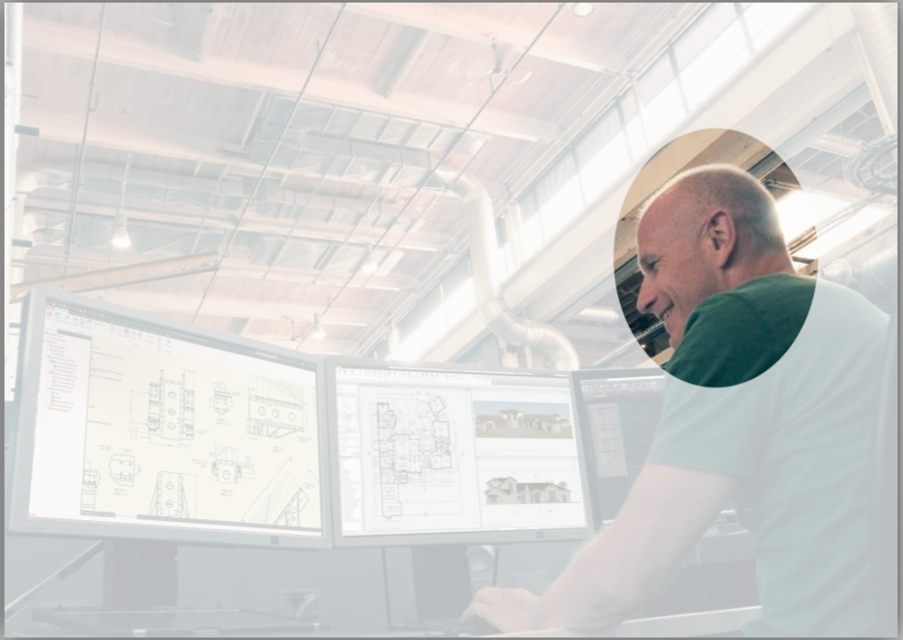

Number of Cities X2
200,000 people/day
About 13,000 buildings/day

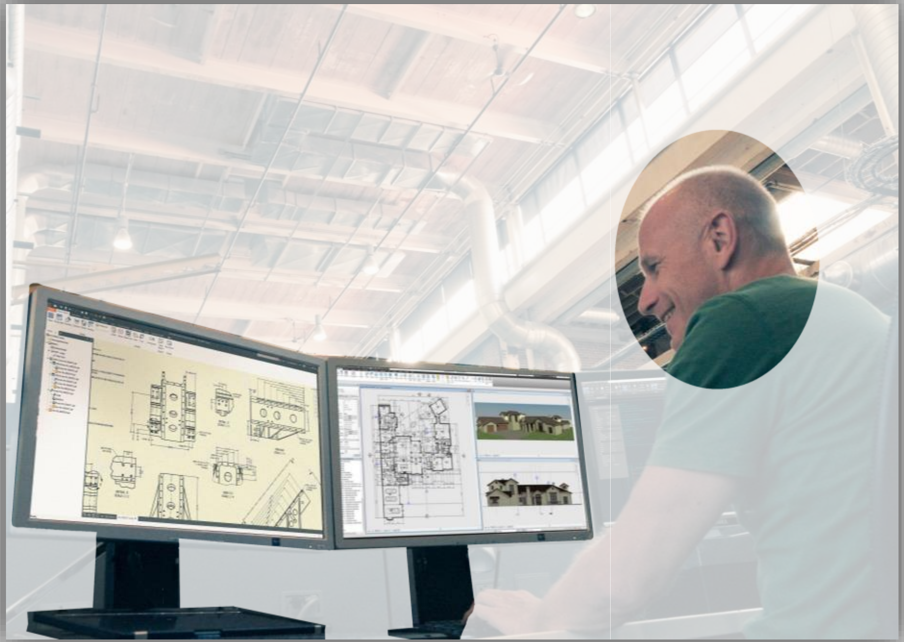

3,600
MORE BUILDINGS PER DAY


MORE
IS INEVITABLE
LESS
IS A REALITY
OPPORTUNITY OF
BETTER

DESIGNS TODAY

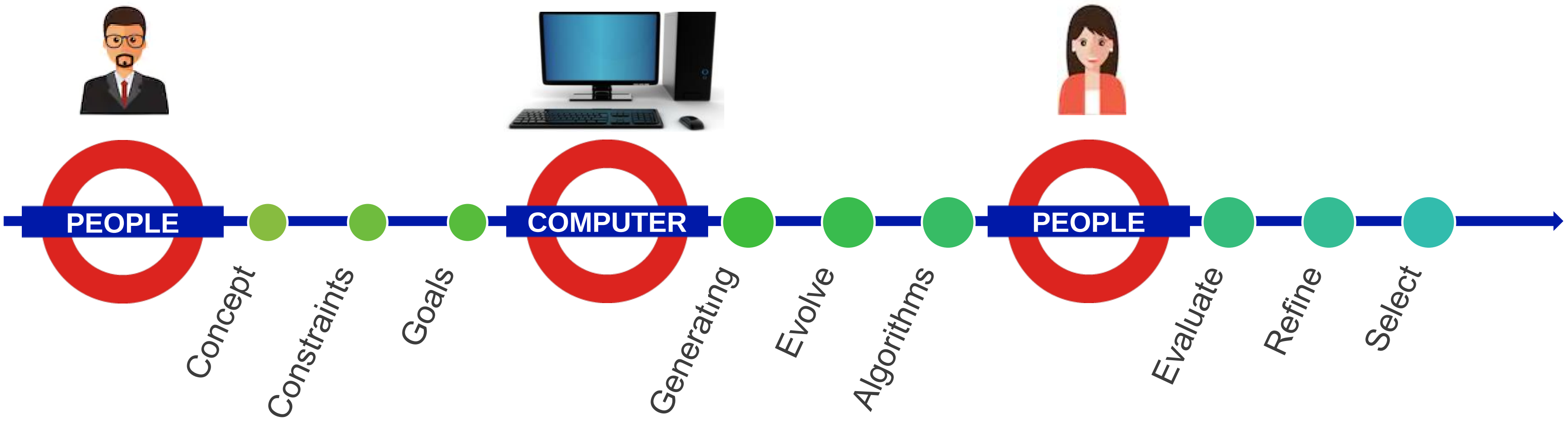






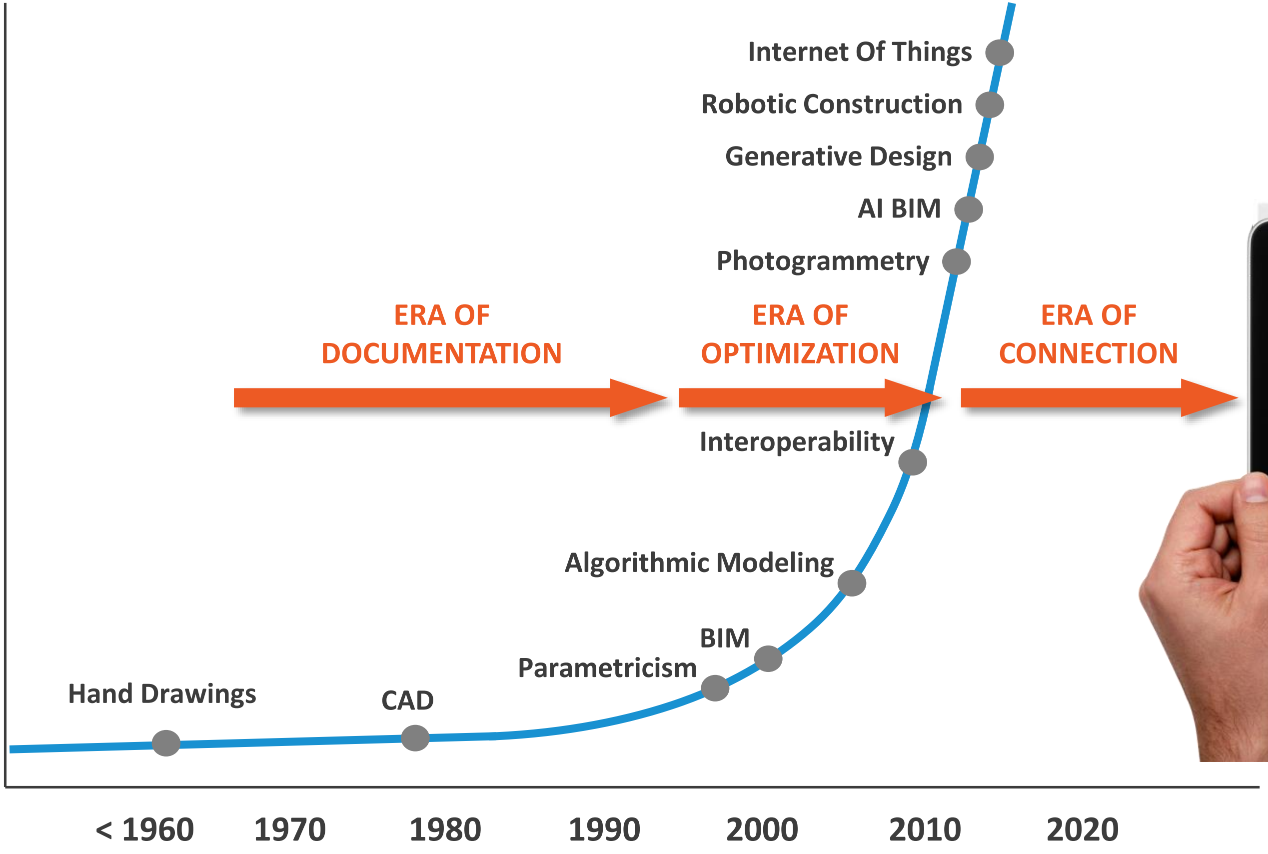
TRADITIONAL DESIGN PROCESS

GENERATIVE DESIGN PROCESS

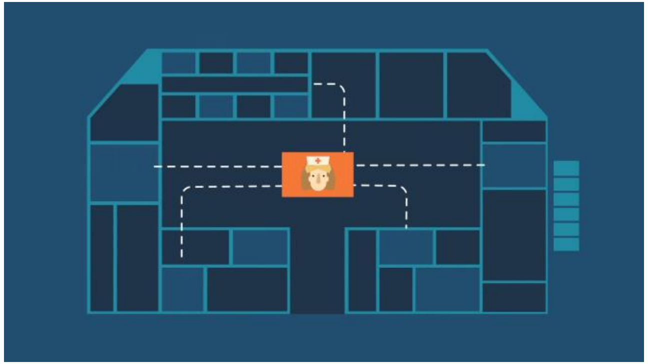


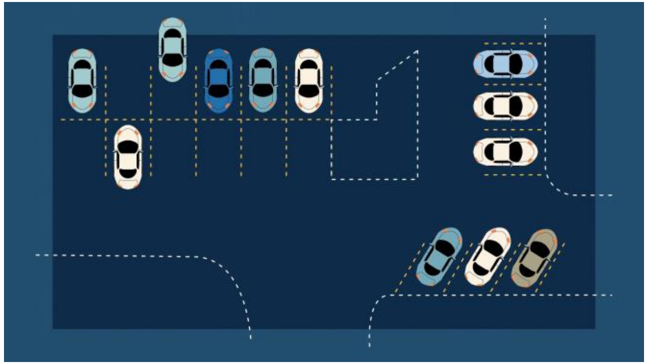
Generative design is a methodology and a process more than a singular product or tool

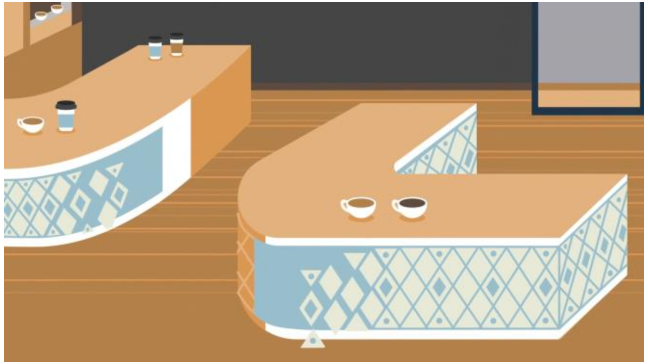
Accelerating Growth in AEC Technology



Generative Design in Architecture Gives Designers More Options… Faster



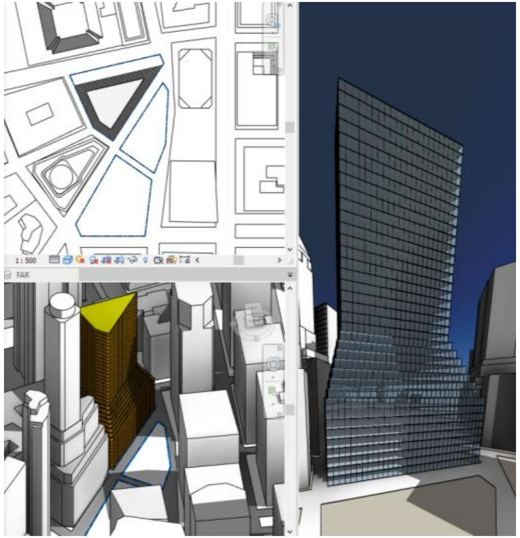




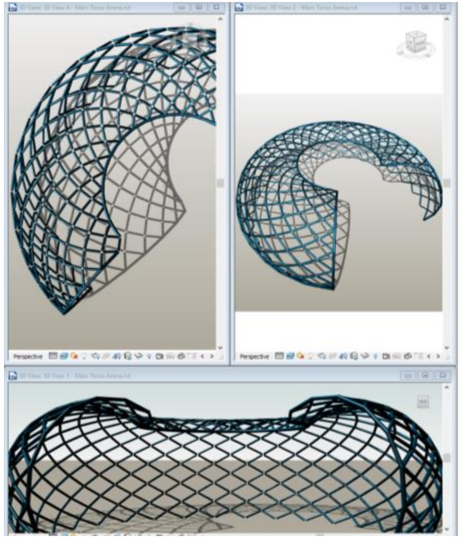
What level of design progression ?

Cases

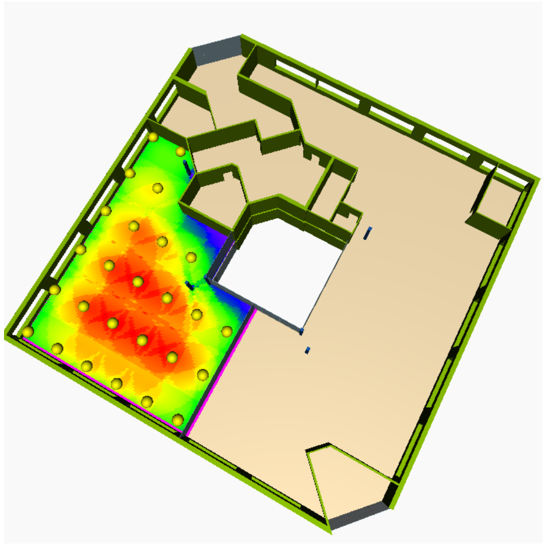
Conceptual Tower Mass



Structure Waste Optimization

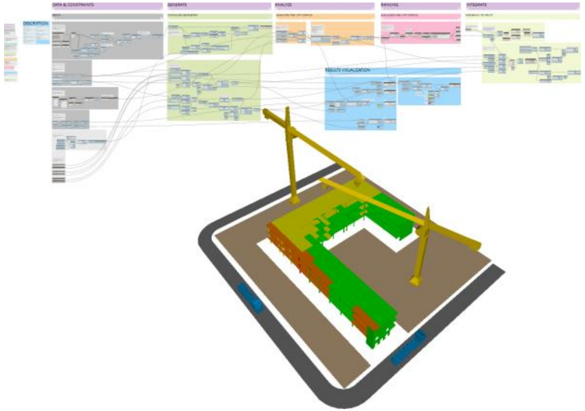


Light Distribution

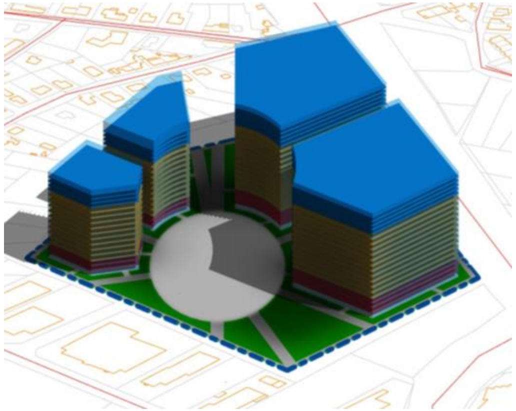


More Cases

Tower Crane Positioning



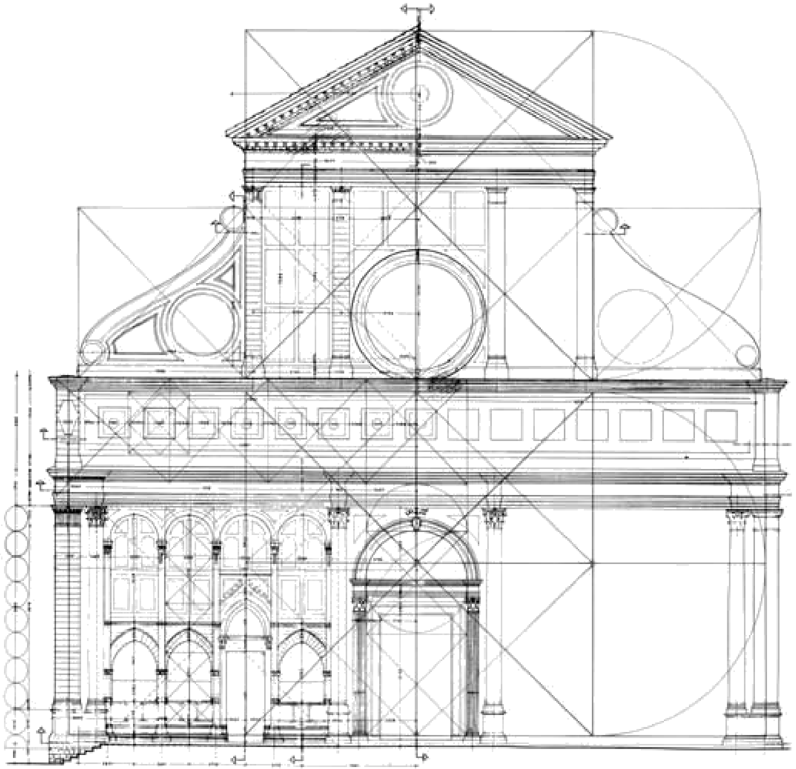
Urban Planning

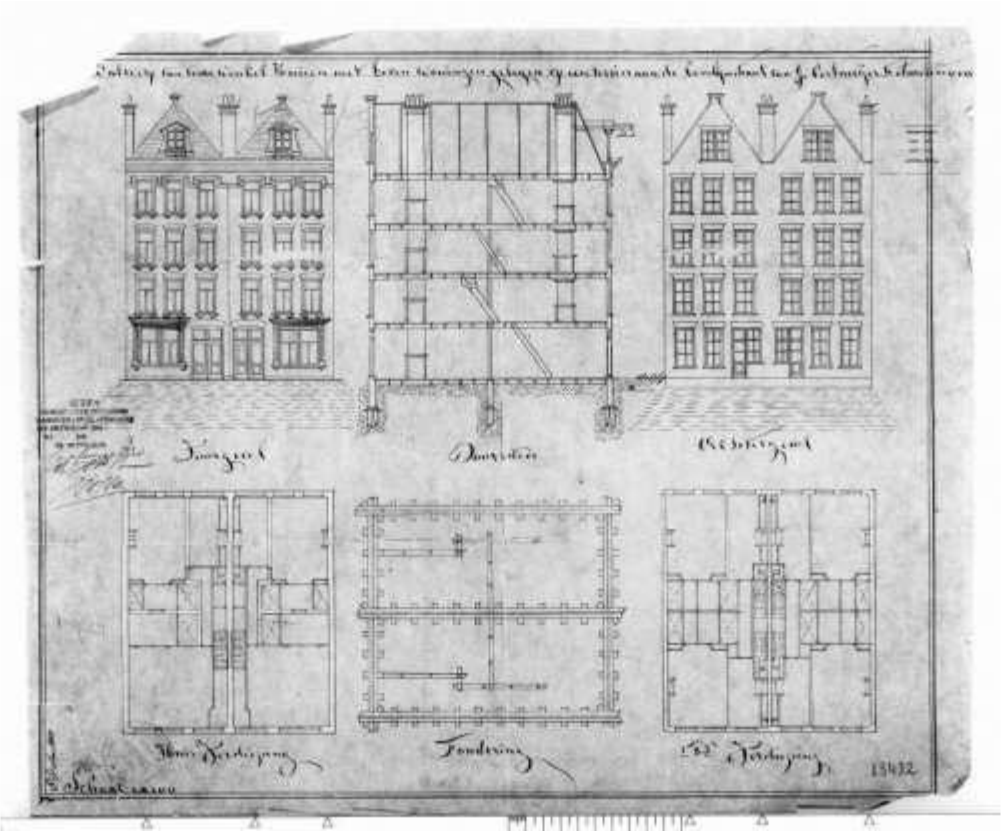


Parking Layout

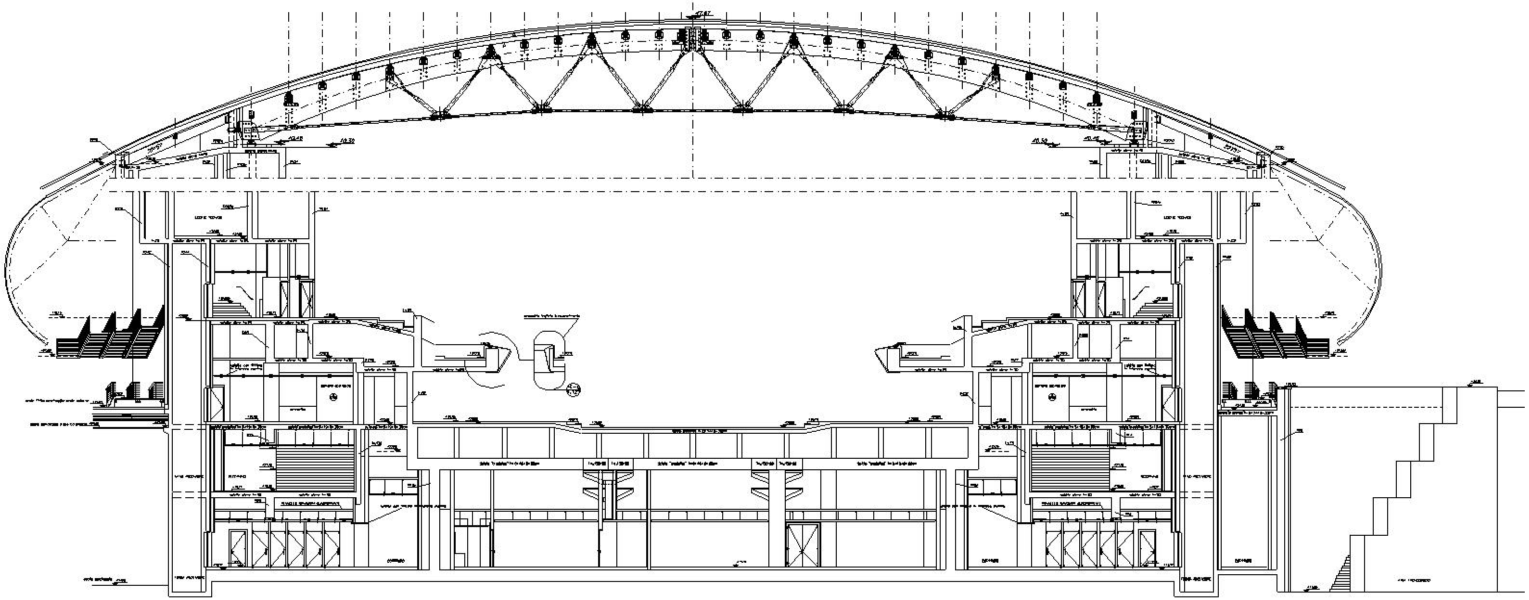
Traditional Design

Sketching





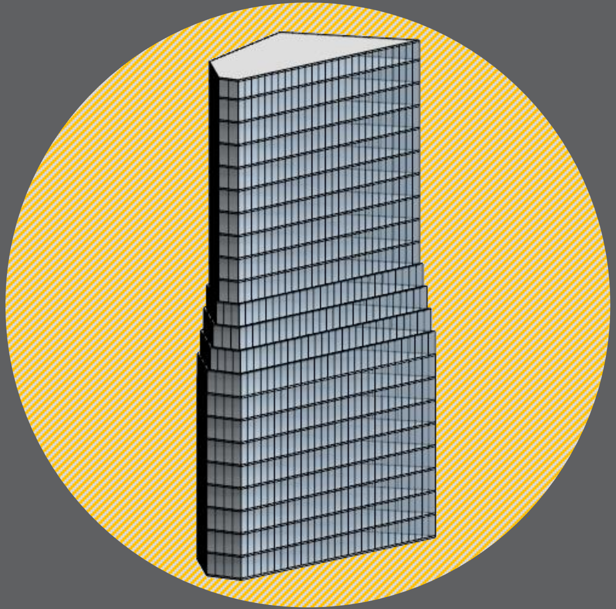
Computer Aided Drafting



Parametric Design

PARAMETRIC DESIGN

Designer/engineer uses computer as passive machine



one human + one computer = limited design

Parametric Modeling

Parametric Modeling

$$a = 2$$

$$b = 1$$

$$a - b = c$$

Parametric Modeling

$$a = 2$$

$$b = 1$$

$$a - b = c$$

f(x)

Parametric Modeling

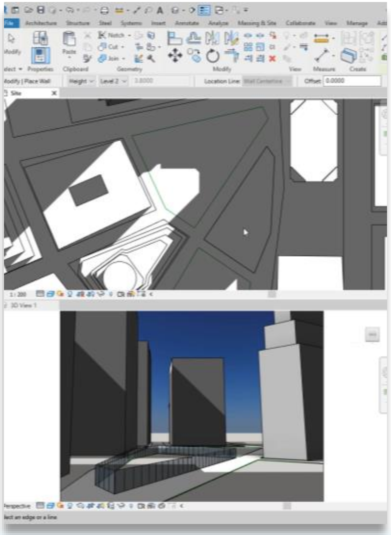
a = 

b = 

a – b = 

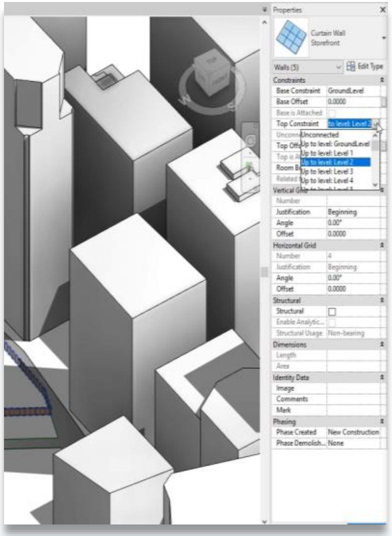
Conceptual Tower Mass – Design Model

AUTODESK® REVIT®



Create Geometry

AUTODESK® REVIT®

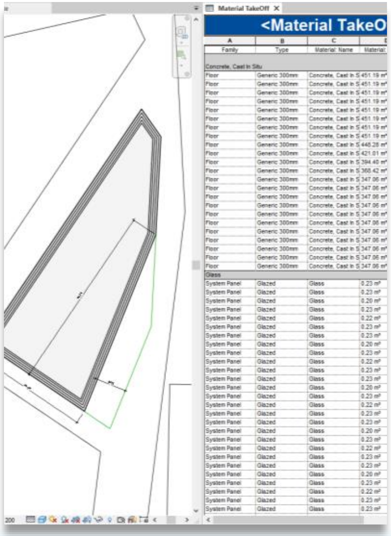


Assign Parametric Constraints

AUTODESK® REVIT®

Modify Parameters

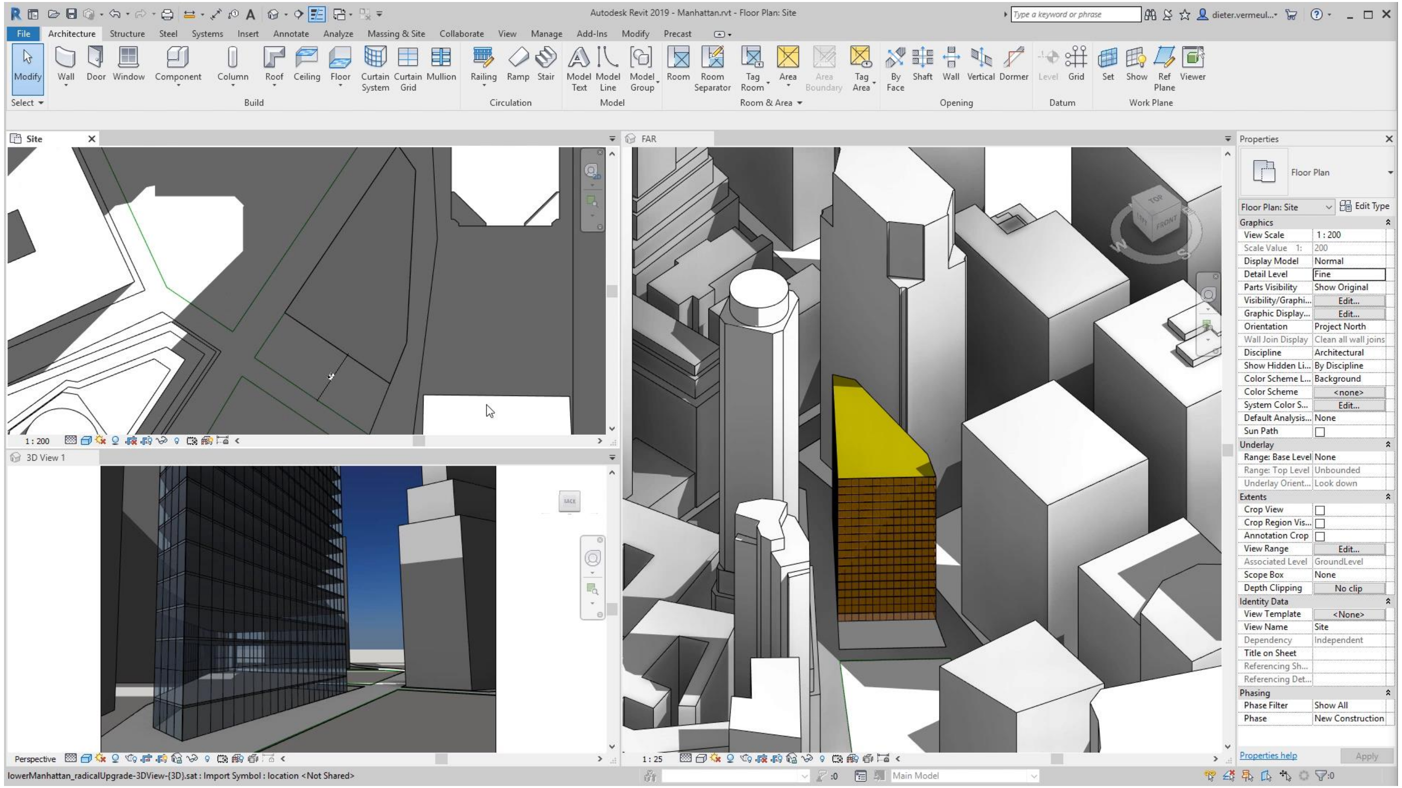
AUTODESK® REVIT®



Document the Idea

Conceptual Tower Mass – Design Model

Parametric Modeling with Autodesk Revit



Design Automation

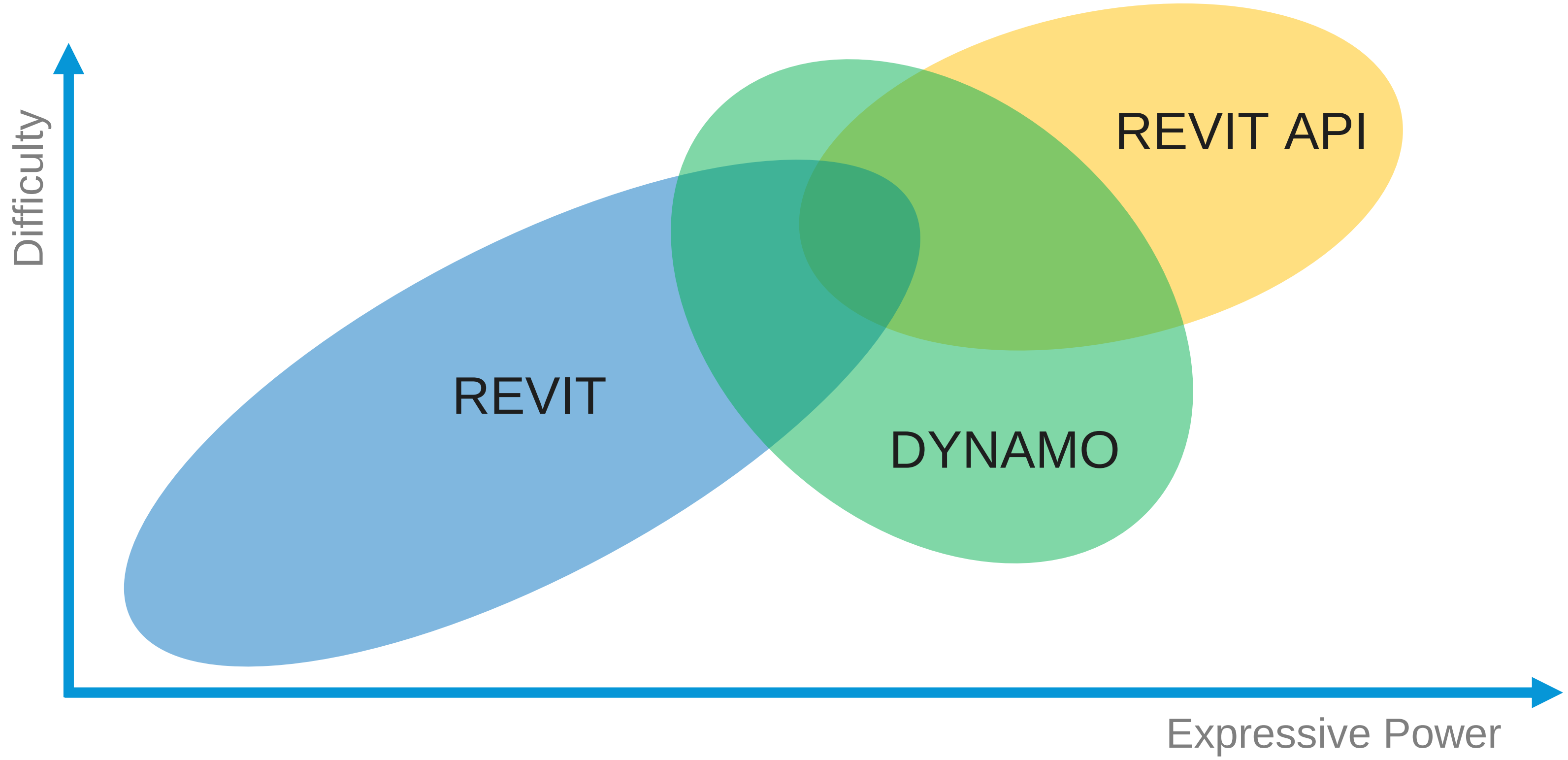
input

design
automation

output

Dynamo

Ecosystem to increase capabilities

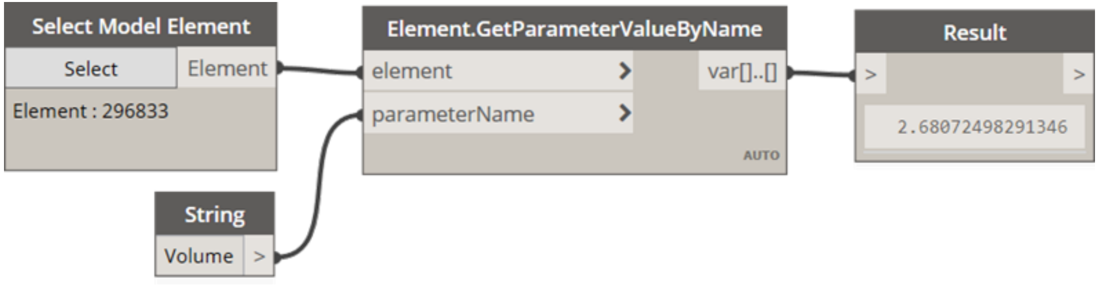


Dynamo to simplify things

PROGRAMMING

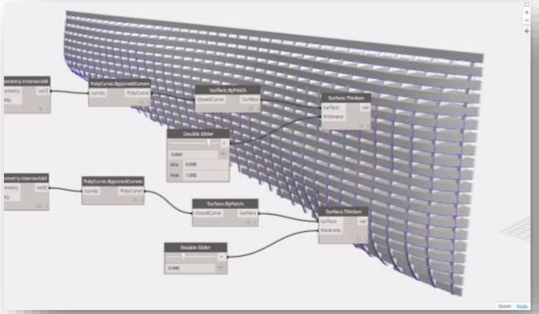
```
void GetElementParameterInformation(Document document, Element element)
{
    // Format the prompt information string
    String prompt = "Show parameters in selected Element: \n\r";

    StringBuilder st = new StringBuilder();
    // iterate element's parameters
    foreach (Parameter para in element.Parameters)
    {
        st.AppendLine(GetParameterInformation(para, document));
    }

    // Give the user some information
    TaskDialog.Show("Revit", prompt + st.ToString());
}

String GetParameterInformation(Parameter para, Document document)
{
    string defName = para.Definition.Name + "\t : ";
    string defValue = string.Empty;
    // Use different method to get parameter data according to the storage type
    switch (para.StorageType)
    {
        case StorageType.Double:
            //covert the number into Metric
            defValue = para.AsValueString();
            break;
        case StorageType.ElementId:
            //find out the name of the element
            Autodesk.Revit.DB.ElementId id = para.AsElementId();
            if (id.IntegerValue >= 0)
            {
                defValue = document.GetElement(id).Name;
            }
            else
            {
                defValue = id.IntegerValue.ToString();
            }
            break;
        case StorageType.Integer:
            if (ParameterType.YesNo == para.Definition.ParameterType)
            {
                if (para.AsInteger() == 0)
                {
                    defValue = "False";
                }
                else
                {
                    defValue = "True";
                }
            }
            else
            {
                defValue = para.AsInteger().ToString();
            }
            break;
        case StorageType.String:
            defValue = para.AsString();
            break;
        default:
            defValue = "Unexposed parameter.";
            break;
    }

    return defName + defValue;
}
```

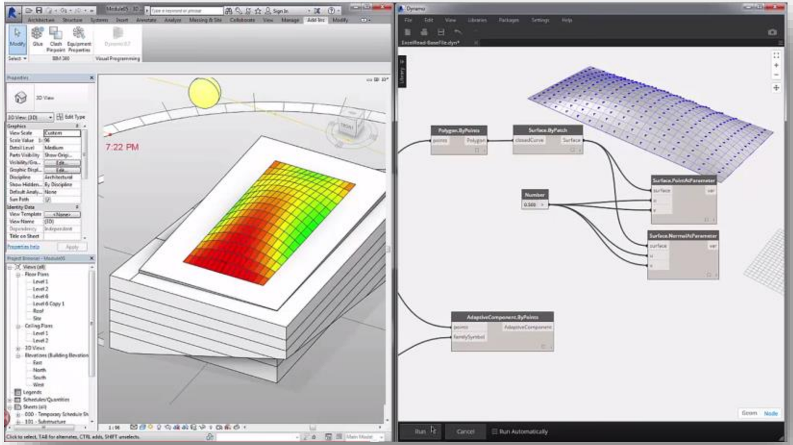
VISUAL SCRIPTING



Dynamo offers more benefits

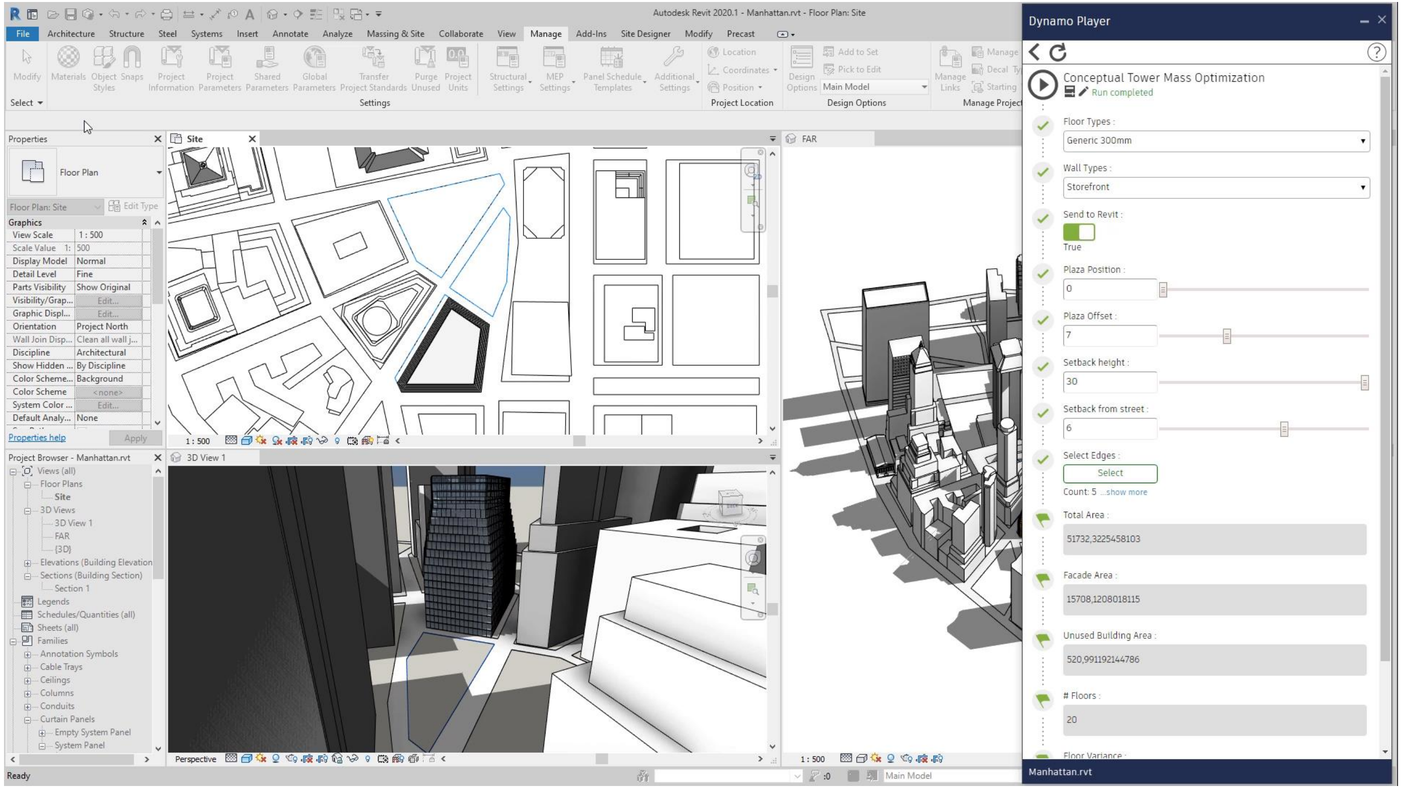
- Provide simple, coherent, and capable programming tools for people who make things
- Foster a collaborative design computation ecosystem
- Share tools within teams and across disciplines
- Generate sophisticated designs from simple data
- Automate repetitive tasks





Conceptual Tower Mass - Automated Placement

Design Automation with Revit and Dynamo Player

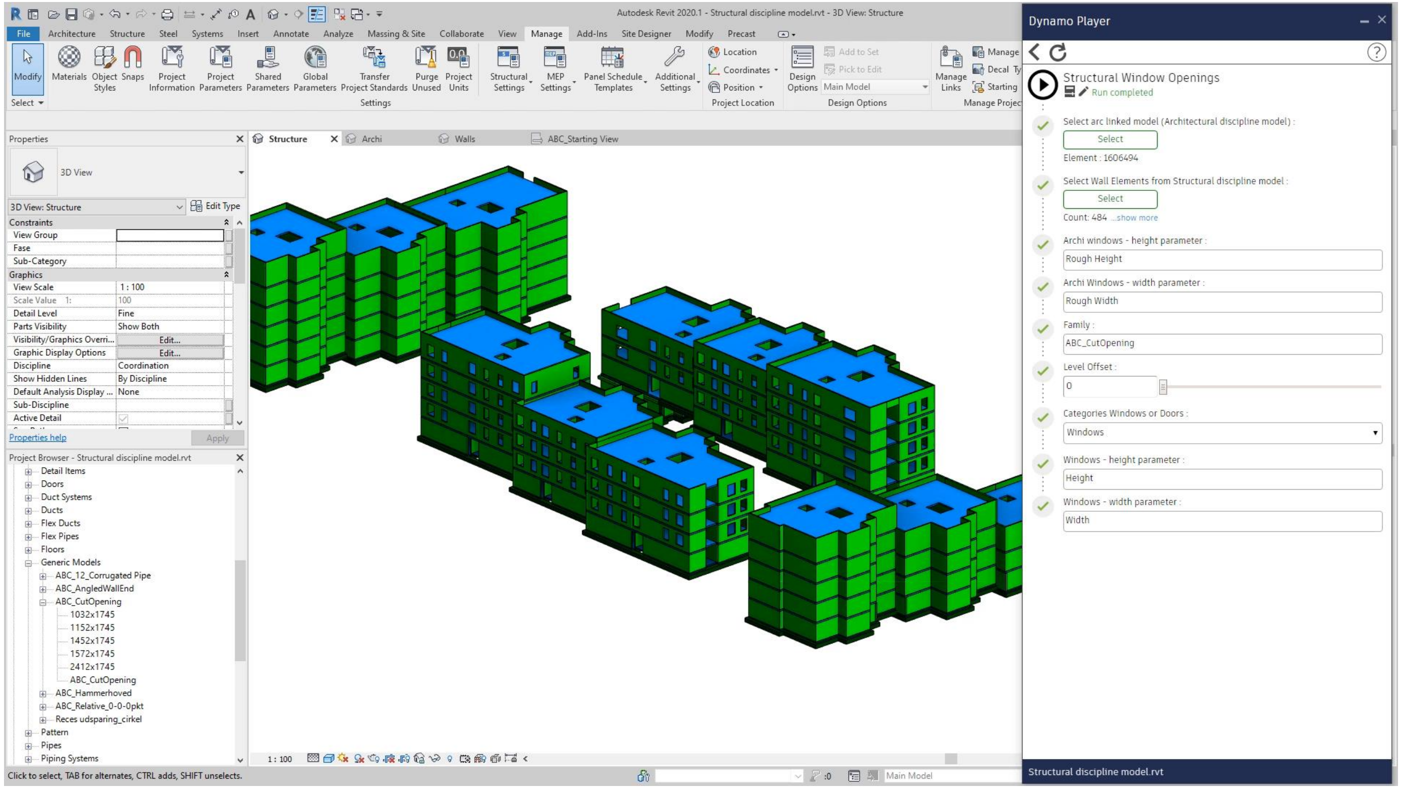


Cut Openings in Structural Walls

Design Automation with Revit and Dynamo

ABCLAUSEN

Thanks for contributing:
Jesper Wallaert, AB Clausen, Denmark



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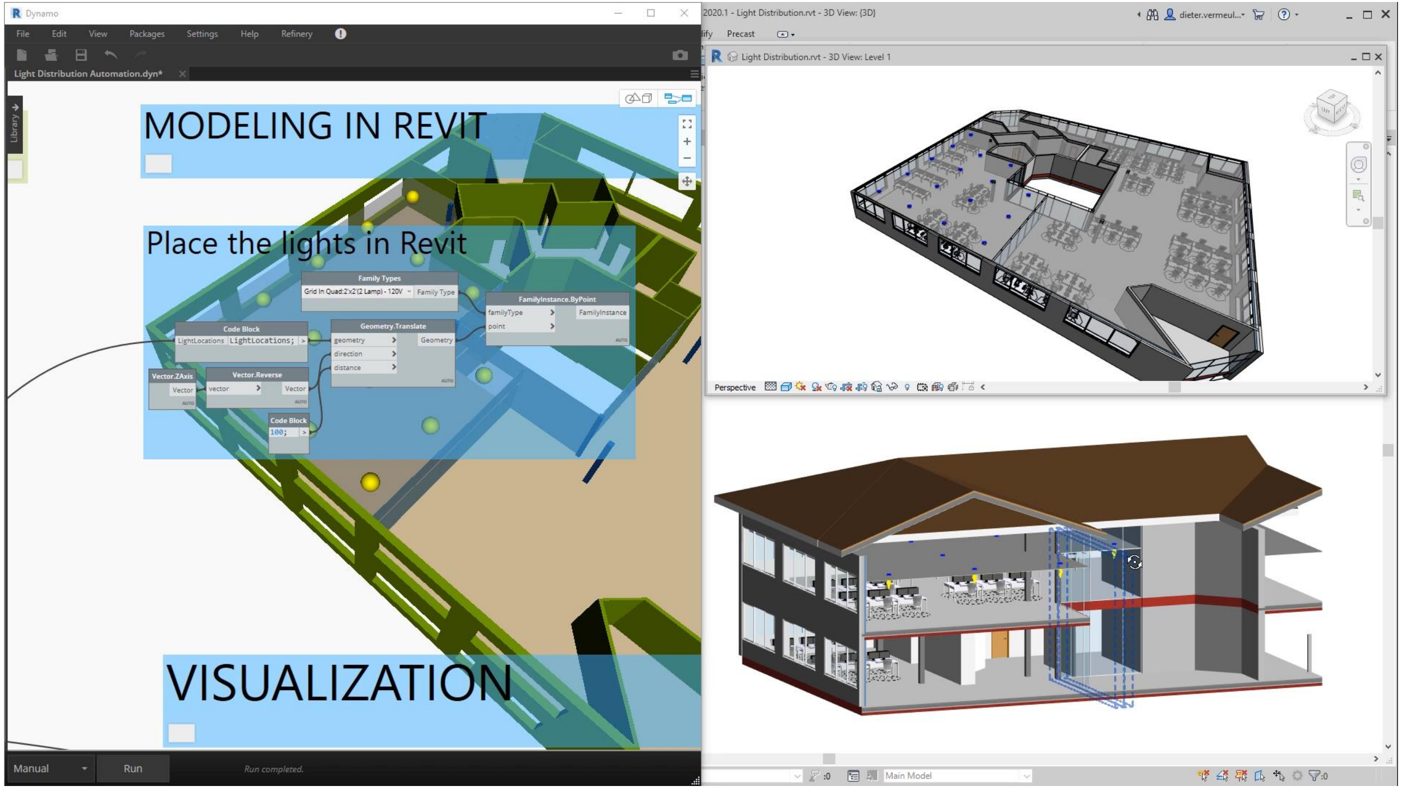
Light Placement Automation

Design automation with Revit and Dynamo



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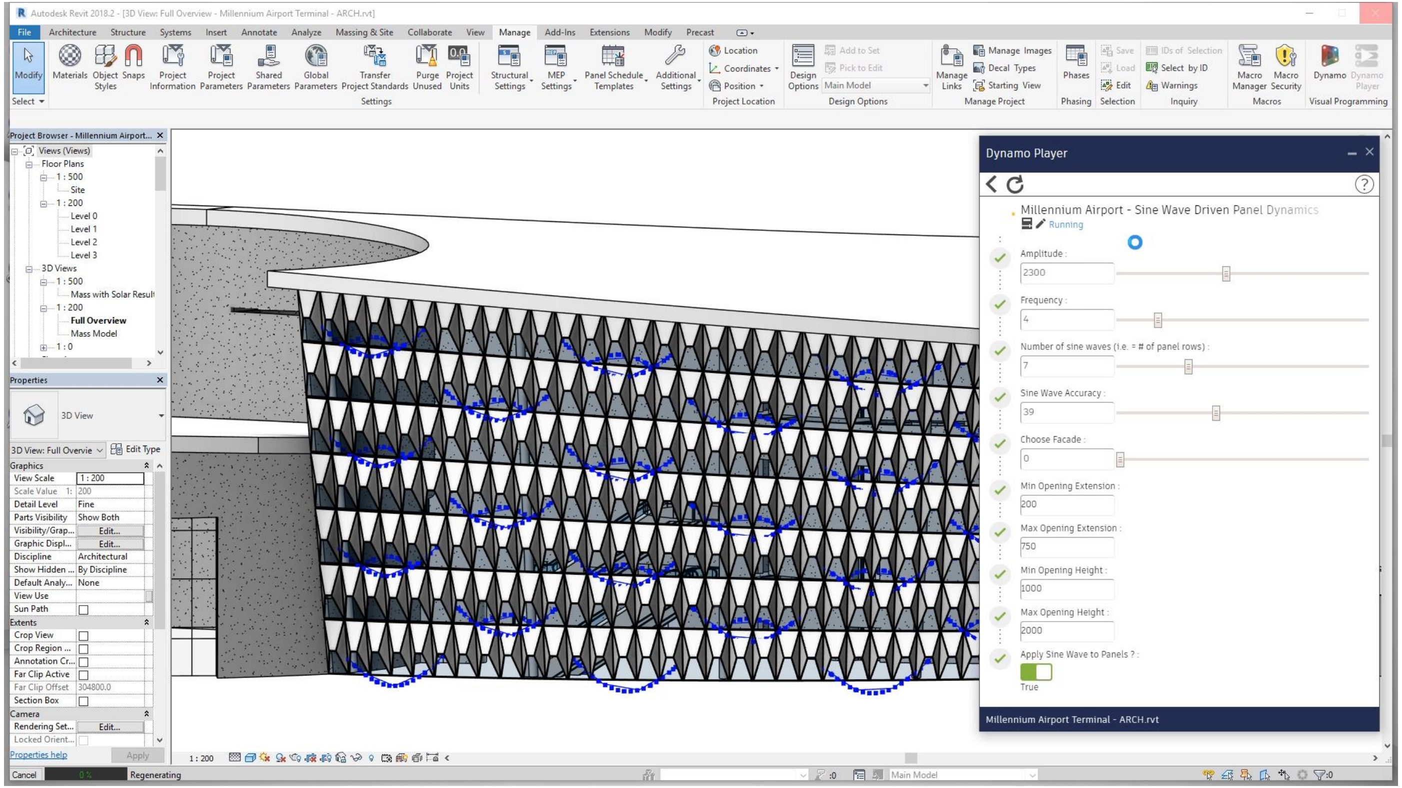
Façade Panels with Mathematical Influence

Design Automation with Revit and Dynamo Player



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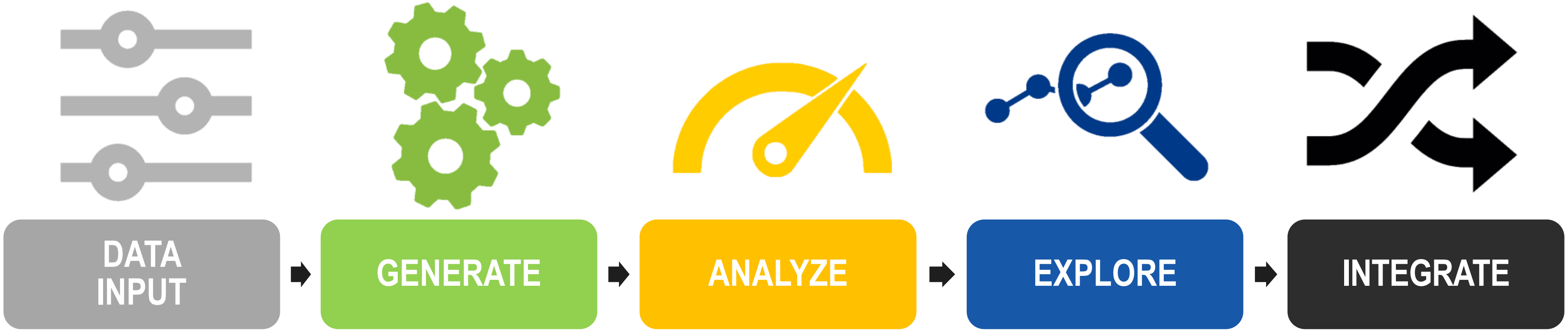
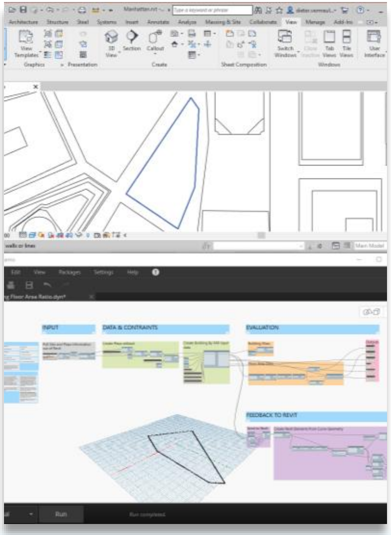
Computational Modeling

Computational Modeling Process



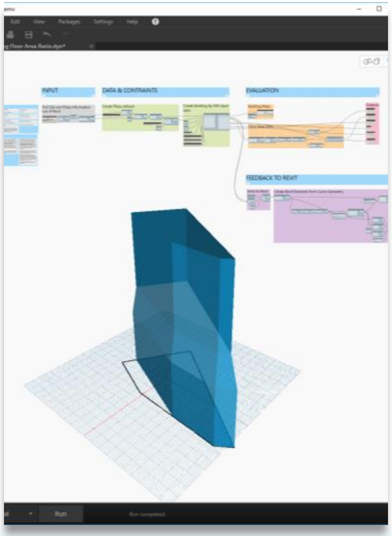
Conceptual Tower Mass with Computational Modeling

DYNAMO FOR REVIT



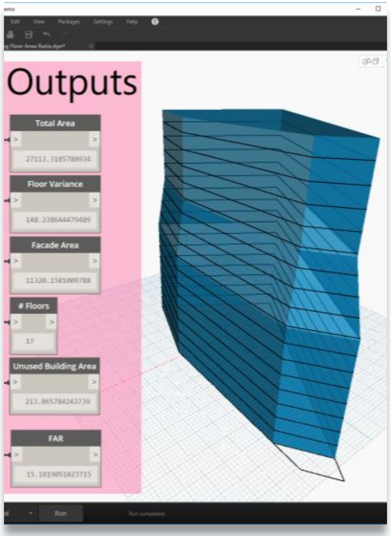
Get Boundaries

DYNAMO FOR REVIT



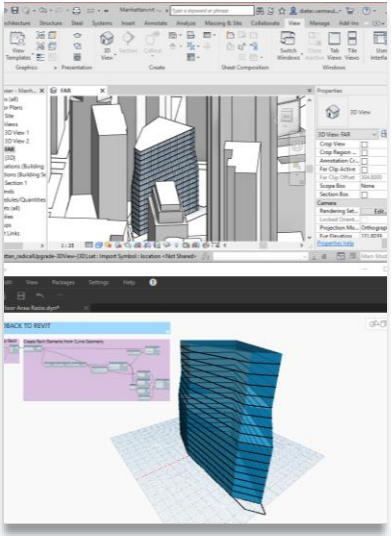
Generate Geometry

DYNAMO FOR REVIT



Analyze & Evaluate

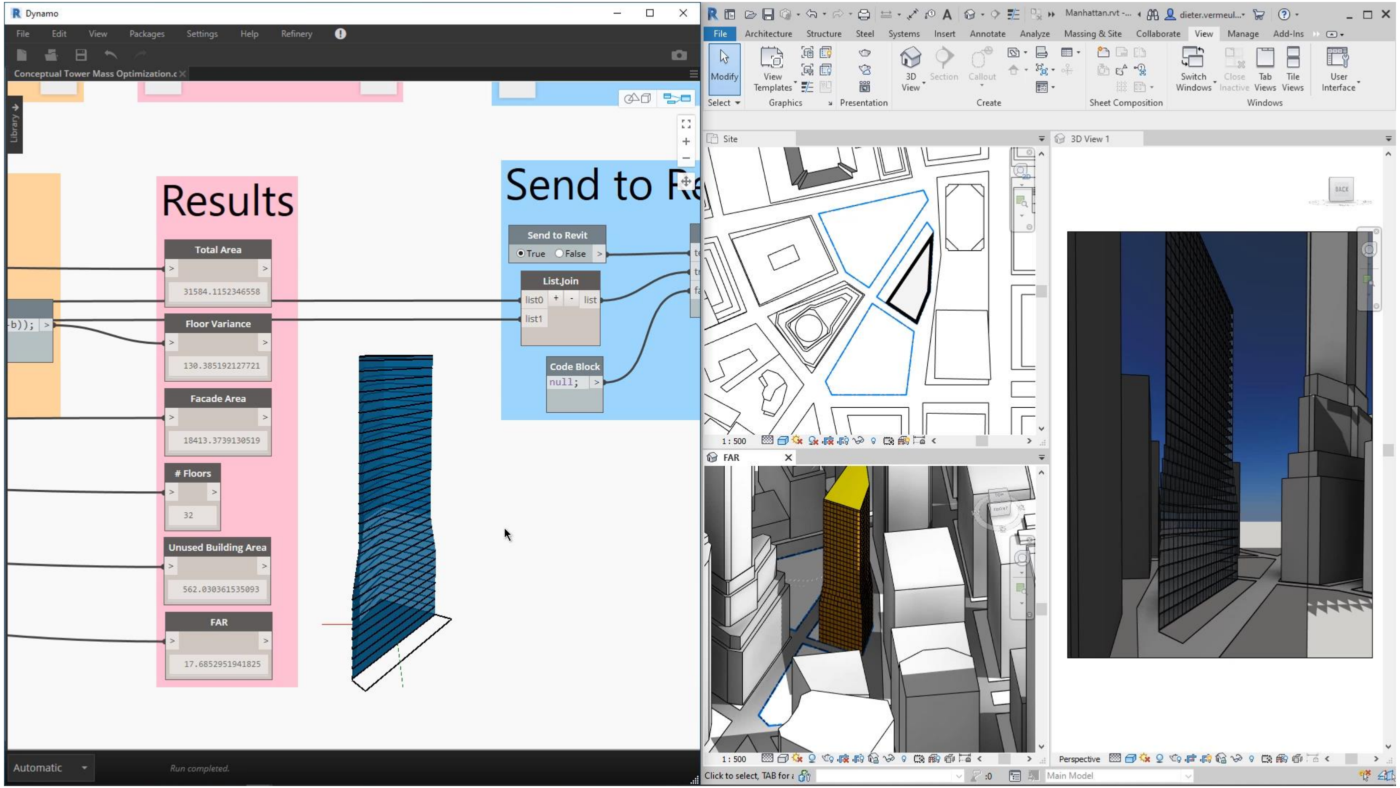
AUTODESK® REVIT®



Model Integration

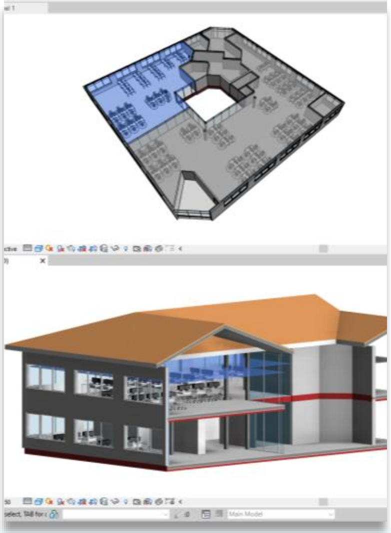
Conceptual Tower Mass

Computational Modeling with Revit and Dynamo



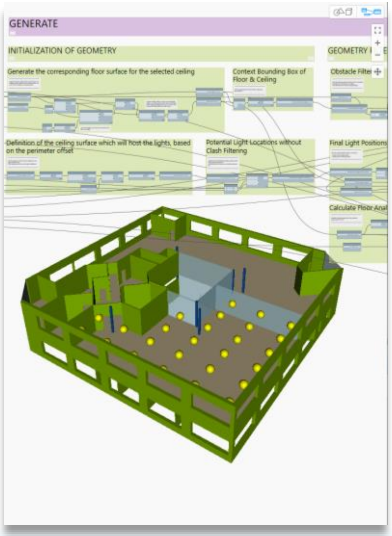
Light Distribution Analysis

AUTODESK® REVIT®



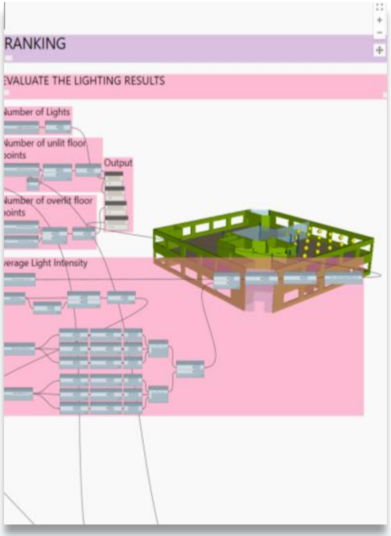
Get Revit Context

DYNAMO FOR REVIT®



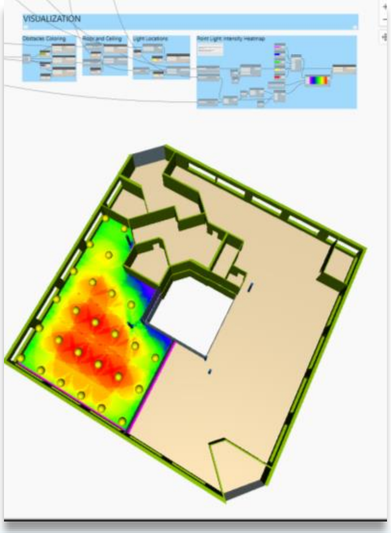
Generate Option for Light Distribution

DYNAMO FOR REVIT®



Conceptual Analysis Point Intensity

DYNAMO FOR REVIT®

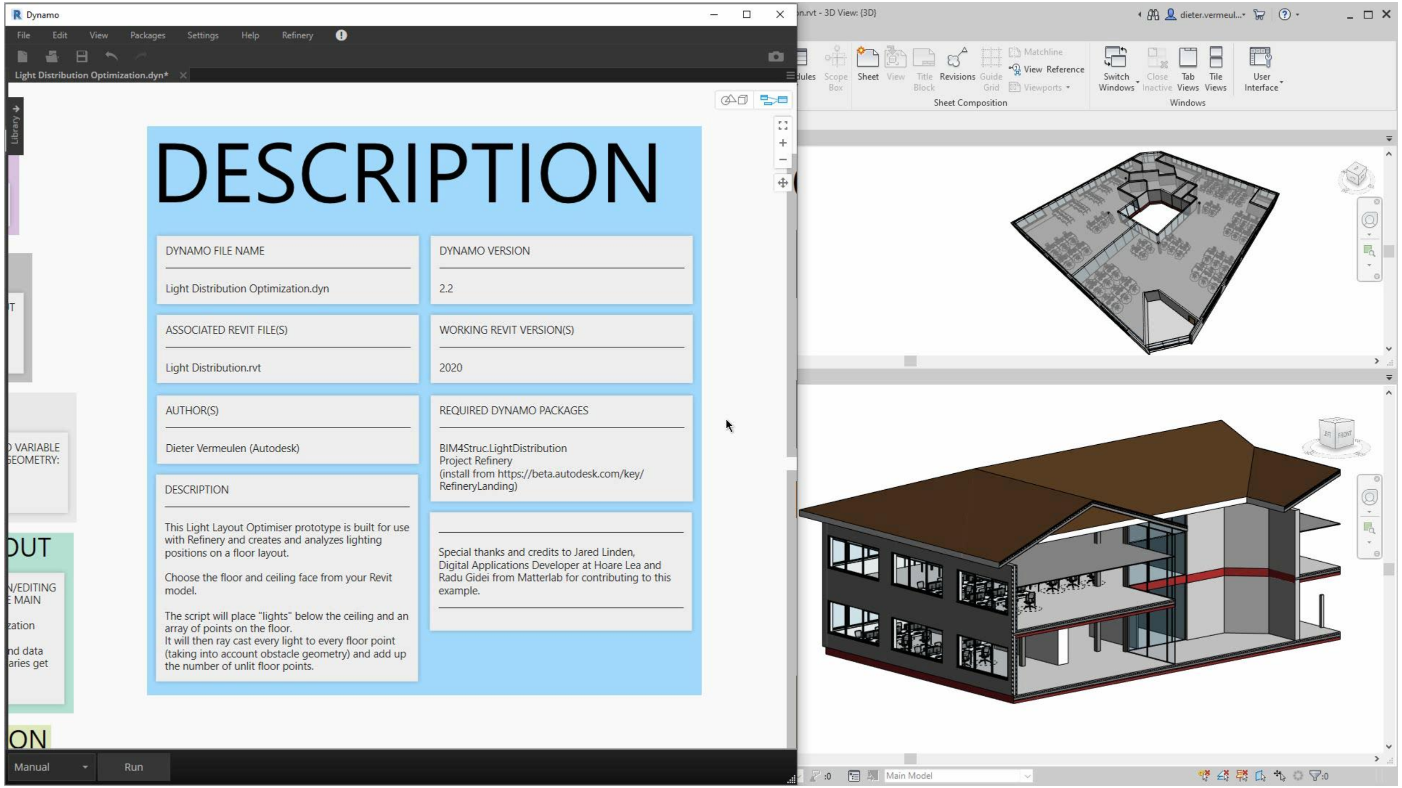


Evaluation

Light Distribution Analysis

Computational Modeling with Revit and Dynamo

Special thanks for contributing:
Jared Linden, Hoare Lea, UK
Radu Gidei, Matterlab, UK



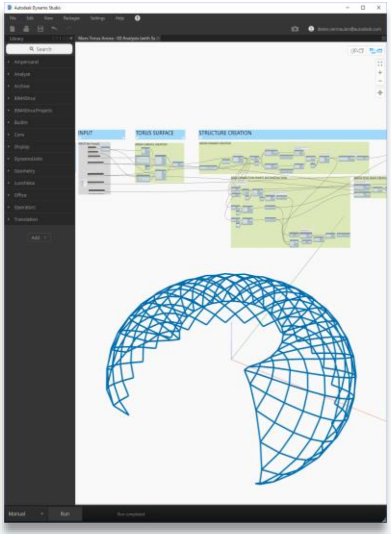
Steel Diagrid Waste Evaluation

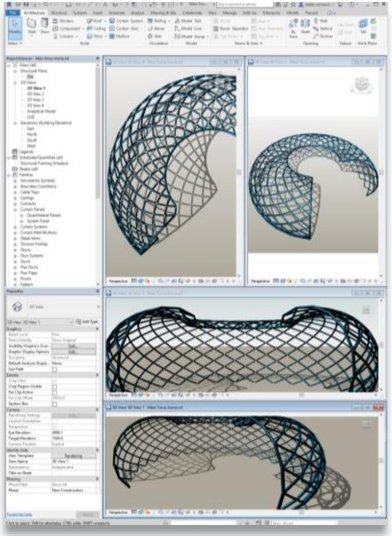
DYNAMO FOR REVIT

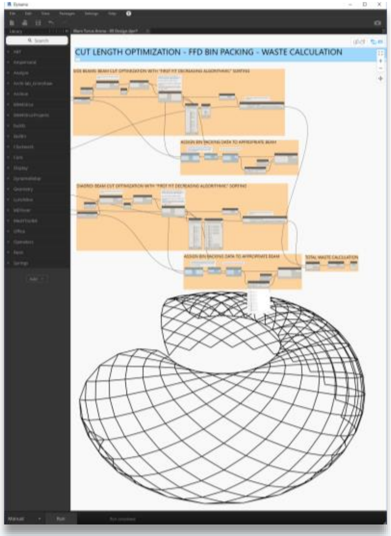
AUTODESK® REVIT®

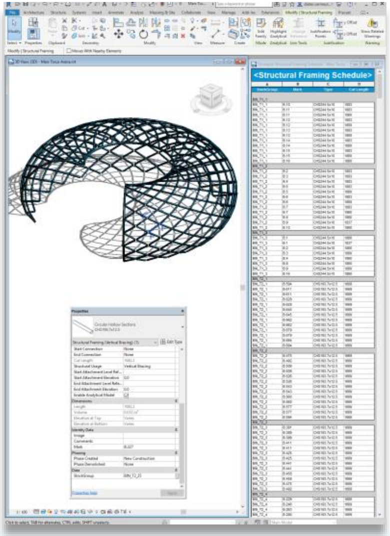
DYNAMO FOR REVIT

AUTODESK® REVIT®









System Definition

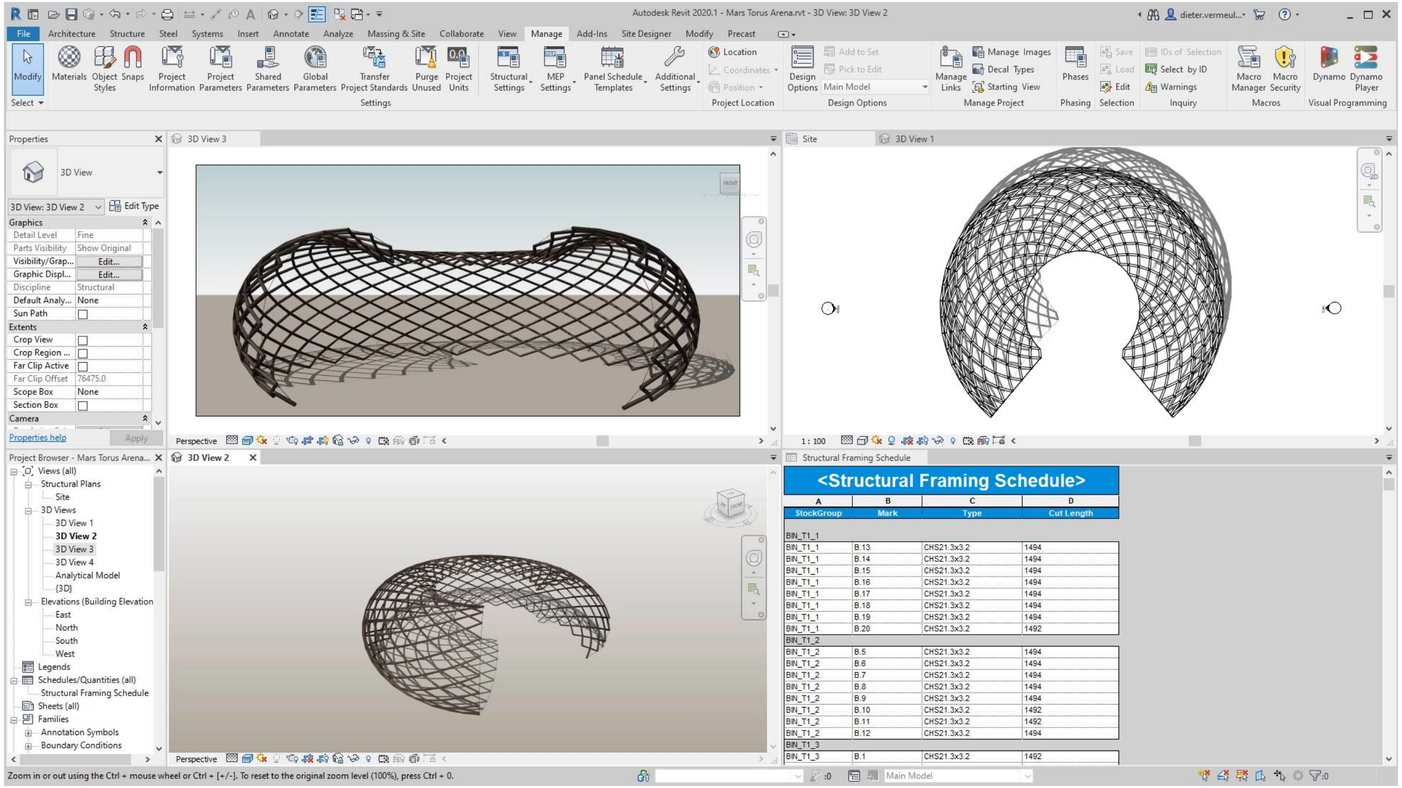
Automate Structural Design

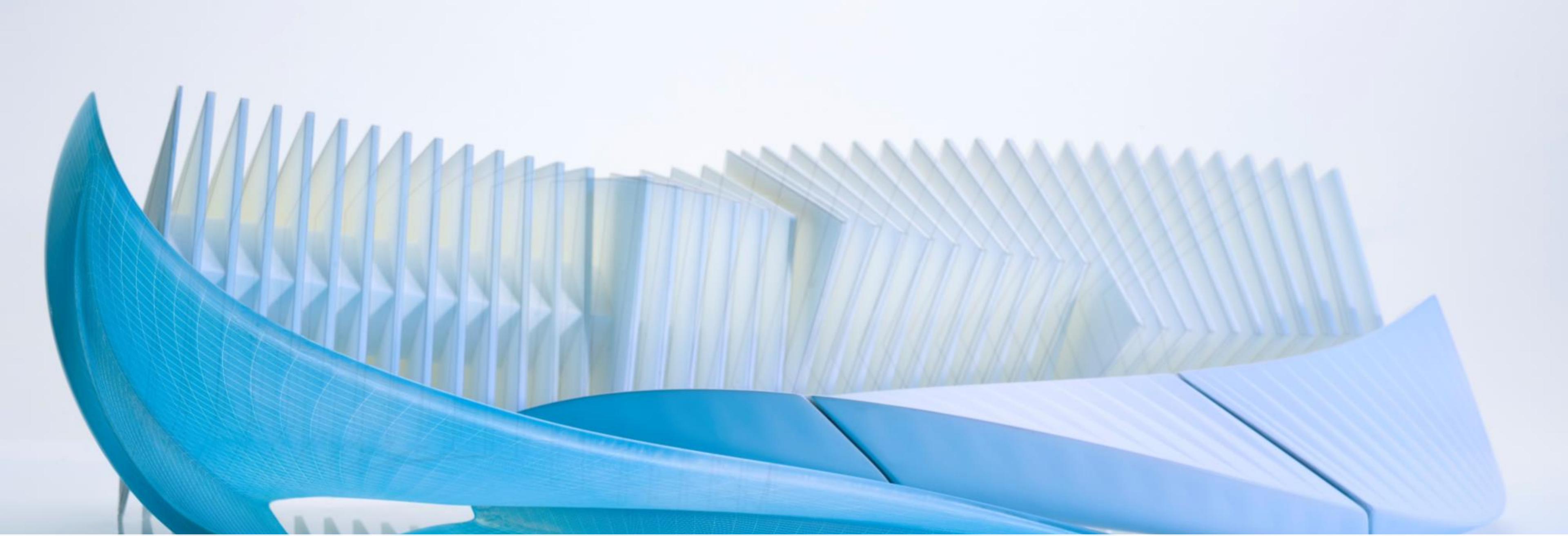
Cut Length Optimization

Integration of Results

Steel Diagrid Waste Evaluation

Computational Modeling with Revit and Dynamo

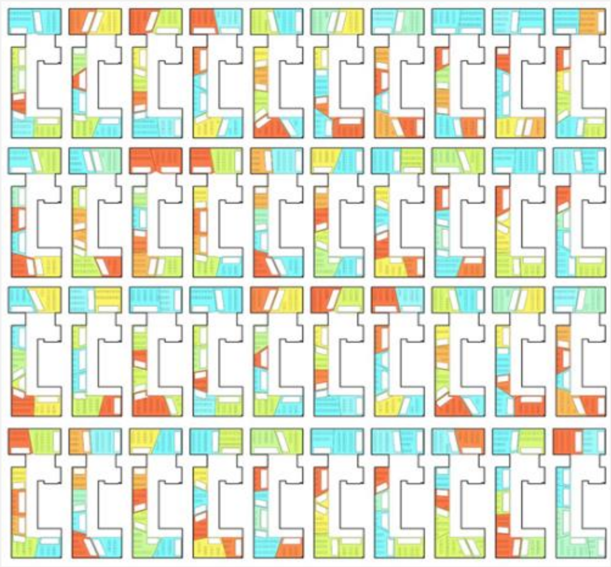




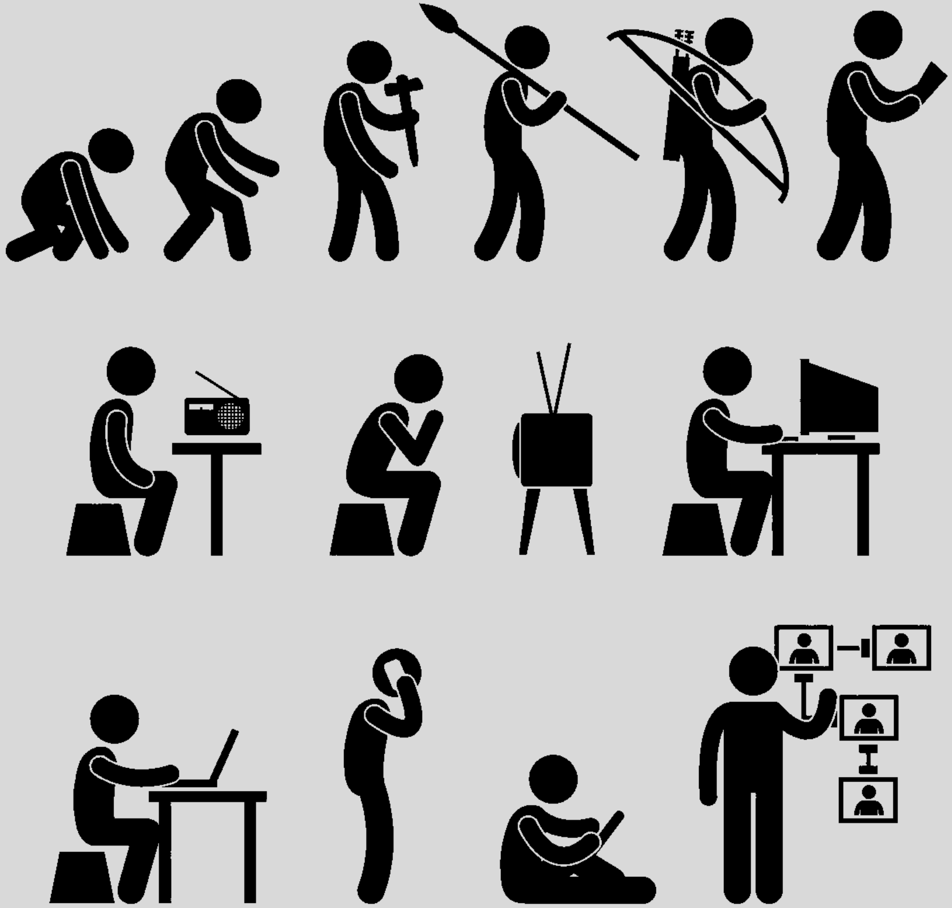
Generative Design

GENERATIVE DESIGN

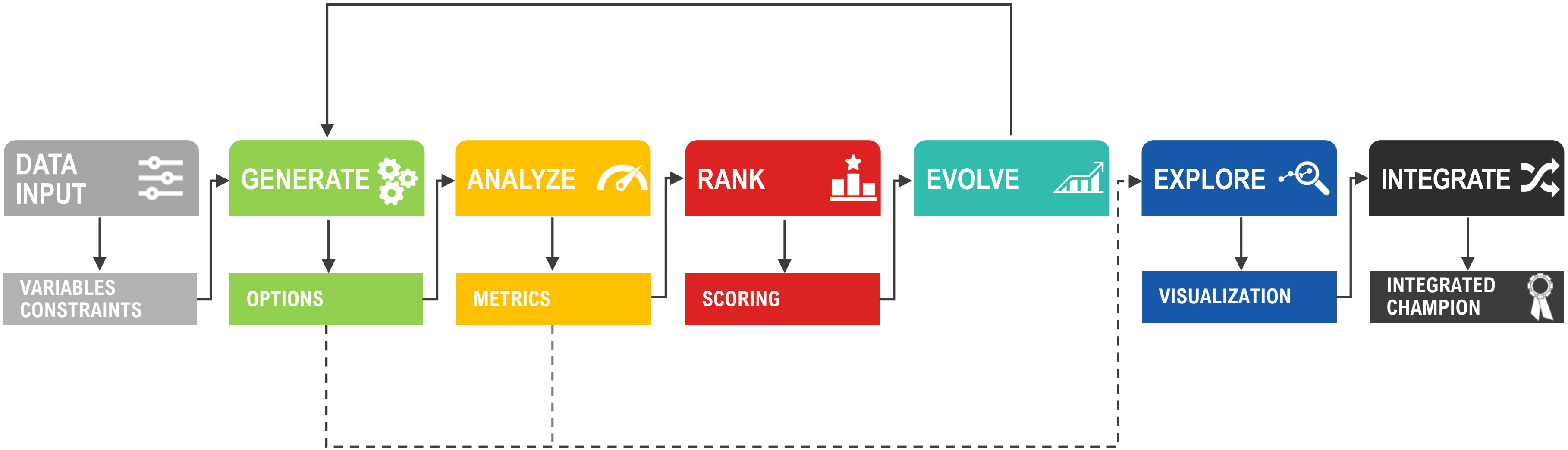
Computer and designer/engineer
unite as cocreators



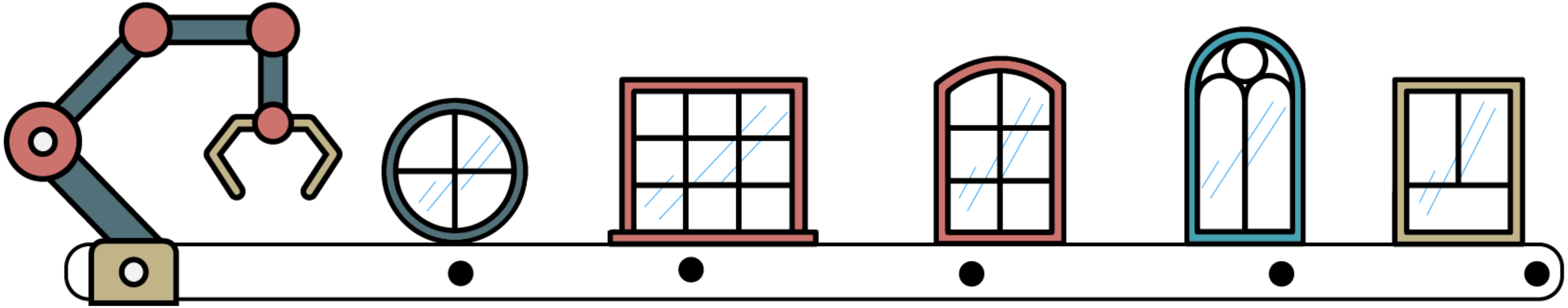
one human + computational algorithms + computing power = 100s to 1000s of design options



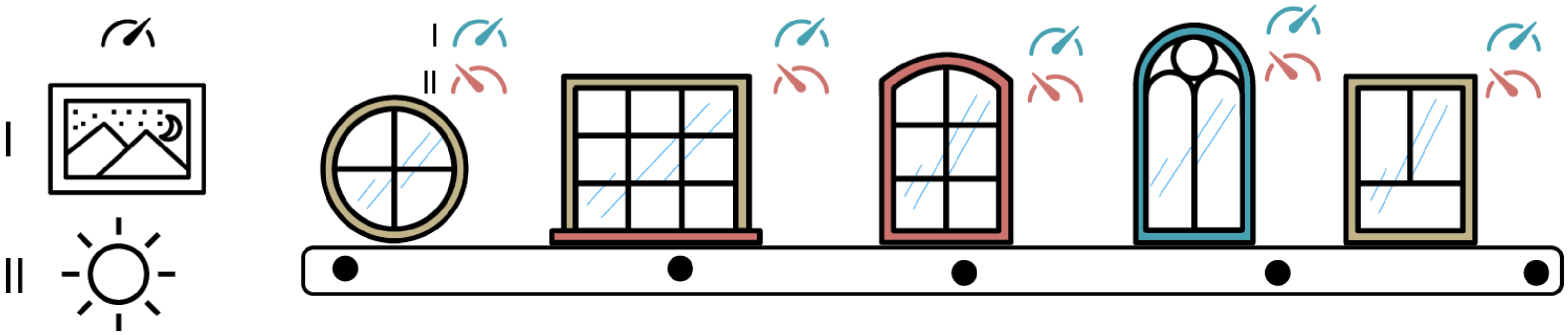
Generative Design Process



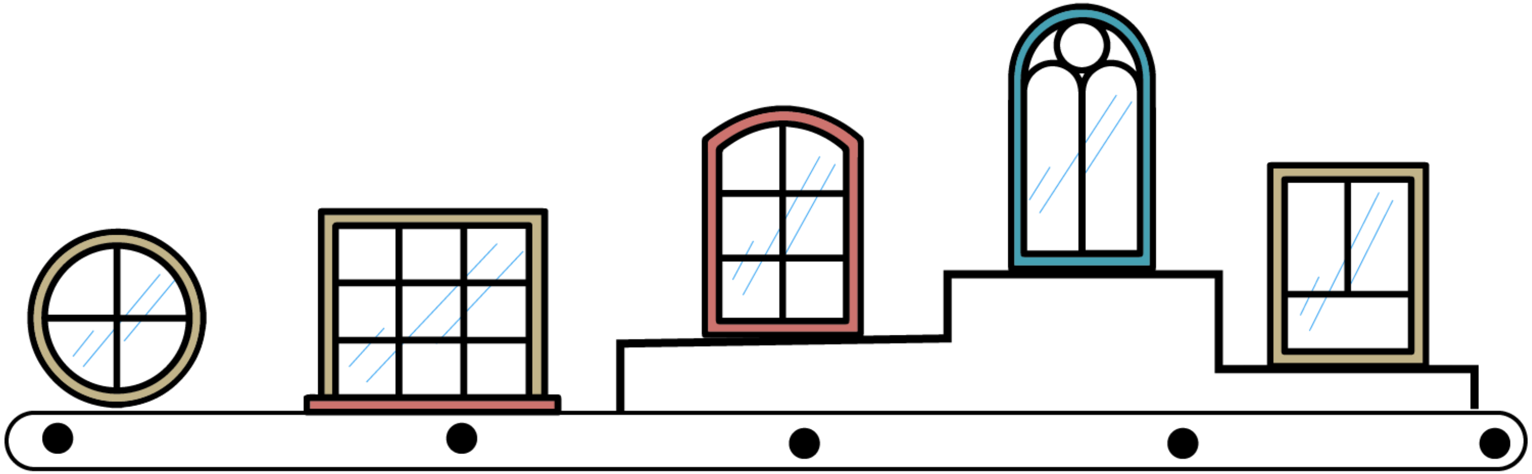
GENERATE



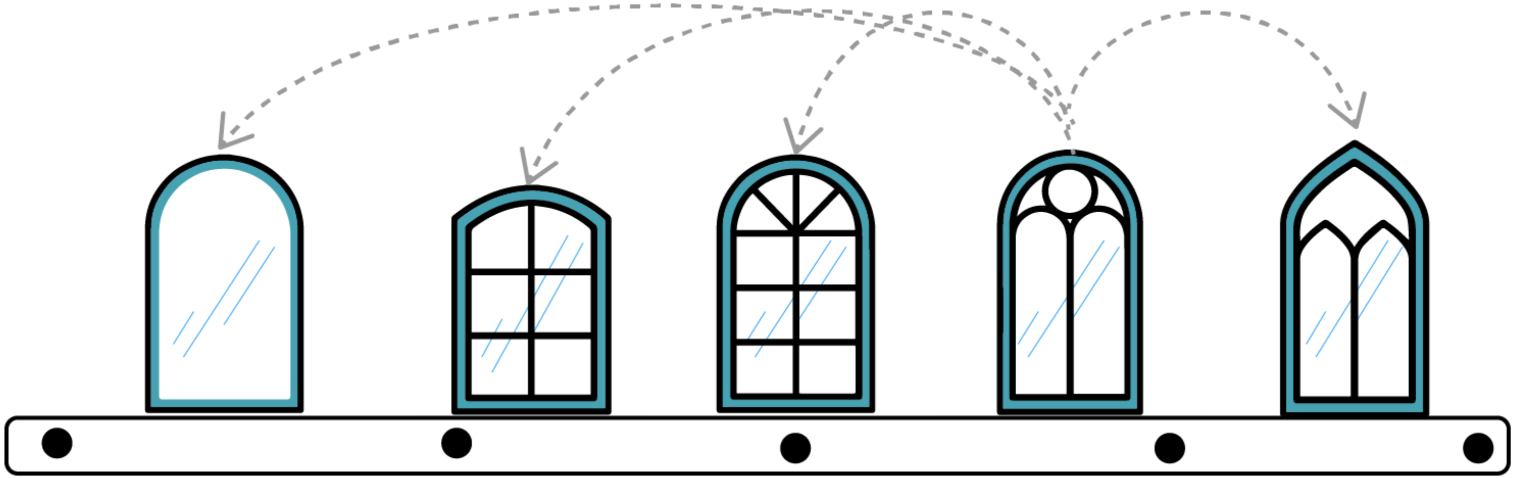
ANALYZE



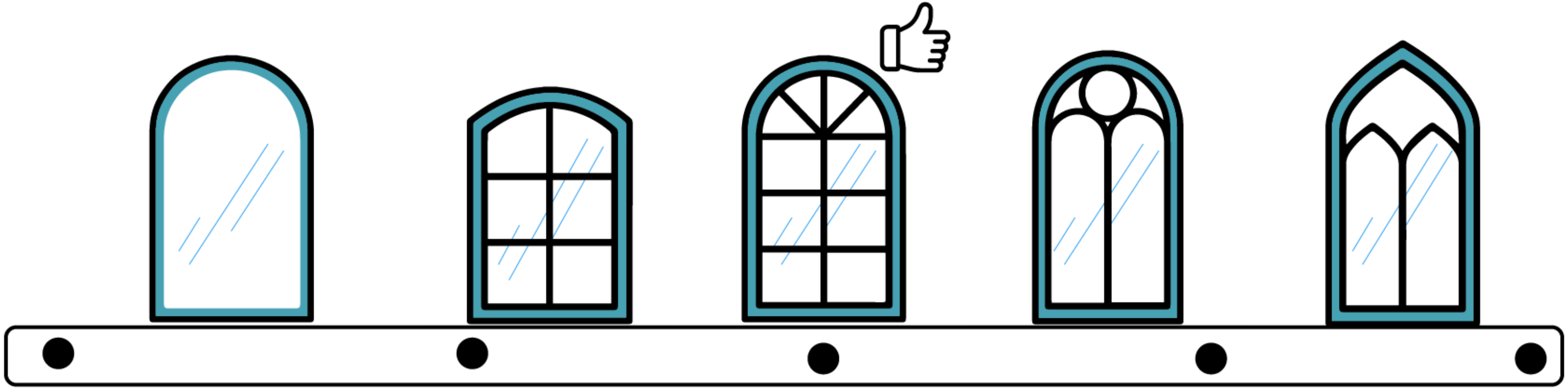
RANK



EVOLVE



EXPLORE

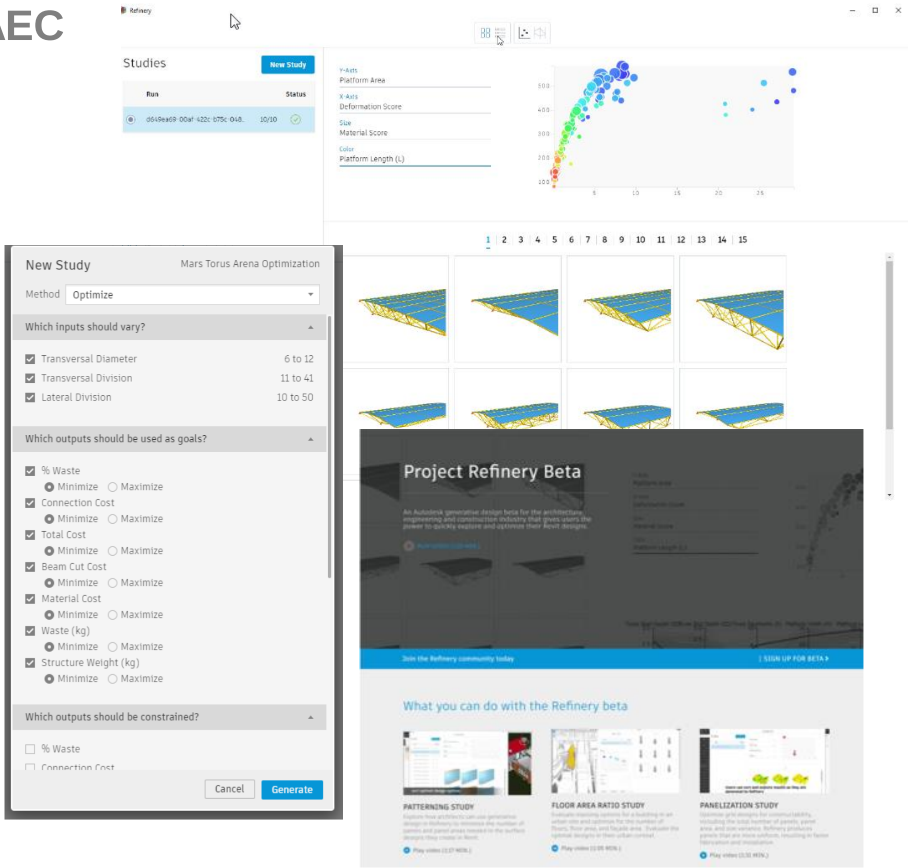


INTEGRATE

Refinery

Public Beta Project for Generative Design in AEC

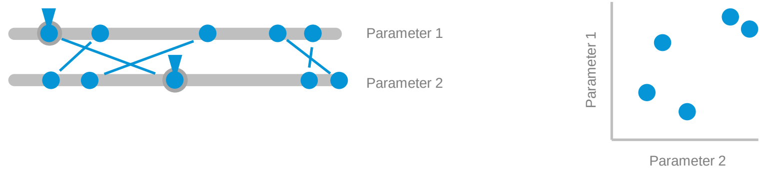
- Explore and optimize designs
- Uses NSGA-II optimization algorithm
  Learn more here:
  https://www.iitk.ac.in/kangal/Deb_NSGA-II.pdf
- Advanced results display
- Syncing selected option back to Dynamo
- More information and beta access:
  www.autodesk.com/solutions/refinery-beta



Types of studies | Generation Methods

4 TYPES	INPUTS	DESIGN SPACE	OUTCOME

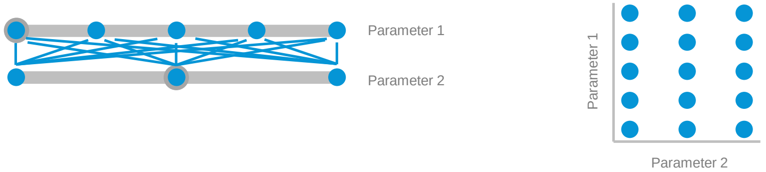
RANDOMIZE



5 DESIGNS
defined by user

CROSS PRODUCT

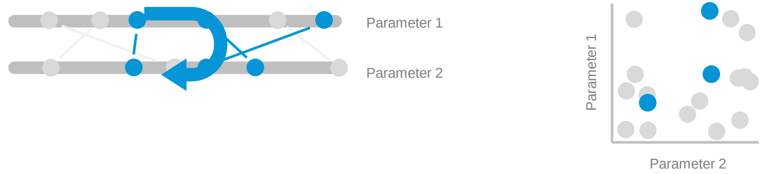
5x
3x



5 x 3 = 15 DESIGNS
user defines sampling density

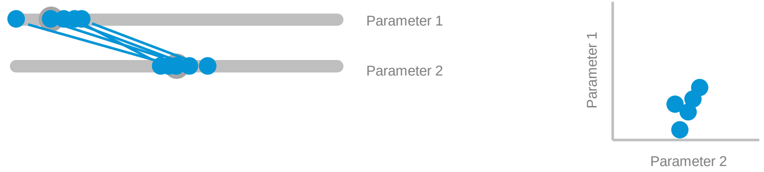
OPTIMIZE

generation 1 population of 3
generation 2 population of 3
…
generation 6 population of 3



3 x 6 = 18 DESIGNS
user defines population size and number of generations

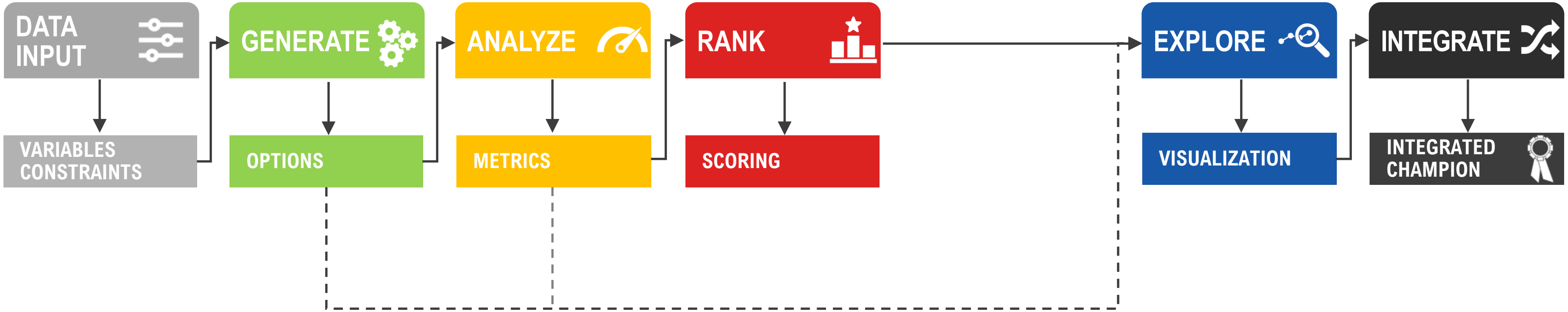
LIKE THIS



5 DESIGNS
defined by user

OPTION GENERATION

Option Generation Process



Conceptual Tower Mass Randomization

DYNAMO FOR REVIT

DYNAMO FOR REVIT

PROJECT REFINERY

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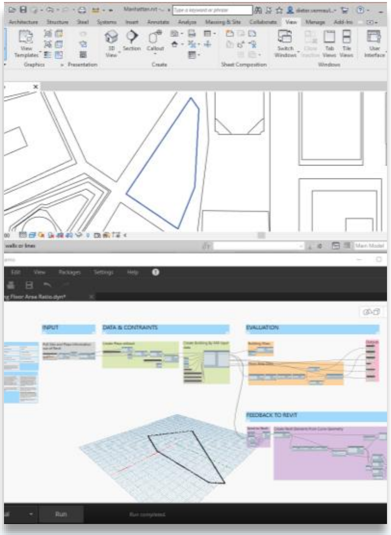
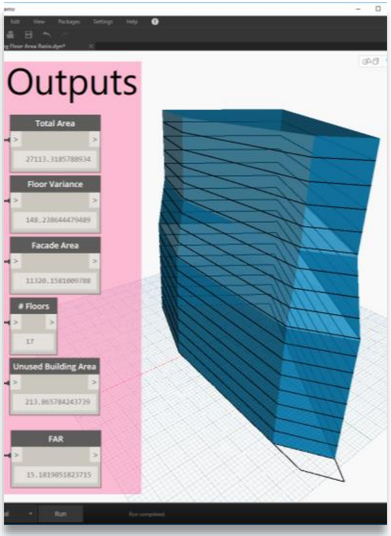
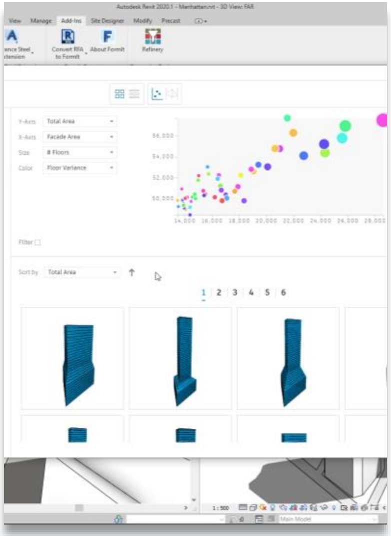
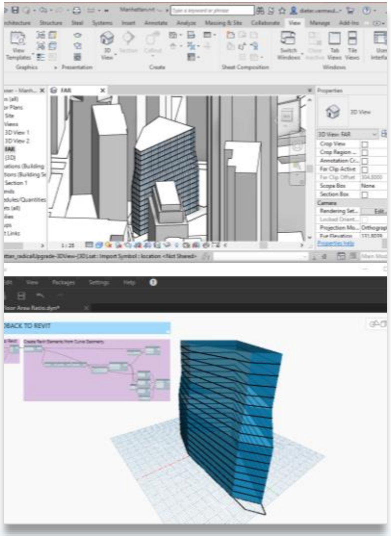




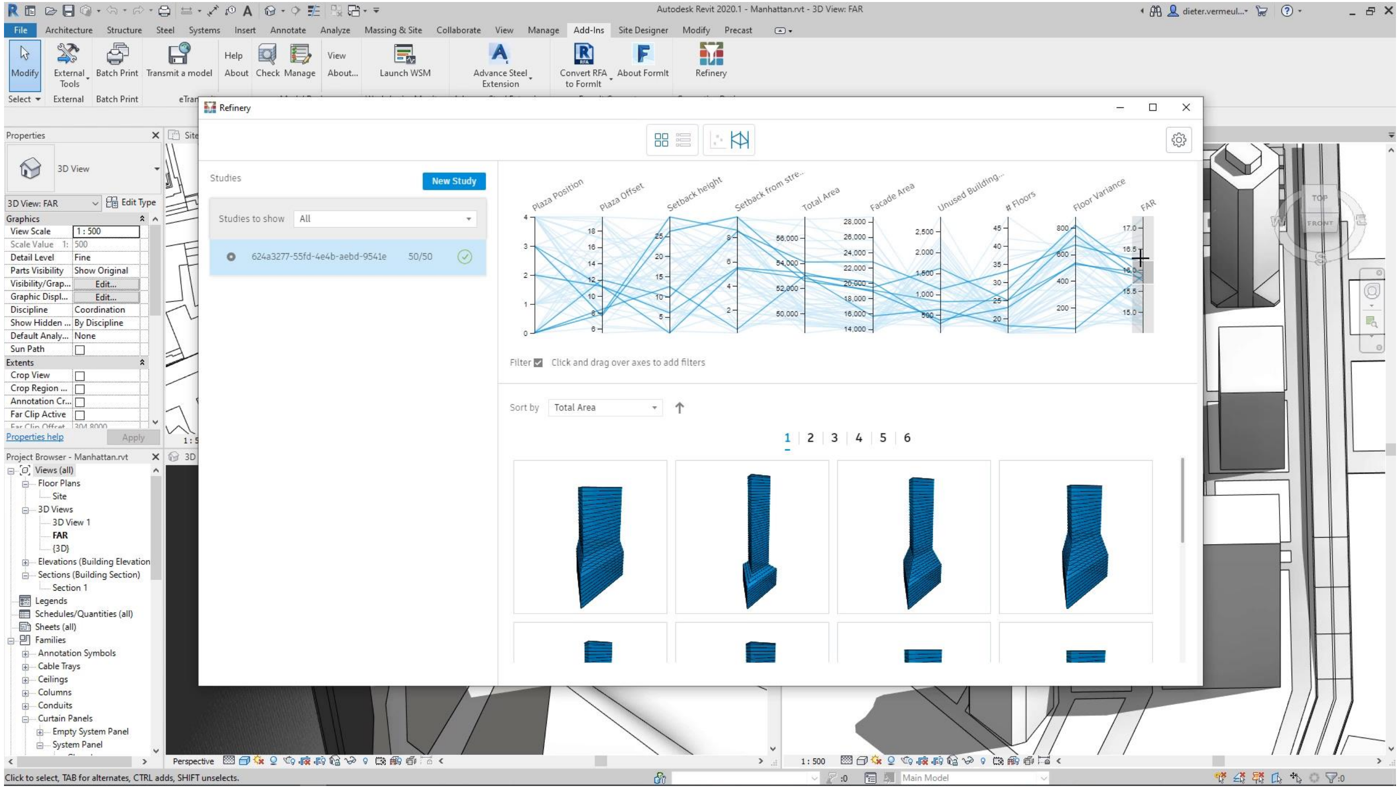


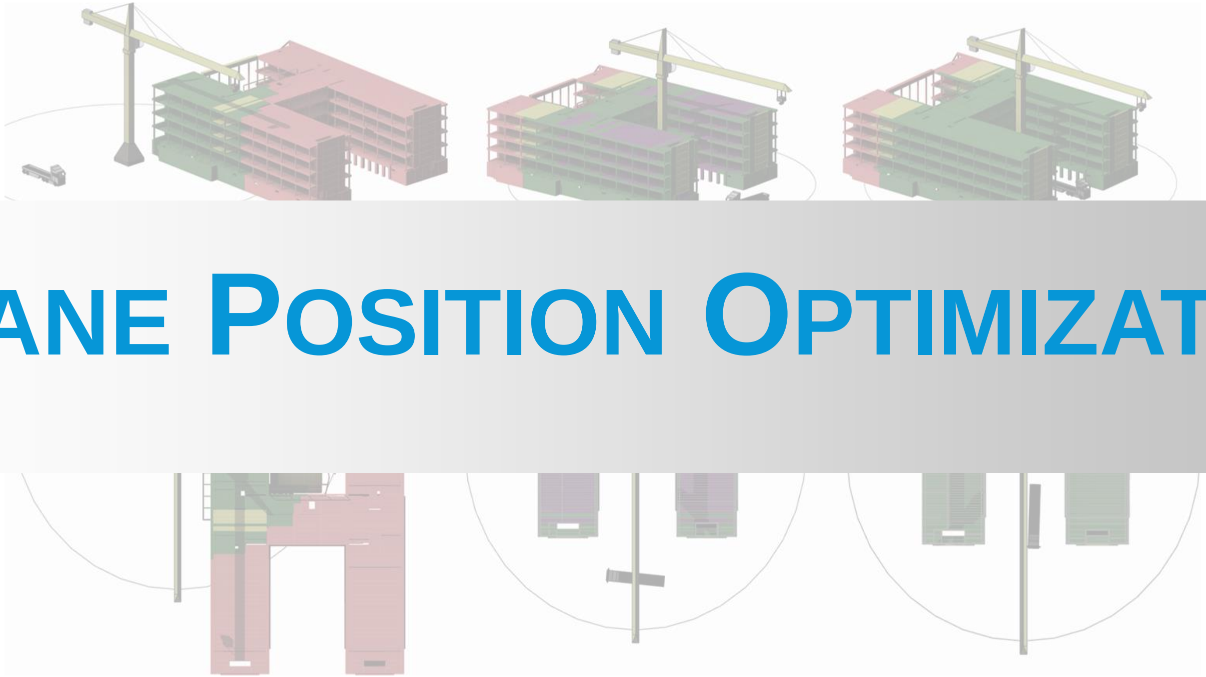


Get Boundaries → Computational Model → Generate Options → Model Integration

Conceptual Tower Mass Randomization

Option Generation with Dynamo and Refinery





Crane Position Optimization

Crane Position Randomization

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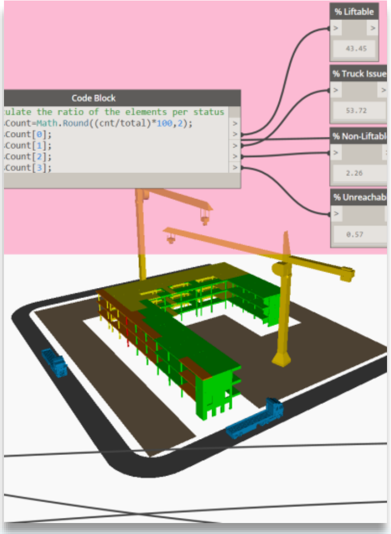
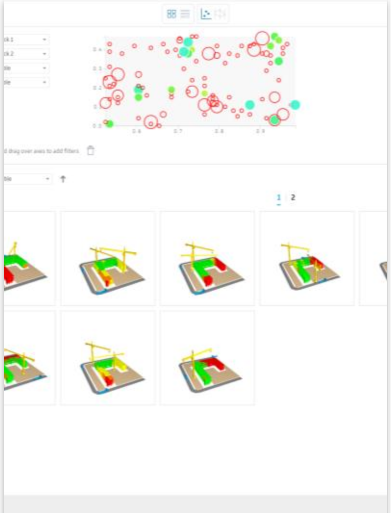
PROJECT REFINERY

AUTODESK® REVIT®

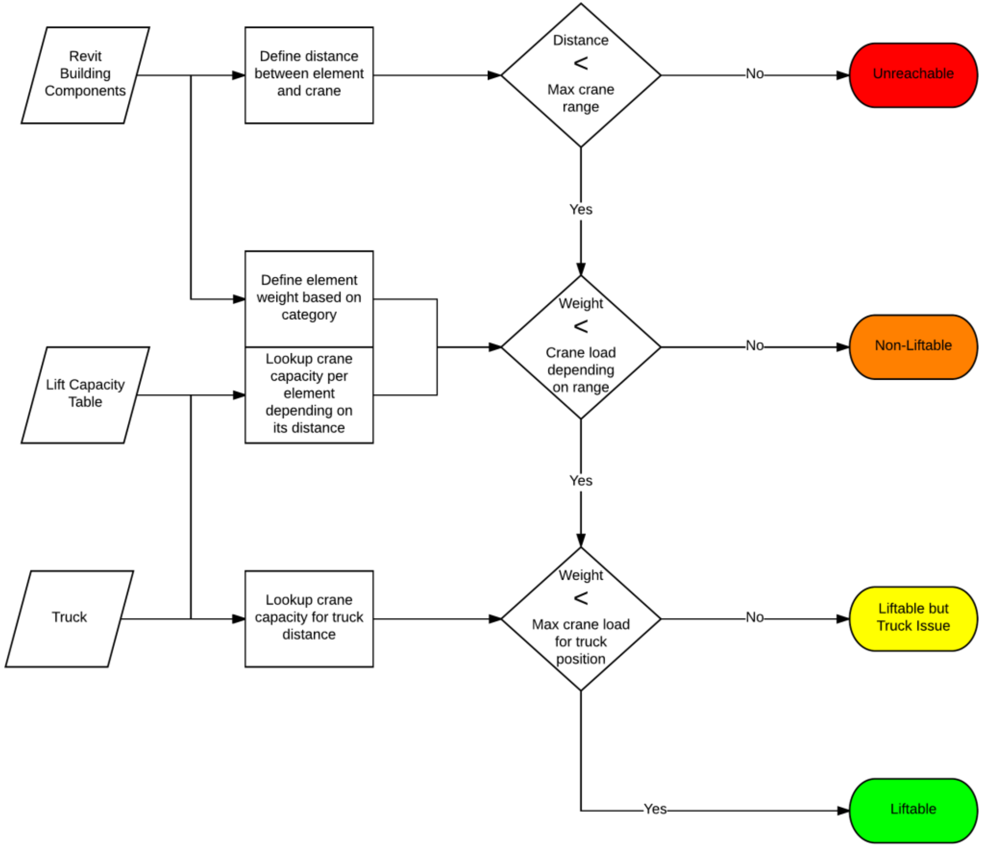




Create Design Model → Crane Position Analysis → Randomization of Options → Send to Design Model

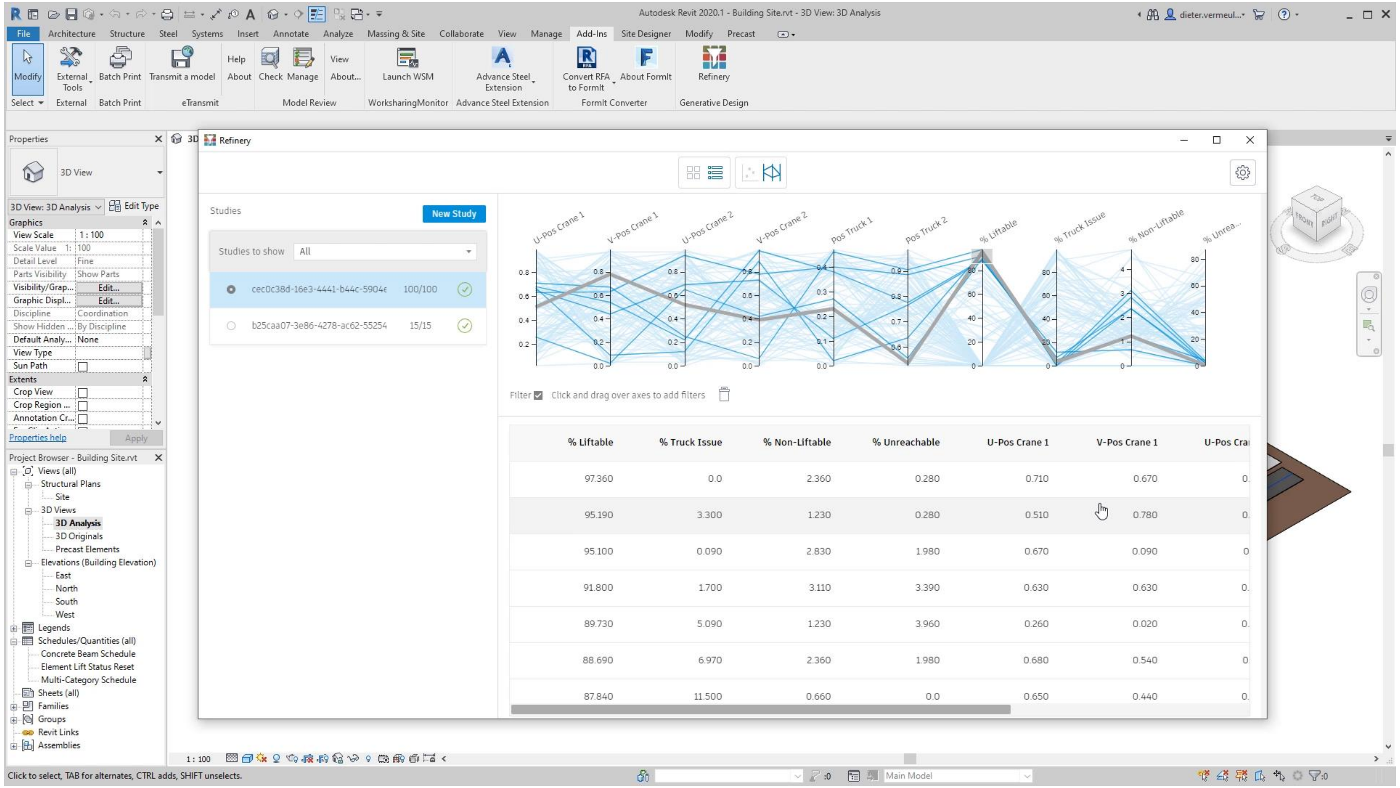
Crane Position Analysis

Flowchart Approach



Crane Position Randomization

Option Generation with Dynamo and Refinery



@BIM4Struc

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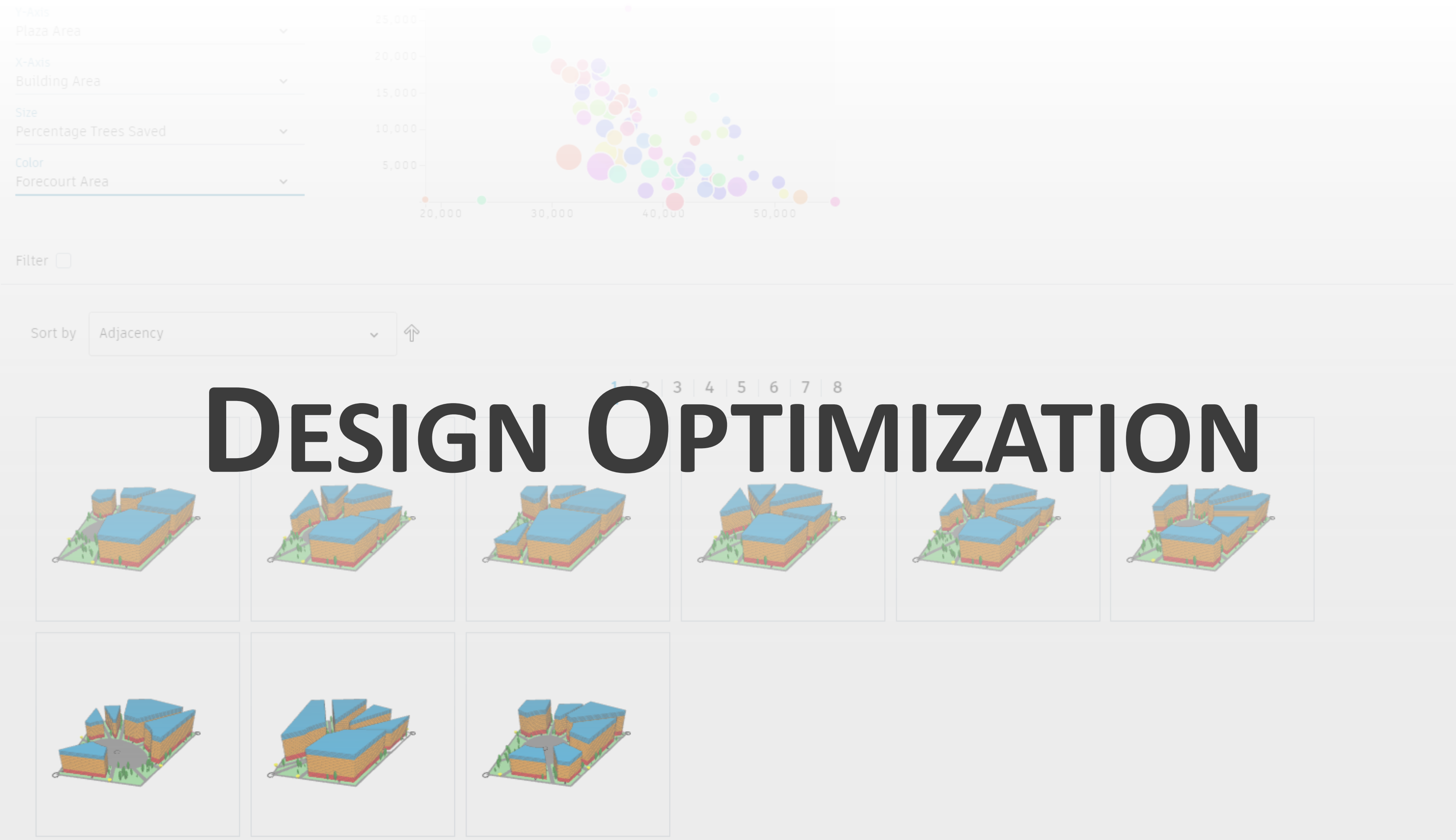
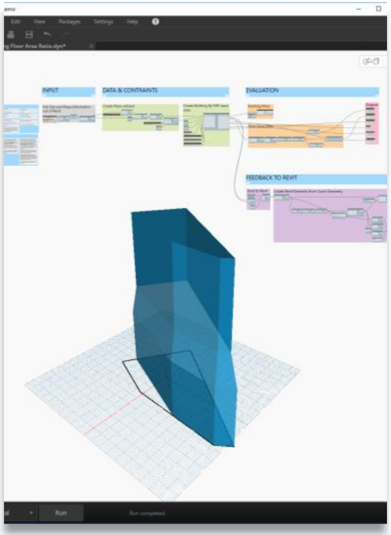
Design Optimization



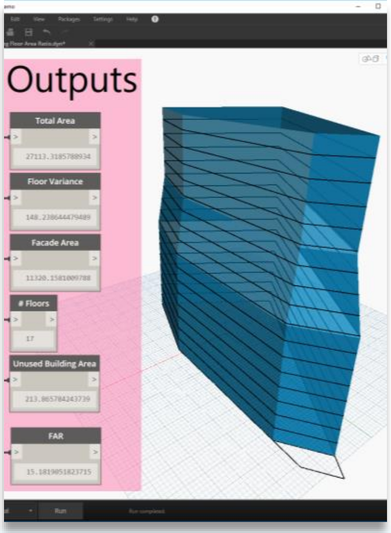
Conceptual Tower Mass Optimization

DYNAMO FOR REVIT



Data and Constraints

DYNAMO FOR REVIT



Define Computational Model

PROJECT REFINERY

Optimization Champion Selection

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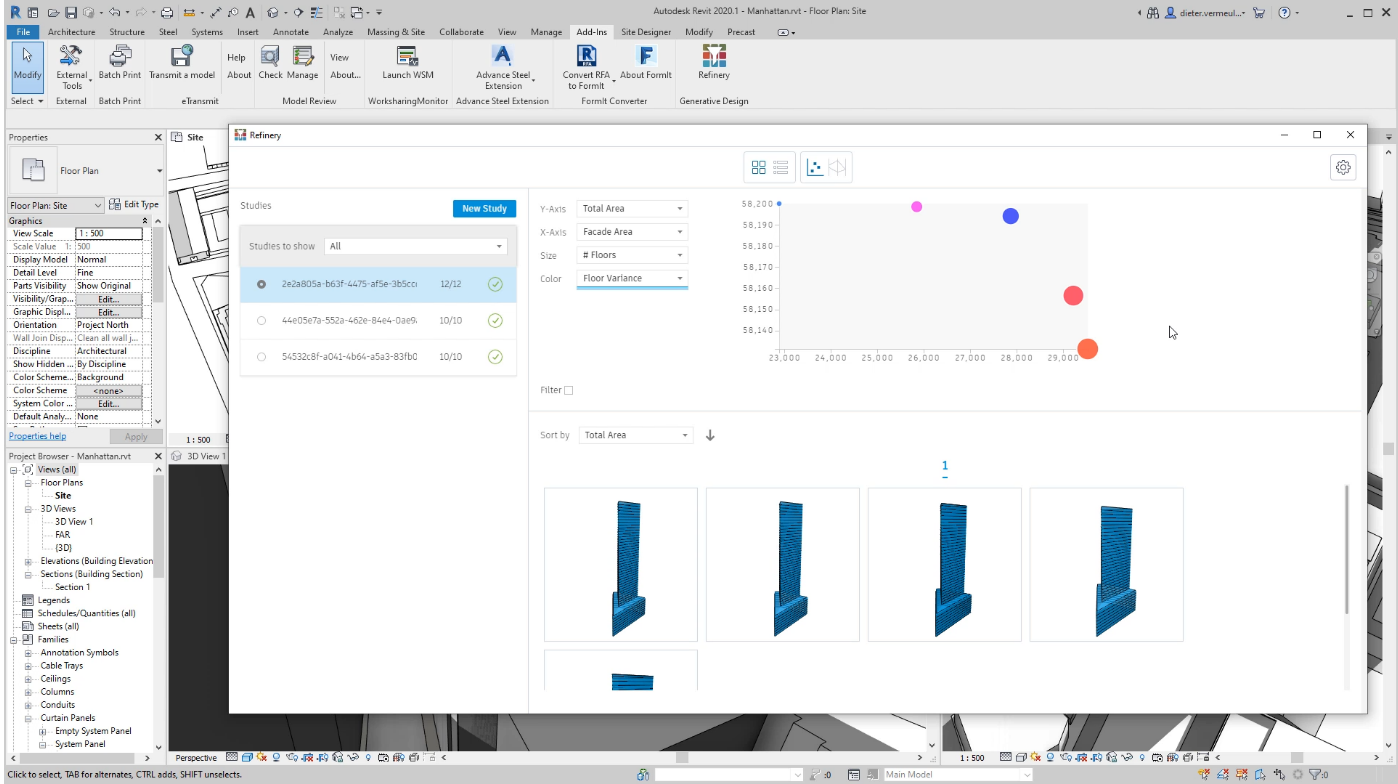
Integrate in design

Conceptual Tower Mass Optimization

Optimization with Refinery



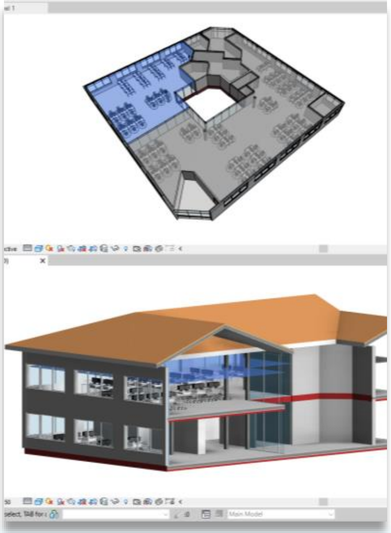
Light Distribution Optimization

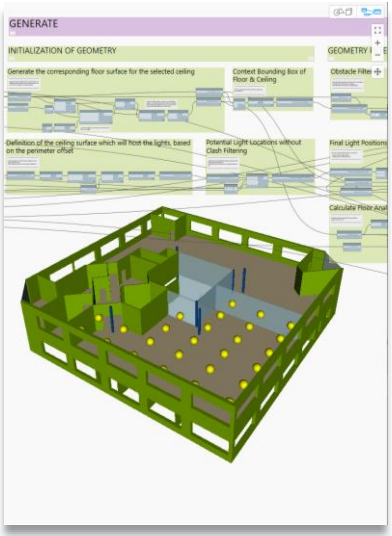
AUTODESK® REVIT®

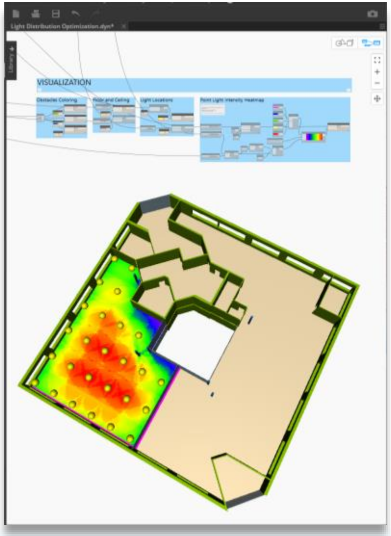
DYNAMO FOR REVIT®

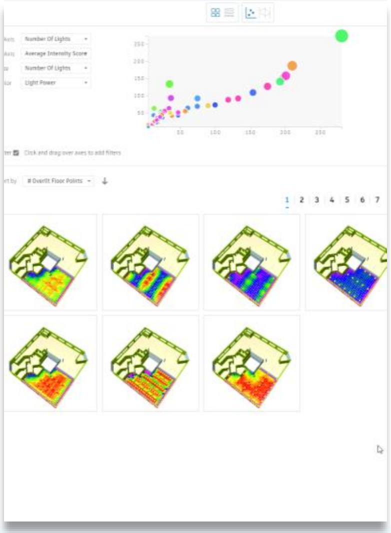
DYNAMO FOR REVIT®

PROJECT REFINERY









Data & Constraints

Generate

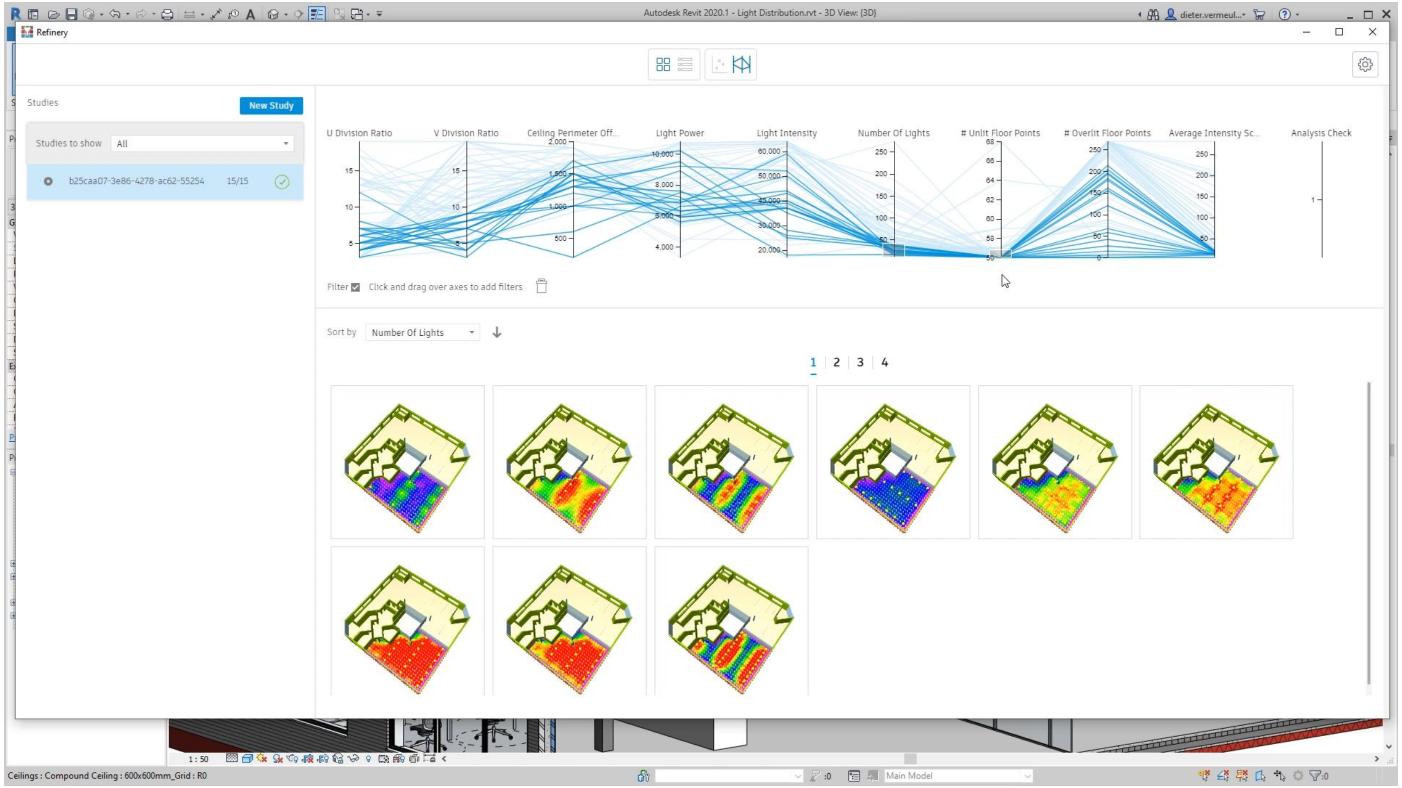
Analyze
&
Ranking

Evolve
Explore Results

Light Distribution Optimization

Design Optimization with Revit, Dynamo and Refinery

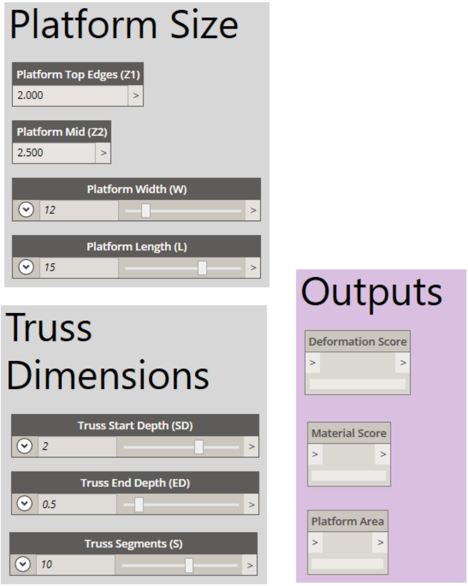
Special thanks for contributing:
Jared Linden, Hoare Lea, UK
Radu Gidei, Matterlab, UK

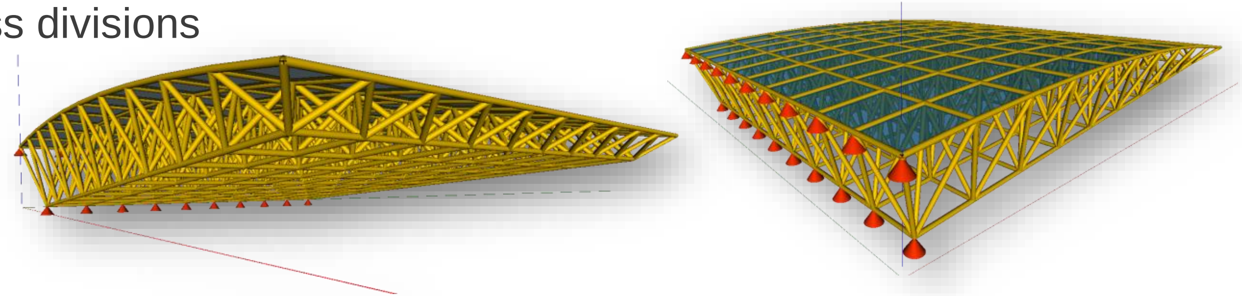


Spatial Truss Optimization

Design Optimization with Dynamo, DynaShape and Refinery

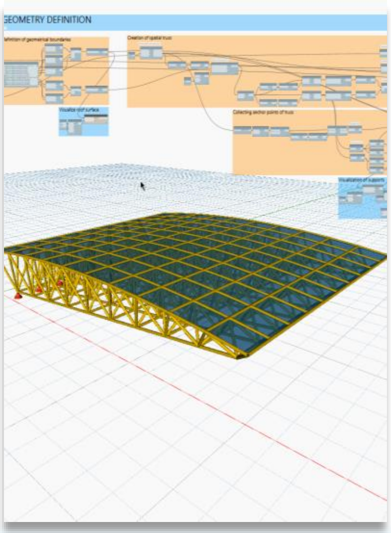
- Search for the best spatial truss configuration with
  - Maximal Platform Area
  - Minimal Deformation
  - Minimal Structure Weight
- by changing the geometry inputs for
  - Width and length of platform
  - Start depth of the truss
  - End depth of the truss
  - Truss divisions





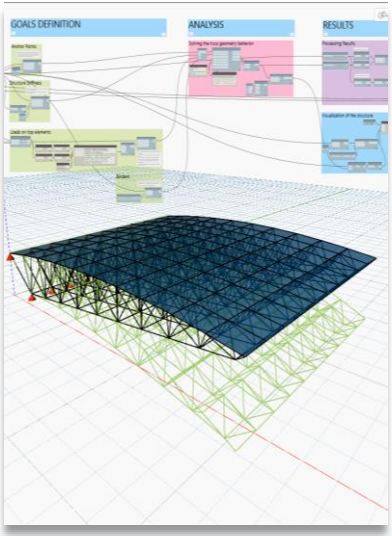
Spatial Truss Optimization

DYNAMO



DYNAMO

DynaShape



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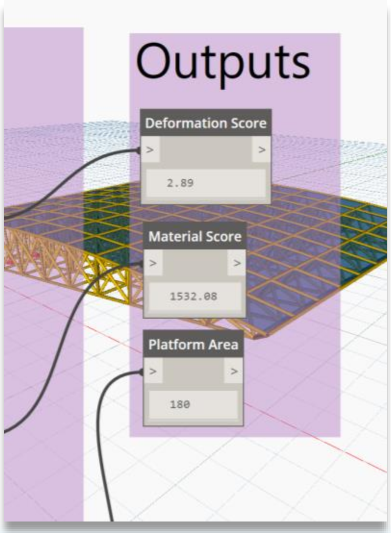

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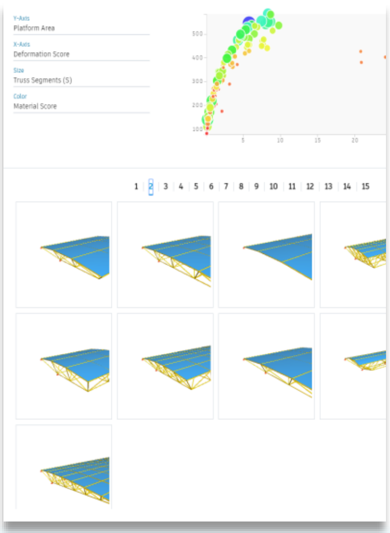
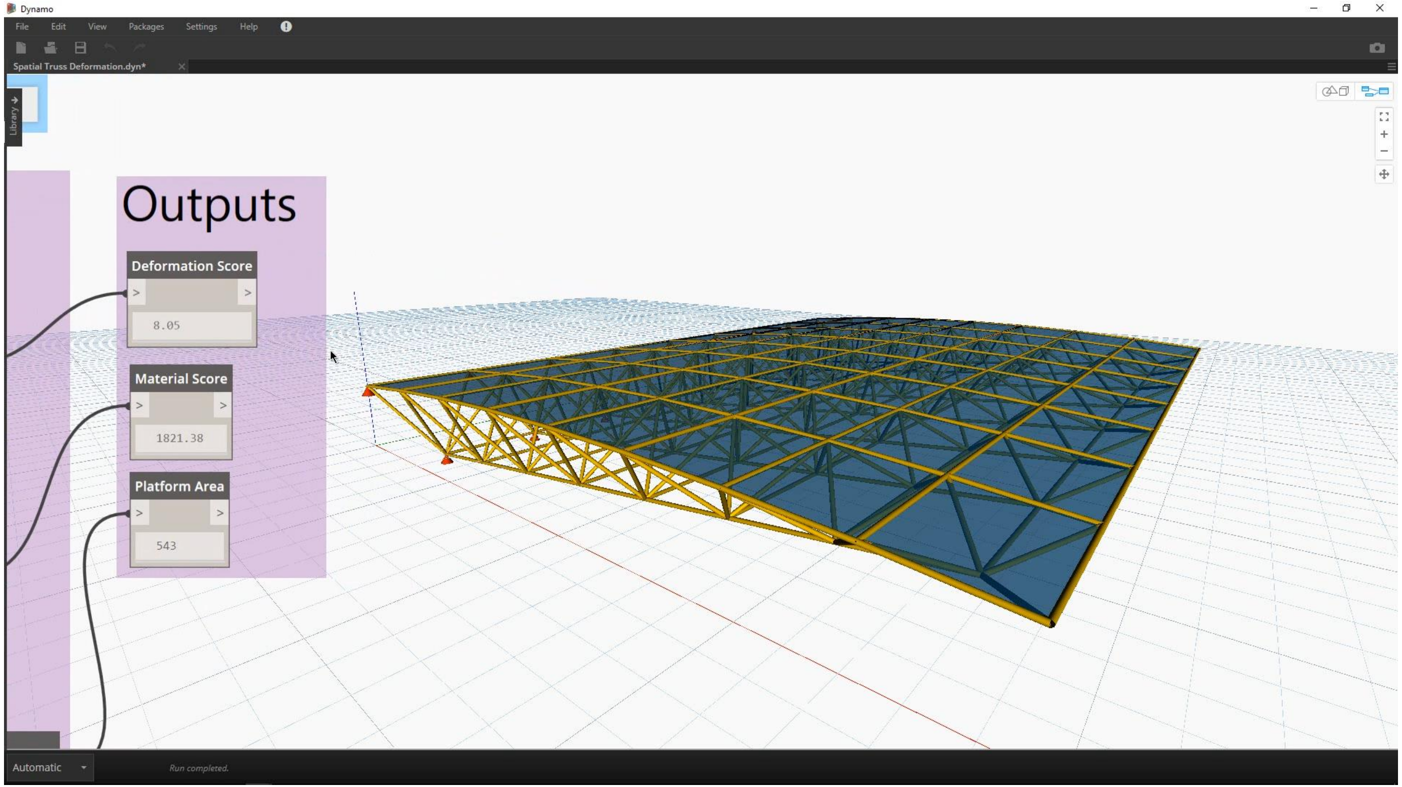


Geometry Definition → Deformation Analysis → Results Evaluation → Optimization in Refinery

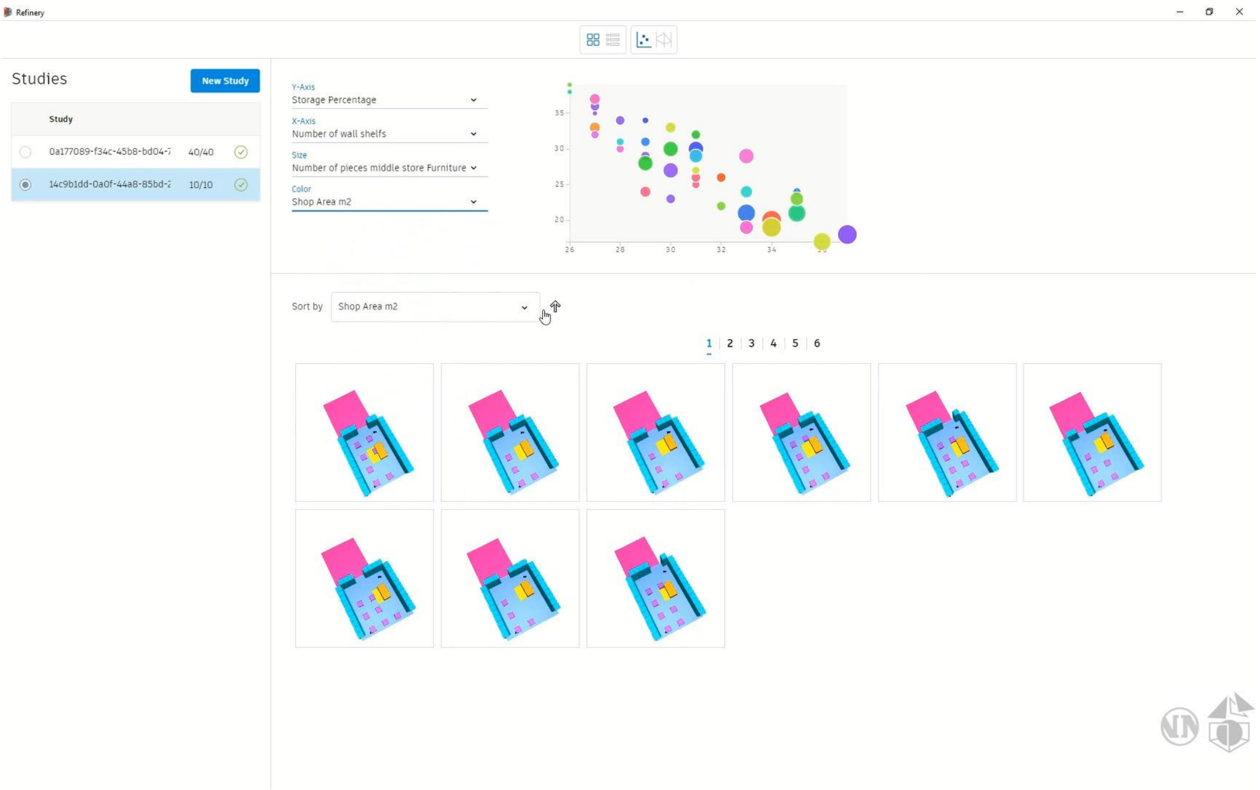
Spatial Truss Optimization

Design Optimization with Dynamo, DynaShape and Refinery



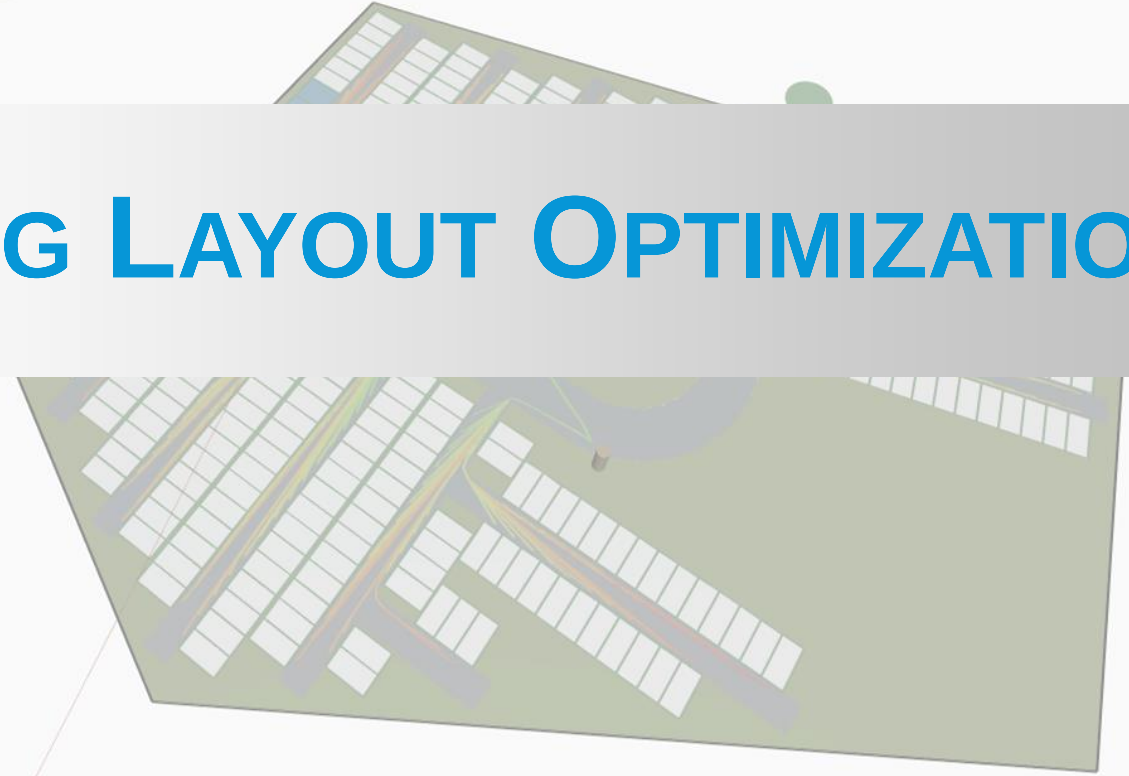
Shop Layout Planning

Optimize the ratio of shop and storage area of a liquor store



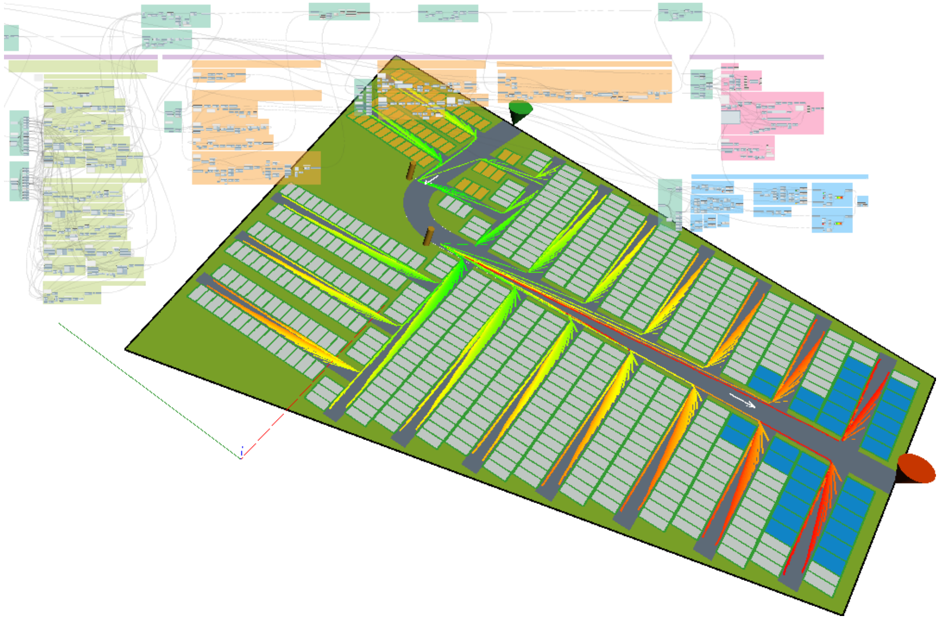
STAMHUIS BOUWBEDRIJF

PARKING LAYOUT OPTIMIZATION



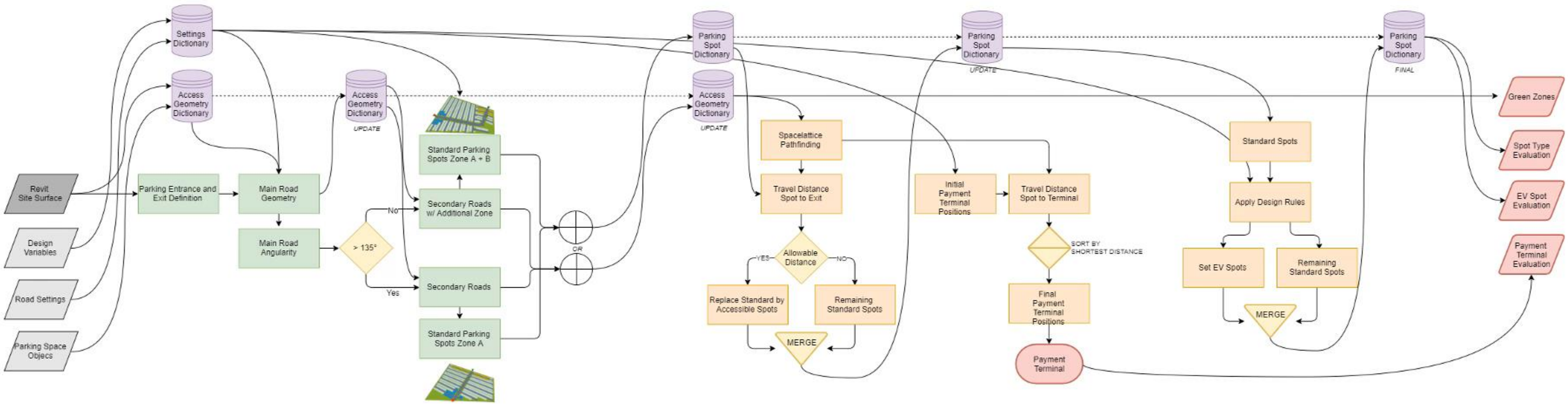
Objective of the Optimization

- Layout of main roads, secondary roads
- Number of parking spots
- Assignment of accessible spots
- Concentration of spots for electrical vehicles
- Green zones
- Walking distances to payment terminals



Parking Layout Optimization

Process



Parking Layout Optimization

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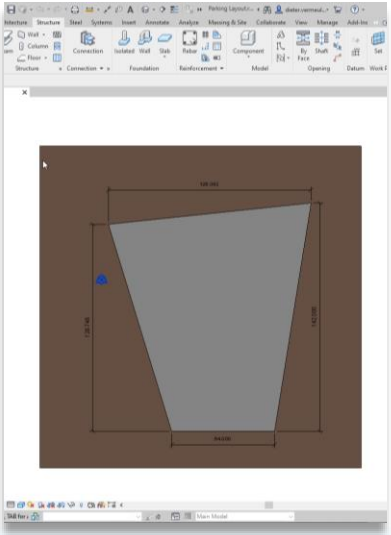
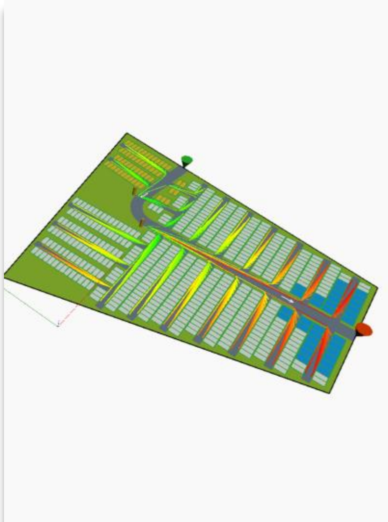


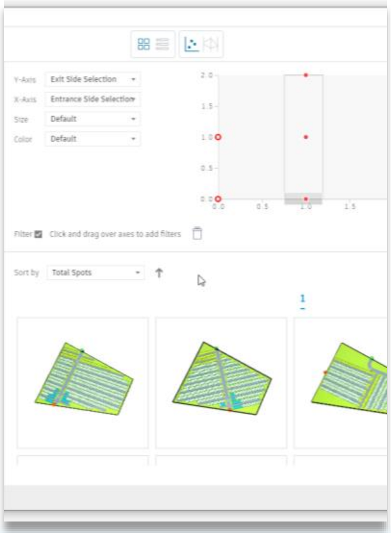
Data & Constraints

DYNAMO FOR REVIT®



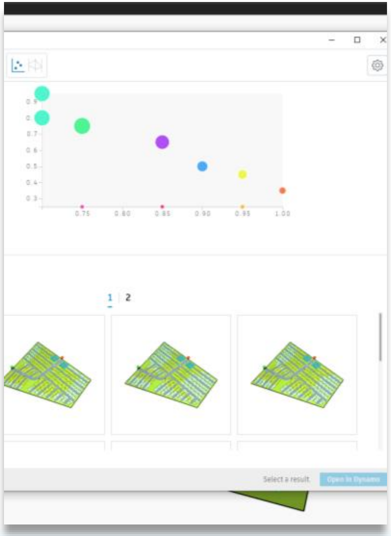
Analysis & Ranking

PROJECT REFINERY



Layout Option Generation

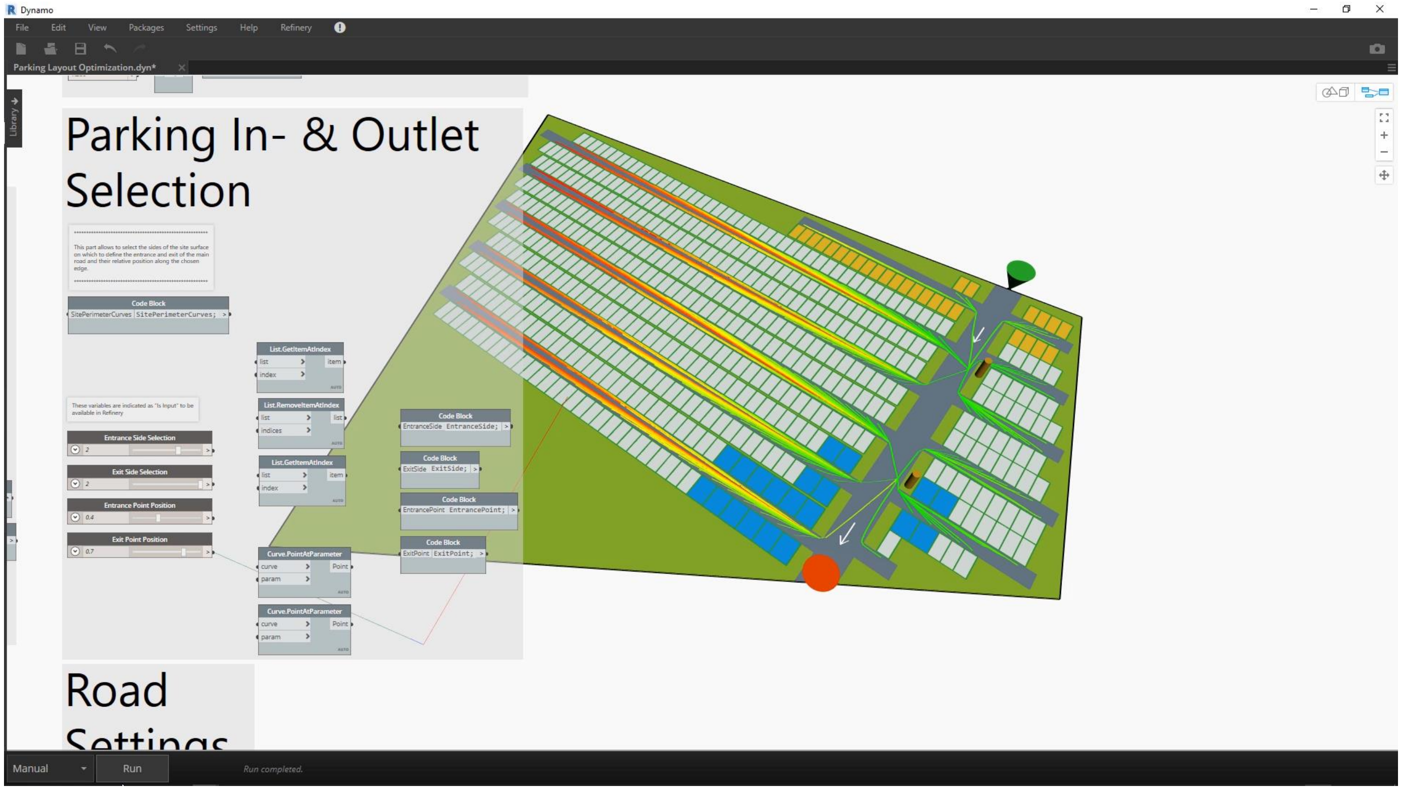
PROJECT REFINERY



Optimization of EV spots and terminals

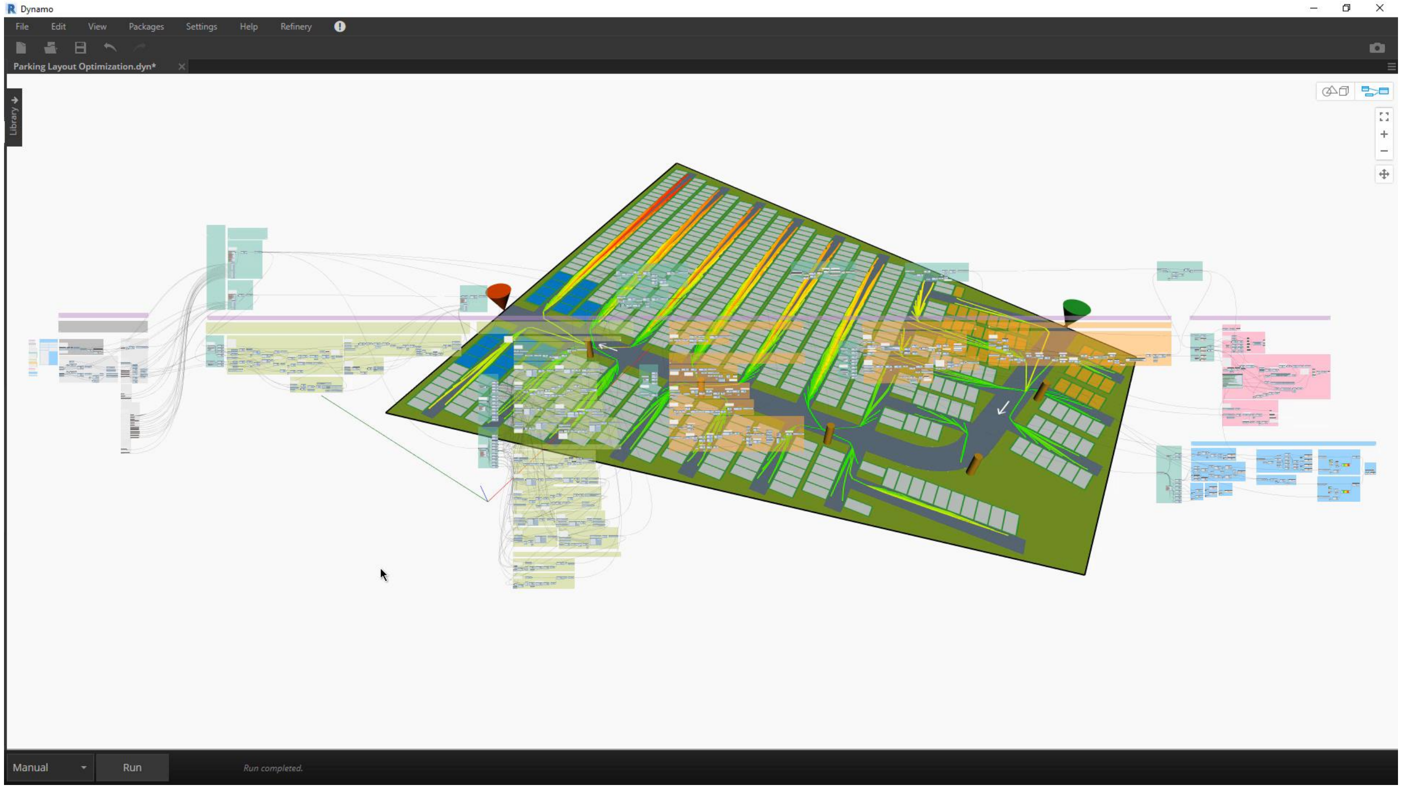
Parking Layout Optimization

Computational Model



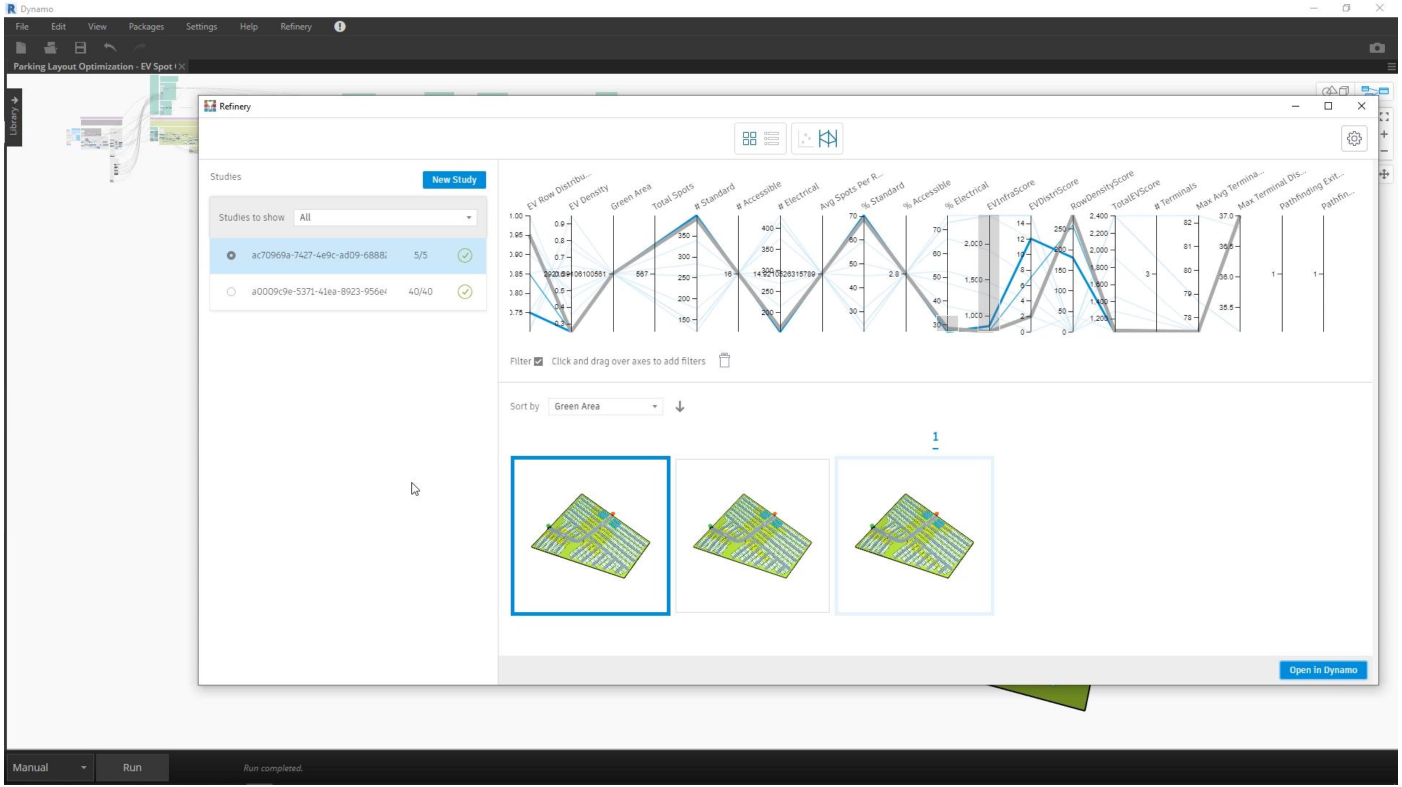
Parking Layout Optimization

Option Generation of Possible Layouts



Parking Layout Optimization

Optimization of spots for electrical vehicles



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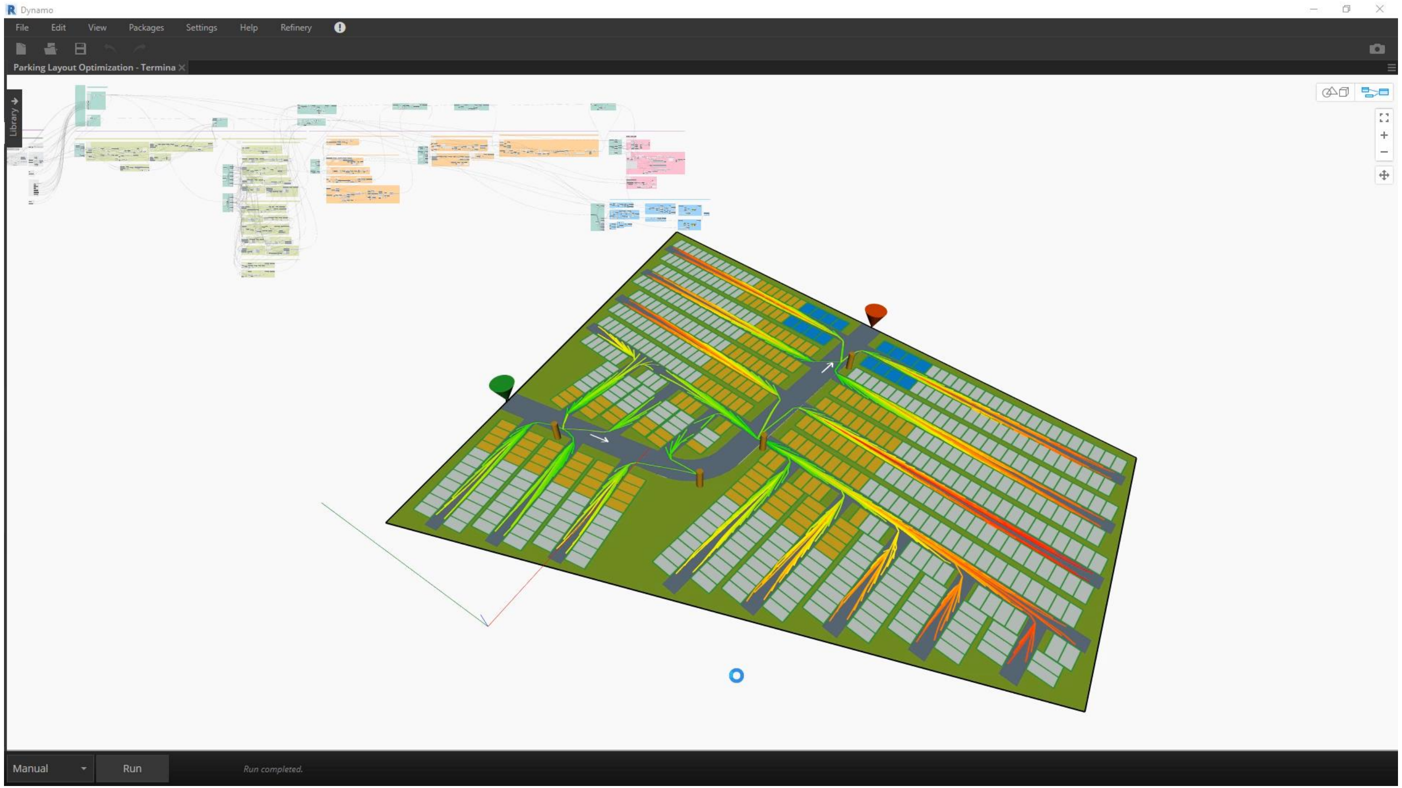
Parking Layout Optimization

Optimization of payment terminals position



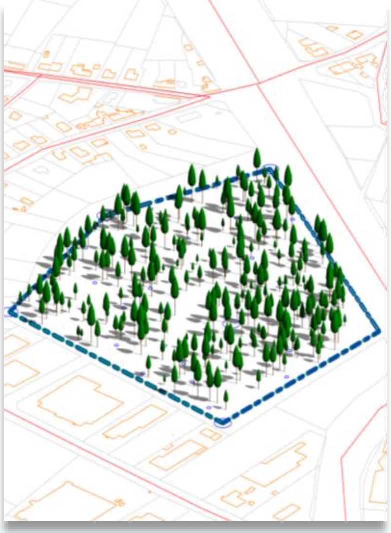
Alternative Site Selection

Script is generically useable

URBAN PLANNING

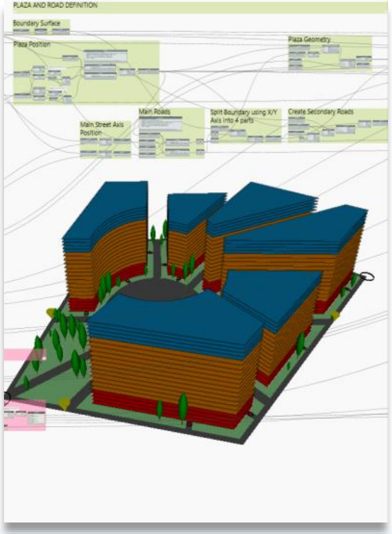
Urban Planning

DYNAMO FOR REVIT®



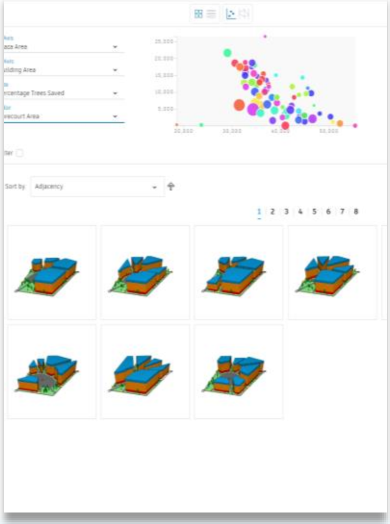
Data and Constraints

DYNAMO FOR REVIT®



Computational Model

PROJECT REFINERY



Optimization of Solutions

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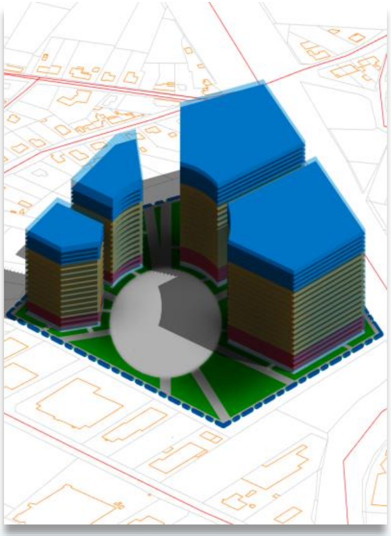
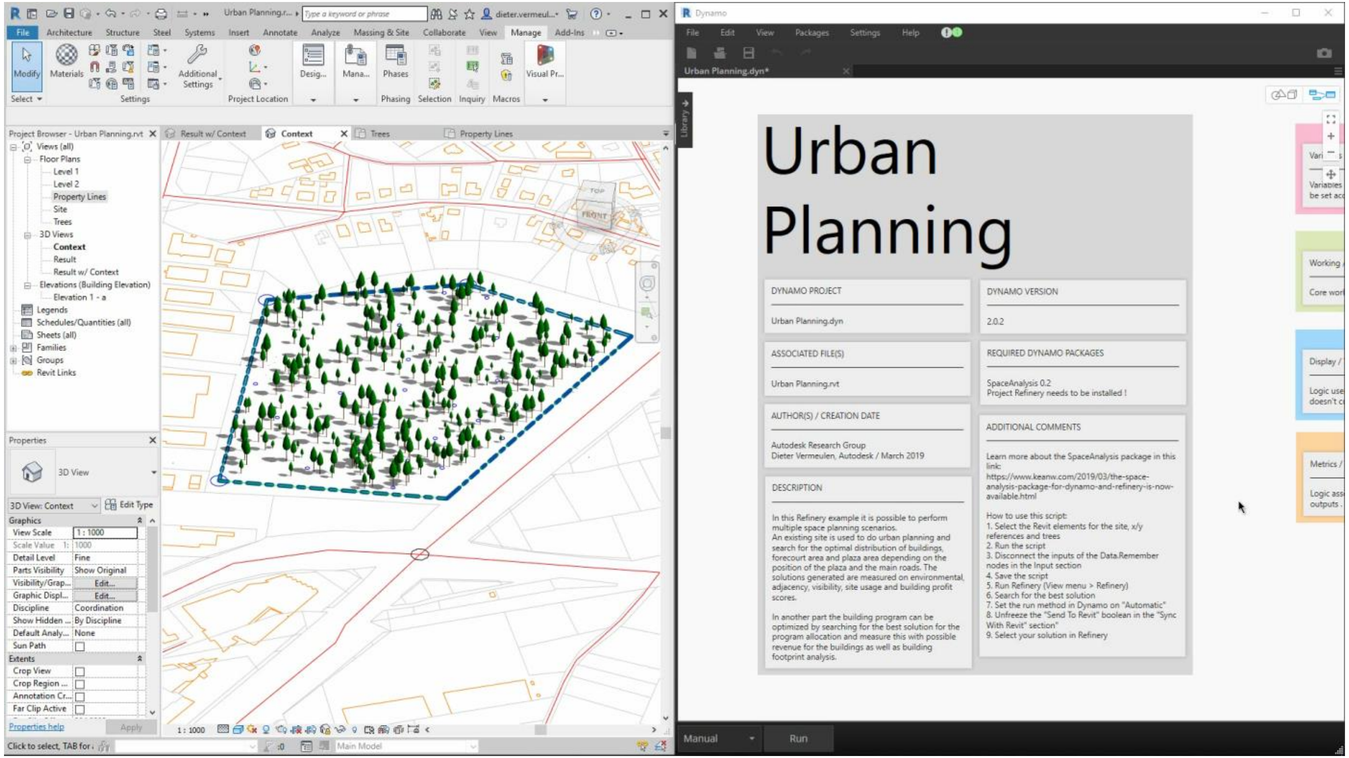


Generate model

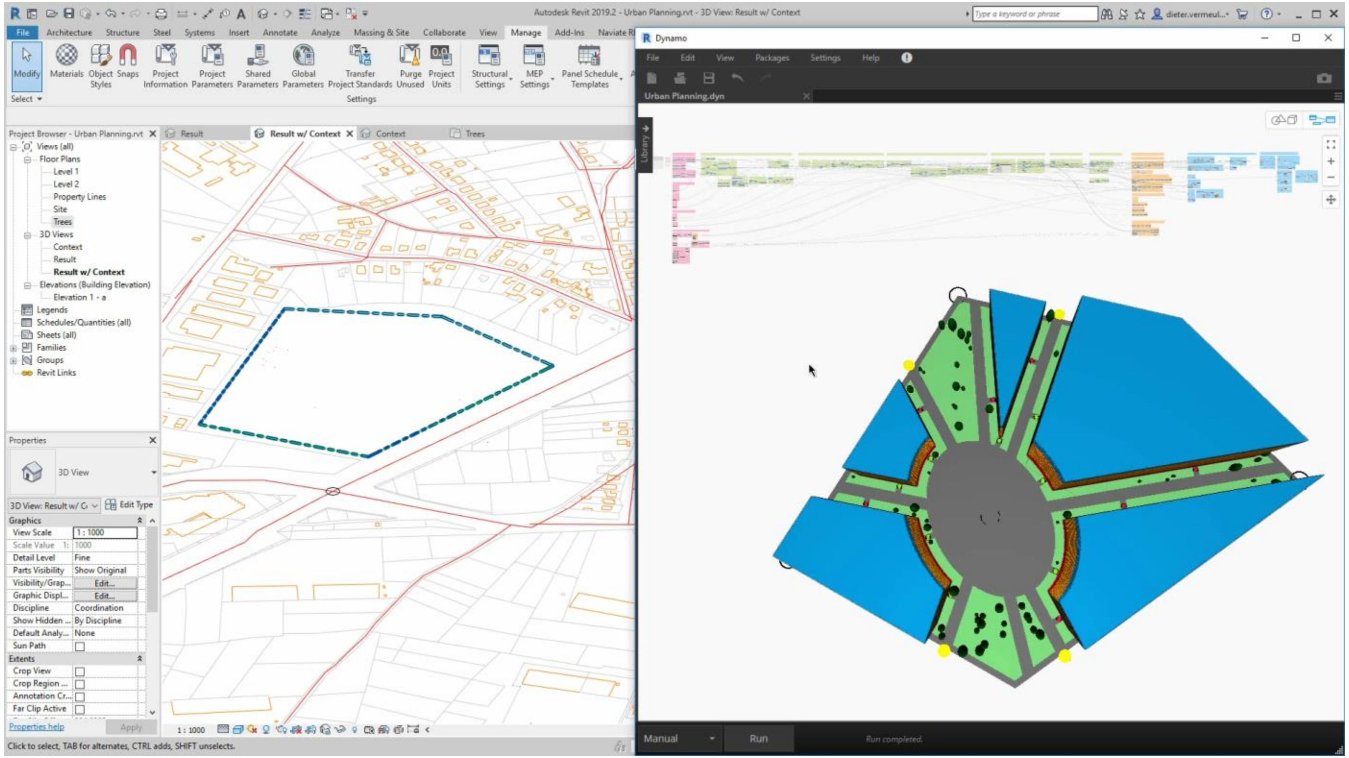
Urban Planning

Computational Model with Dynamo



Urban Planning

Optimization with Refinery



Design Technology Progression

TRADITIONAL DESIGN
RECORDING DECISIONS

PARAMETRIC DESIGN
ASSOCIATING GEOMETRY

GENERATIVE DESIGN
DESCRIBING GOALS + CONSTRAINTS

COMPUTER AIDED DRAFTING

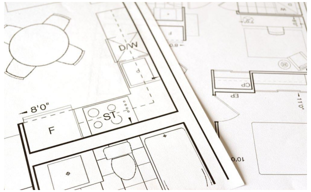
PARAMETRIC MODELING

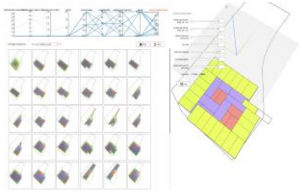
DESIGN AUTOMATION

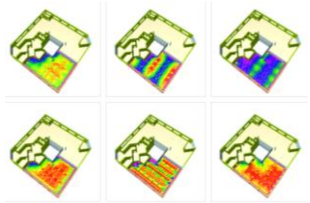
COMPUTATIONAL MODELING

OPTION GENERATION

DESIGN OPTIMIZATION







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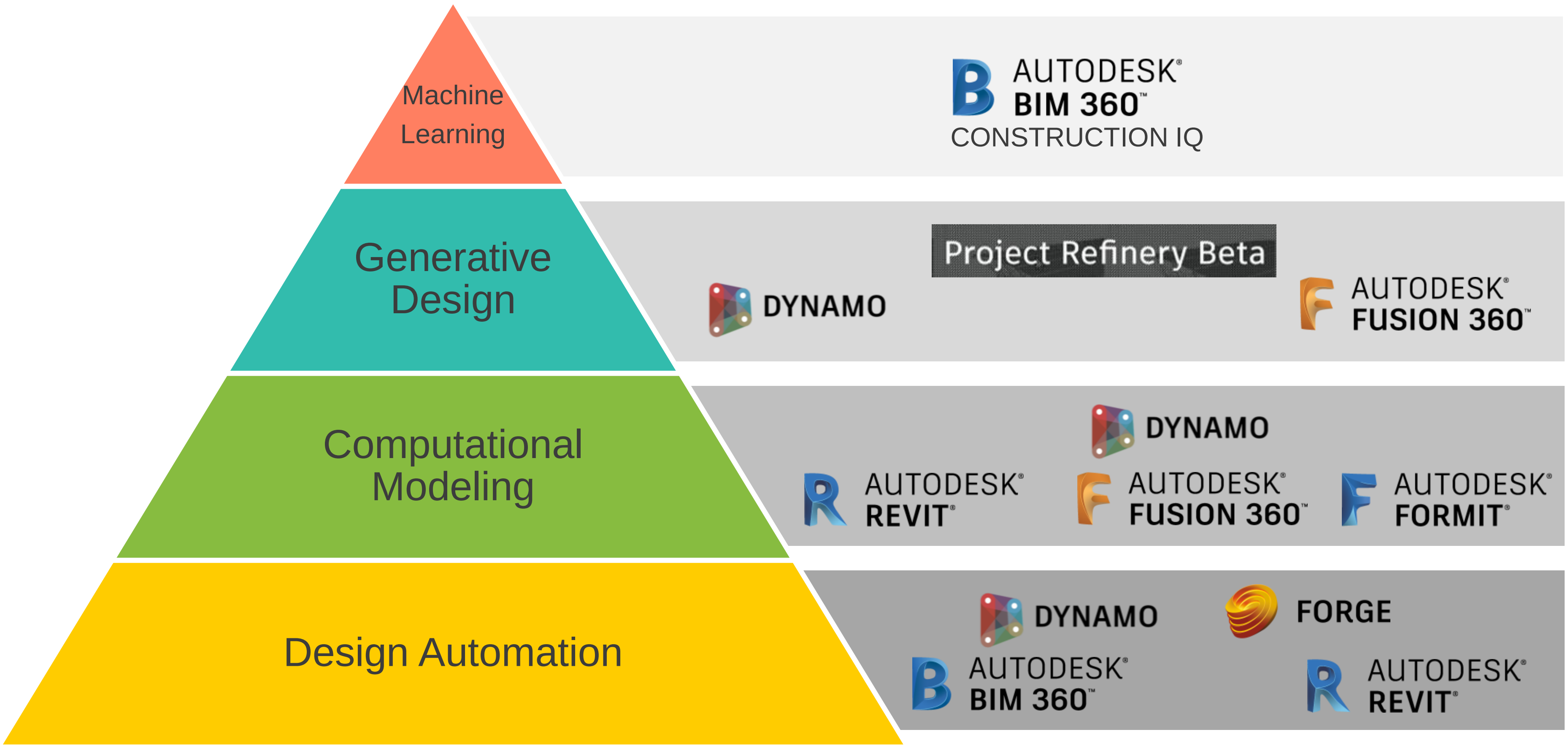
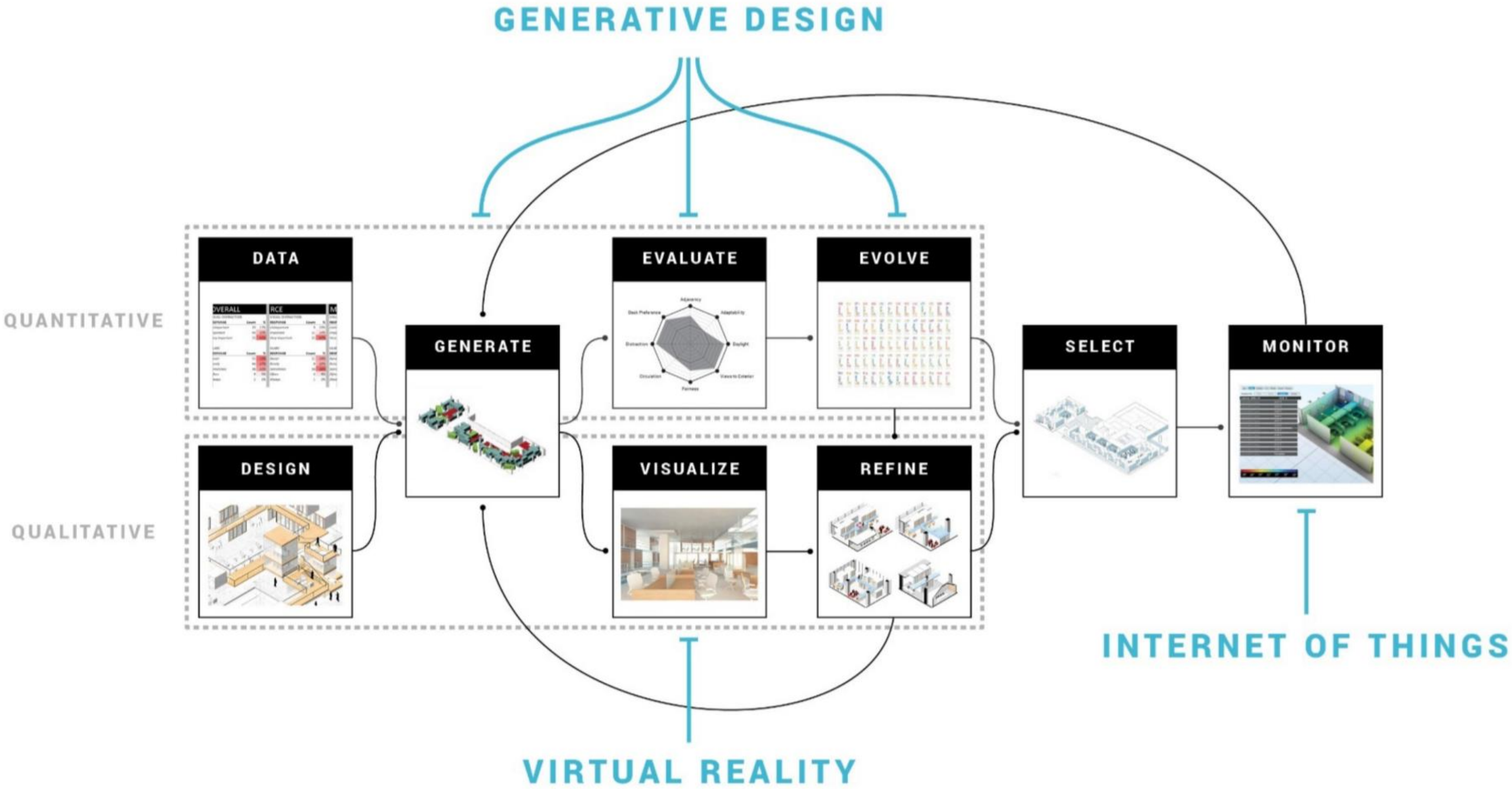

Machine Learning
AUTODESK BIM 360 CONSTRUCTION IQ
Generative Design
Project Refinery Beta
DYNAMO
AUTODESK FUSION 360
Computational Modeling
DYNAMO
AUTODESK REVIT
AUTODESK FUSION 360
AUTODESK FORMIT
Design Automation
DYNAMO
FORGE
AUTODESK BIM 360
AUTODESK REVIT



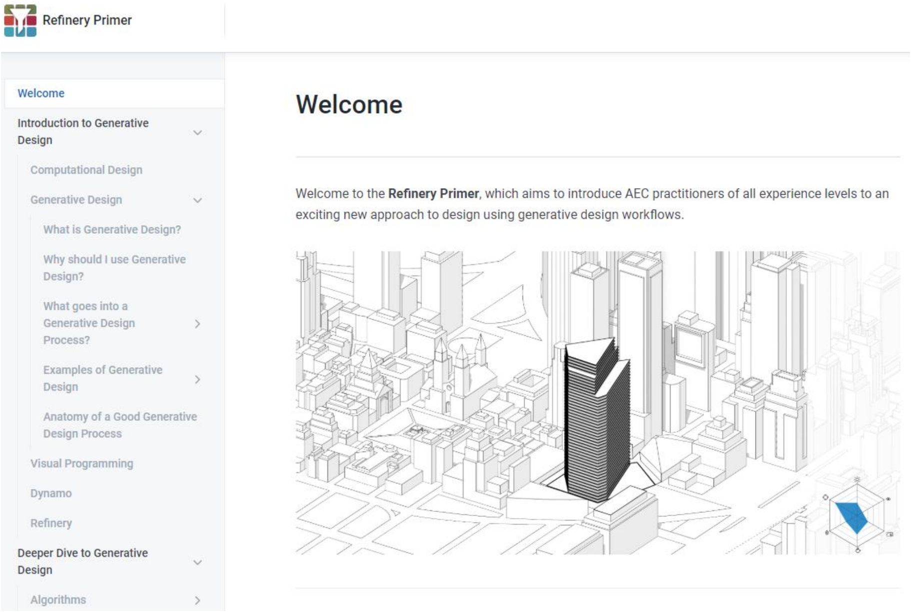
GENERATIVE DESIGN
QUANTITATIVE
QUALITATIVE
DATA
DESIGN
GENERATE
EVALUATE
VISUALIZE
EVOLVE
REFINE
SELECT
MONITOR
VIRTUAL REALITY
INTERNET OF THINGS

What level of design progression ?

You know what to do ! 🤜

Check this out!

https://refineryprimer.dynamobim.org/



The full presentation with embedded videos

will be available for download on

[this link]

after November 18th, 2019

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