

From Design Automation to Generative Design in AEC

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Learning Objectives

- Learn how to apply design automation techniques in your designs
- Learn how to execute computational modelling and bring it to generative design
- Learn how to build your own optimization with Dynamo and Refinery in different scenarios
- Learn about space and urban planning in practice

Description

In the architecture, engineering, and construction (AEC) industry, we are challenged to consider many design options, to find the fittest solution in the shortest time, and to be leaders in economic and sustainable designs. During this presentation, you'll learn about how computational design techniques can help you improve your design process for buildings. In this class, you'll discover how our products generate better outcomes for designs using computational and generative design techniques. You'll get an overview of how 'traditional' design improves with design automation, computational modeling, and generative design methods with Dynamo and Refinery. All of this will be taught using examples from the architectural, urban planning, and structural industry.

Speaker

Working as a Technical Sales Specialist AEC for the Northern European region at Autodesk, Dieter is specialized in the products of the Computational Design and Engineering portfolio. Within that domain he helps their customers to learn more about new and innovative workflows and solution strategies. He is an evangelist and big influencer of the power of generative and computational design in the AEC industry. He has been given numerous presentations about these topics at conferences worldwide.



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Table of Contents

Learning Objectives	1
Description	1
Speaker	2
Table of Contents	3
Disclaimer	5
Introduction	6
Progression from Traditional to Generative Design	7
Generative design as an Autodesk product strategy	9
Goals, Generators, Evaluators: A Generative Design Mental Model	10
Definition of 'Generative Design'	10
Generative Design Process	11
Generative Design in AEC with "Project Refinery"	12
Types of studies with Refinery	13
Optimize in Refinery	14
Project Refinery – Interesting Information	14
Getting Started	14
Refinery Sample Files	14
Examples	15
Example 1: Conceptual Tower Mass	16
Description	16
Packages	16
Workflow	17
Dynamo Script Overview	18
Dataset	19
Example 2: Structure Waste Optimization	20
Description	20
Packages	20
Workflow	21
Dynamo Script Overview	22
More Information	23
Dataset	23
Example 3: Light Distribution Optimization	24
Description	24
Packages	24

Workflow.....	24
Dynamo Script Overview	25
Credits	27
Dataset.....	27
Example 4: Spatial Truss Optimization.....	28
Description.....	28
Packages.....	29
Workflow.....	29
Dataset.....	29
Example 5: Tower Crane Positioning	30
Description.....	30
Packages.....	30
Workflow.....	31
Dynamo Script Overview	32
More Information	33
Dataset.....	33
Example 6: Urban Planning.....	34
Description.....	34
Packages.....	34
Workflow.....	35
Dataset.....	35
Example 7: Parking Layout	36
Description.....	36
Packages.....	37
Workflow.....	37
Known Issue	38
Dataset.....	39
Downloadable Materials.....	40
Other references	41
More Generative Design Classes?.....	41

Disclaimer

This presentation may make statements regarding future events and development efforts for our products and services.

These statements reflect our current expectations based on what we know today. Our plans are not intended to be a promise or guarantee of future delivery of products, services or features and purchasing decisions should not be made based upon these statements.

We do not assume any responsibility to update this roadmap to reflect events that occur or circumstances that exist after the publish date of this roadmap.

Introduction

Imagine you are planning the interior for an office building. In one scenario, your first step is to define the design parameters by describing the amount of light you want for desks depending on the season, the desired views for conference rooms, and the maximum amount you want to spend for construction. After you define the criteria, your design tools generate all the best possible outcomes with a single analysis and evaluate the alternatives. This all takes place in a fraction of the time that it normally takes you to manually arrive at one or two best guess approximations. In the other scenario, you sit down and manually calculate how your design parameters impact other aspects of the office building like energy loads and construction costs. You tediously go through the hundreds of location variables - kitchens, bathrooms, desks, or communal space placements - produced by your choices as the design develops.

This entire process takes days or weeks as you review the options.

How might it change the way you design if, like in the first scenario, your software could help discover the implications of the goals you define instead?

Now think about a typical construction project and shifting your approach to the actual procedure of building - and not just what you're building, but how it is built. Cost overruns and waste are always the enemies of construction. What if you could mitigate these potential risk factors with better recommendations on materials or by scheduling and sequencing job site work?

What is the right strategy for placing precast concrete panels?

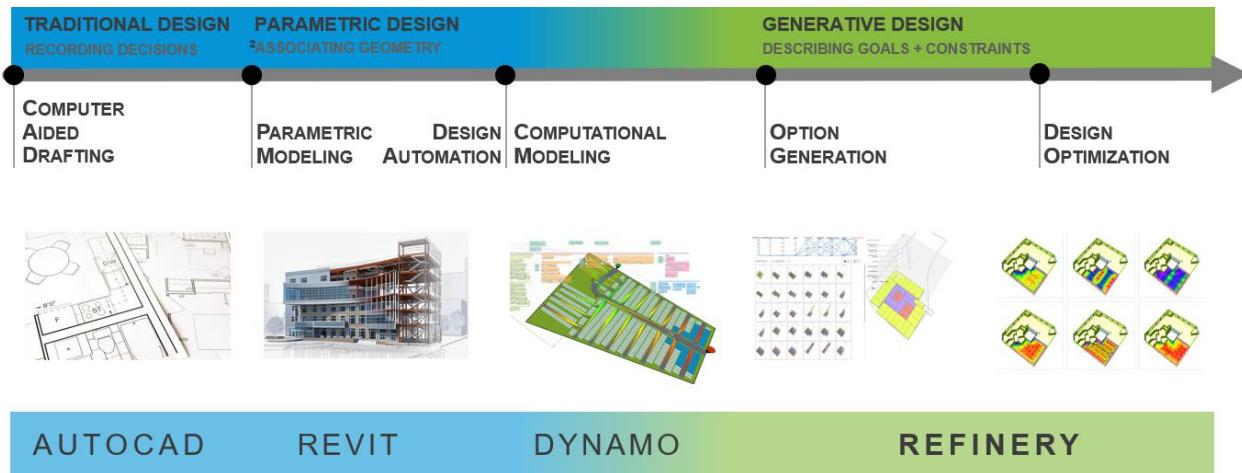
Or the optimum placement of a crane? A software algorithm can test numerous scenarios for potential solutions to find the best one.

These are the objectives of generative design; a technique that uses computation to augment the designer's ability to define, explore, and choose alternatives through automation. Generative design is more than a methodology; it embodies many applications and techniques. It will continue to grow more potent and useful with technology advancements such as artificial intelligence and machine learning.

But, at its heart, generative design is about providing practitioners with the ability to quickly explore, optimize, and make informed decisions to complex design problems.

Progression from Traditional to Generative Design

The design technology in the AEC Industry is progressing towards the Generative Design model. The biggest difference can be seen in the mindset of a designer.



In **Traditional Design** a designer uses basic techniques like sketching to describe the idea that is inside the mind.

For example: "Drawing of a wall with a door in it"

With AutoCAD the designer can apply Computer Aided Drafting.

In **Parametric Design** the user defines relationships between traditionally drawn or sculpted elements.

For example: "This door depends upon this wall and will move with it."

Contrast this with the traditional CAD environment, where each point, line, text, etc has no relationship to any other. In the parametric design environment changes to one piece of data creates changes in other pieces of data. Generally, these systems are limited by the ability to make direct relationships, such as a window that depends on a hosted relationship to a wall. In the building industry, Revit can be used for this stage.

With **Design Automation** the user gets the ability to automate tasks within parametric models, by driving the parameters with automated scripts.

For example: "Create a door for every x meter of a wall"

The geometry and data are outcomes of the automatic execution of a set of rules and can use traditional modelling elements as inputs. This technique is a level of abstraction from parametric modelling where arbitrary pieces of data are related to others.

Typically, this can be done with Revit and Dynamo.

In **Computational Modelling**, the user explicitly describes a process to create a design outcome.

Example: "Create a number of doors in the wall and evaluate how many exits per unit length"

This method is very close to design automation, except for that here we also have the possibility to evaluate the design outcomes.

It is a generalized way to create data as well as relationships between data. The kinds of relationships that can be defined are versatile (if-then-else, looping, recursive) and users can create more customized reactions to changes in the system.

With **Option Generation**, the user explores of variations of computed rules given different starting points for the calculations

Example: "Show me all the valid places a door could be placed on this wall"

Given a Parametric Model or Computation environment, there are an infinite number of variations you could get by changing and combining inputs. The resulting variations are not distinguished based on one being any better than another. The user is given an opportunity to sort and choose desired variation(s).

With **Design Optimization**, the user defines explicit goals and a computational or parametric model is automatically explored for states that fit those goals

Example: "Find the valid places where doors on this wall are closest to exits"

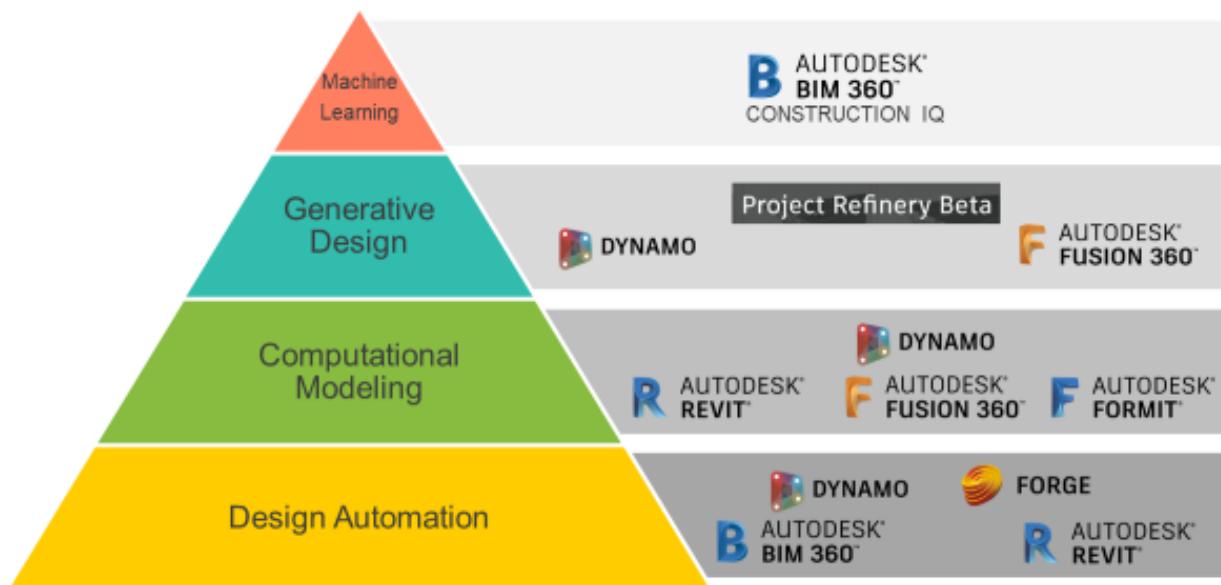
Given a Parametric Model or Computation environment, display the examples of possible states of the model that have certain desirable characteristics.

Ultimately, with **Machine Learning**, the user states outcomes and the system returns conforming results based on historical data.

Example: "Layout interior doors for a hospital egress"

Given a desirable set of characteristics, generate a design or a set of designs that fit the description. Instead of starting from a parametric or computational model, ML based tools use large "learning" datasets where the computer finds patterns that are inferred instead of being explicitly stated.

The products in that area, within the D&M and AEC Industry, that Autodesk is providing are illustrated below:



Generative design as an Autodesk product strategy

Generative design is guiding Autodesk's strategy for creating a better world by encoding professional knowledge. Autodesk's generative design solutions have three characteristics:

- Establish a set of rules that express project design intent and constraints.
- Display the possible outcomes of rules systems to facilitate decision making.
- Capture and preserve information for reuse by industry-specific applications.

The application of Autodesk generative design solutions results in higher quality work, greater speed/productivity, and lower costs. While there are a number of products using some combination of these approaches, we'll talk in more detail about Project Refinery, a beta application that gives users the power to quickly explore and optimize design logic that is encoded in Dynamo.

Rules definition in Refinery comes primarily from Dynamo, a generalized programming environment that allows users to create designs in a step-wise fashion (like a recipe: first do this, then this, etc.) and evaluate them (how big is my result, how far is it from a target geometry, etc.). Project Refinery then executes these algorithms many times to either explore random variations on the base algorithm, systematically exercise all the possible inputs and outputs to the system, or evolve the system by intelligently changing inputs to "find" targeted performance metrics.

Project Refinery also provides another set of features specifically tailored for users to visualize and understand the outputs of the generative systems. Generative systems that have more than one "optimal" goal can produce results that are confusing to understand. Refinery displays numerical, graphical, and geometric results to allow for sorting and comparison. Users can choose options that satisfy requirements or aesthetic sensibilities that might not have been defined in the algorithms themselves.

While drawing on paper or use of generalized programming languages or CAD are a perfectly reasonable part of a generative process, Refinery attempts to drive decisions into practice by being directly connected to mainstream building production applications. The more a generative design process for AEC is deeply connected to existing and emerging project delivery toolchains, the more the user can drive project delivery with optimal outcomes. Current beta workflows are part of a Revit delivery process, and the underlying architecture of the application will allow for rapid integration into additional applications in the future (such as FormIt and Civil 3D).

Goals, Generators, Evaluators: A Generative Design Mental Model

While this is not the only way to think about generative design processes, we have found that a concept of “Goals, Generators, and Evaluators” has been a helpful framework. Goals are a statement of Why we are designing something in the first place, the north star ideas we are pursuing. “A room with a connection to the outdoors”, “a storefront that is attractive to passers-by”. Evaluators determine WHAT we will measure our design against to determine if it works. “All occupants should have visual access to the windows”, “More than 75% of pedestrians on this section of street should be able to read the building store signage”. Generators are HOW we are going to go about making possible design solutions, “Iteratively place desks around the room by random UV coordinates”, “Increase size of signage until visible from all angles”.

In the broad sense, a generative design can be simply be the creation and execution of Generators. An example of a simple Generator would be explorations or "optioneering" done with a Dynamo graph with a slider. A user could move a slider back and forth, seeing options and looking for something that feels right.

Generators become most useful when harnessed to Evaluators that are informed by Goals. In the absence of defined Evaluation logic, a designer may generate lots of options and simply sort and examine the results. If you can measure what is important, you can filter out crappy options and start making decisions quickly.

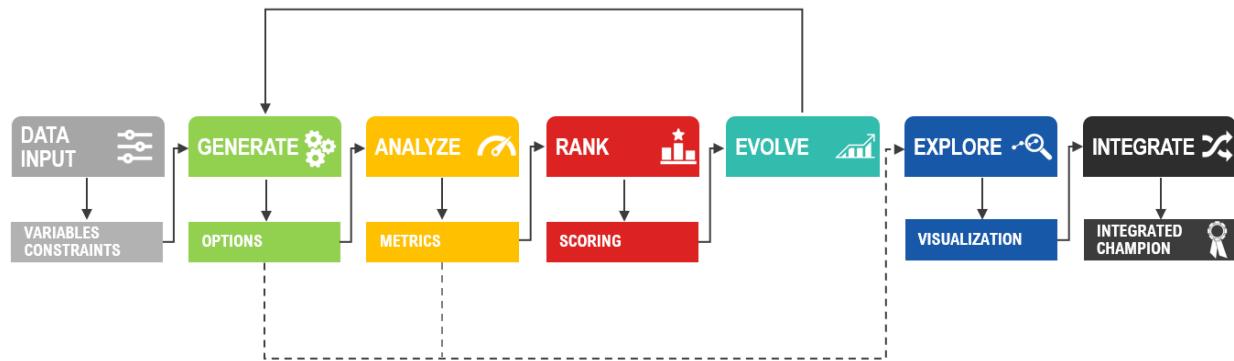
Definition of ‘Generative Design’

A goal-driven approach to design that uses automation to give designers and engineers better insight so they can make faster, more informed design decisions. Your specific design parameters are defined to generate many—even thousands —of potential solutions. You tell the software the results you want. With your guidance it arrives at the optimal design along with the data to prove which design performs best.

Learn more on how Autodesk looks at Generative Design in the AEC Industry here:
<https://www.autodesk.com/solutions/generative-design/architecture-engineering-construction>



Generative Design Process



Generative design allows for a more integrated workflow between human and computer, and as a result both are required to undertake a series of steps that allow the process to take place. These steps can be categorized into the following stages: generate, analyze, rank, evolve, explore, integrate.

Generate

This is the stage when design options are created or generated by the system, using algorithms and parameters specified by the designer.

Analyze

The designs generated in the previous step are now measured or analyzed on how well they achieve goals defined by the designer.

Rank

Based on the results of the analysis, design options are ordered or ranked.

Evolve

The process will use the ranking of the design options to figure out in which direction designs should be further developed or evolved.

Explore

Generated designs are compared or explored by the designer, inspecting both the geometry and evaluation results.

Integrate

After choosing a favorite design option, the designer uses or integrates this design into the wider project or design work.

Here are more resources that may help explain some of the terminology and thinking around generative design techniques:

- David Stasiuk from the Proving Ground on Design Modelling Terminology:
<https://archinate.files.wordpress.com/2018/06/dstasiuk-design-modeling-terminology1.pdf>
- Danil Nagy from The Living on Generative Design:
<https://medium.com/generative-design>
- [Evolutionary Principles applied to Problem Solving](#) by David Rutten

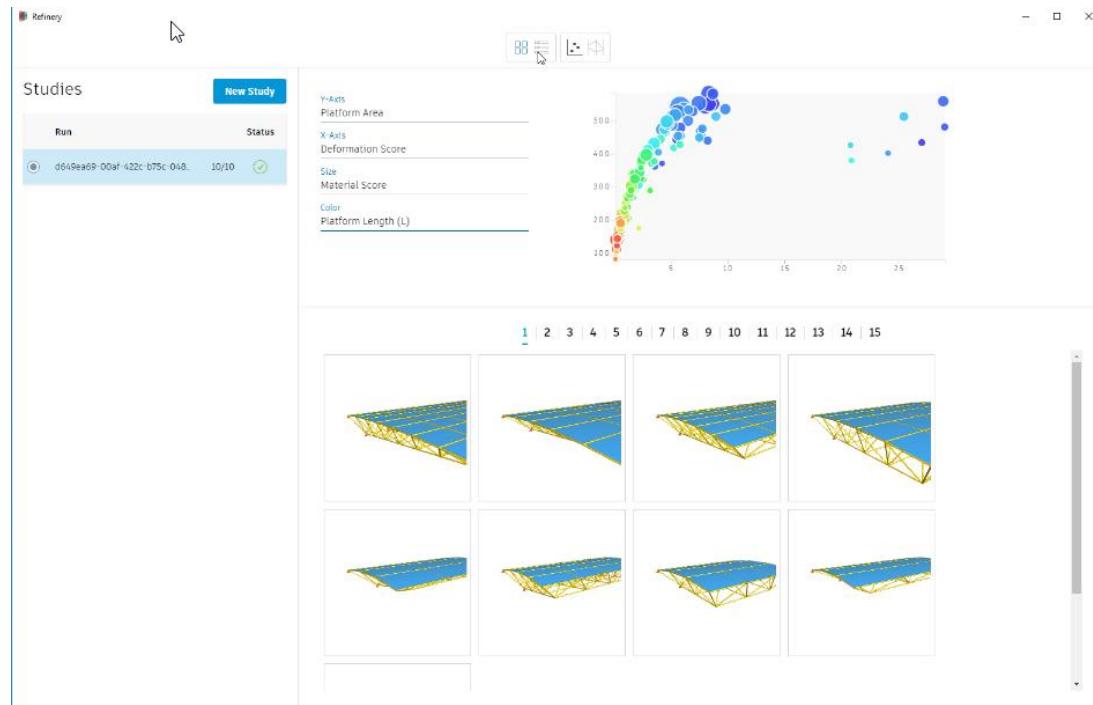
Generative Design in AEC with “Project Refinery”

‘Project Refinery’ is an Autodesk generative design beta for the architecture, engineering and construction industry. It gives users the power to quickly explore, evaluate, and optimize their Dynamo designs.

Project Refinery lets you create design options, set goals, and optimize for those goals. When you choose to maximize or minimize designated outputs, Refinery will return the best options. It also allows users to use the power of the Dynamo Package Manager and run custom nodes, including Python nodes. Refinery runs locally on your computer and allows custom code to take part in design option generation.

Refinery will run in Dynamo for Revit or Dynamo Sandbox and includes a node to cache Revit data for use in option generation. Refinery is still a beta project. There are rough edges, but if you would like to try it out and work with us to advance generative design for AEC we would be thrilled.

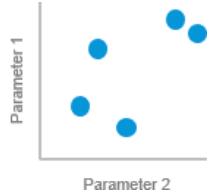
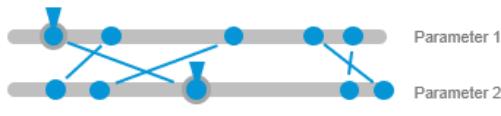
Refinery uses the NSGA-II optimization algorithm (a type of genetic algorithm), which is a meta-heuristic optimization algorithm for multi-objective optimization. Genetic algorithms are commonly used to generate high-quality solutions to optimization and search problems by relying on bio-inspired operators such as mutation, crossover and selection. A genetic algorithm is a population-based optimization. Population-based approaches maintain and improve multiple candidate solutions, often using population characteristics to guide the search. Each round of the optimization processed in the genetic algorithm is called a generation. So, when you set the generation value to 40, the process of selection, cross over, and mutation happens 40 times for each population of 40 designs. You can read more here. The seed simply says where the algorithm should start. If you keep the seed at "64" and then do another run with the same inputs, you should get the same answer.



More information and beta access: <https://www.autodesk.com/solutions/refinery-beta>

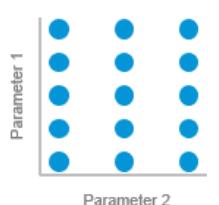
Types of studies with Refinery

RANDOMIZE



With this study type you can obtain random input configurations.

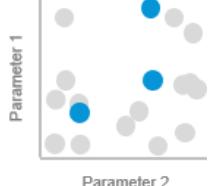
CROSS PRODUCT



If you want to survey the whole design space, you can choose for the “cross-product” option.

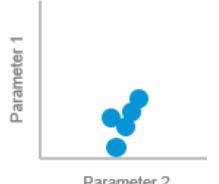
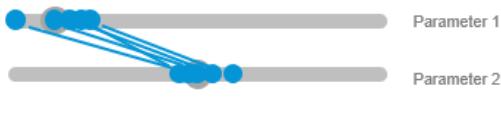
OPTIMIZE

generation 1 population of 3
generation 2 population of 3
...
generation 6 population of 3



With the “Optimize” option you can optimize set of output parameters of a parametric model to improve the performance of your design

LIKE THIS



“Like this” is meant to apply slight variations to your current input configuration

Optimize in Refinery

1. Within Dynamo for Revit, go to the menu Refinery > Export for Refinery...
2. Follow the steps in the dialogue
3. Open Refinery > Launch Refinery
4. Choose “New Study” and pick the title of your script
5. Choose the proper study and parameters.

Project Refinery – Interesting Information

Getting Started

To get access to Refinery, explore this link:

<https://www.autodesk.com/solutions/generative-design/architecture-engineering-construction>

The steps how to use Refinery in an efficient way are described in [this article](#).

The [Refinery Primer](#) aims to introduce AEC practitioners of all experience levels to an exciting new approach to design using generative design workflows.

Refinery Sample Files

A collection of Dynamo sample files created by The Proving Ground and the Autodesk Project Refinery Team to demonstrate how optimization works in Project Refinery. Note Samples v4 have been updated for use with Refinery 0.35.0.

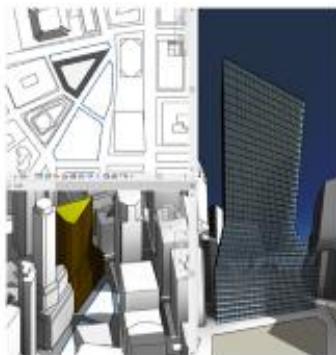
[Download the samples here.](#)

And [read this article](#) for a detailed description of the sample files.

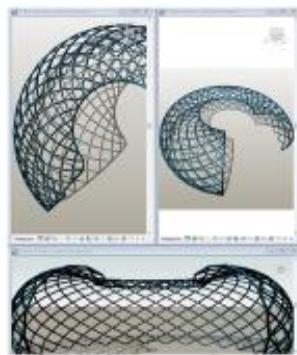
Examples

These examples are used to explain all the several phases to get yourself upskilled to learn about “Generative Design”

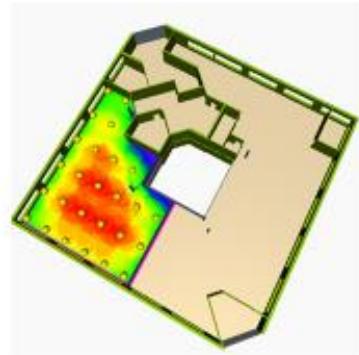
CONCEPTUAL TOWER MASS



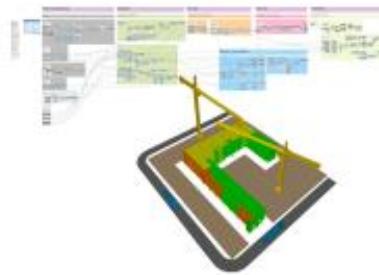
STRUCTURE WASTE OPTIMIZATION



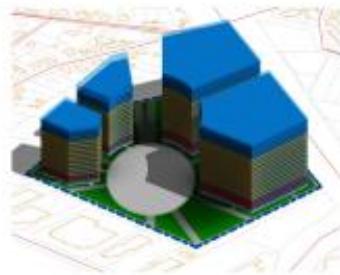
LIGHT DISTRIBUTION



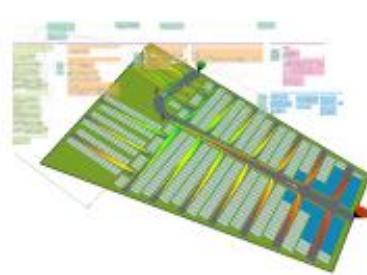
TOWER CRANE POSITIONING



URBAN PLANNING



PARKING LAYOUT



The Dynamo scripts are documented and explained with ‘notes’ embedded in the script.

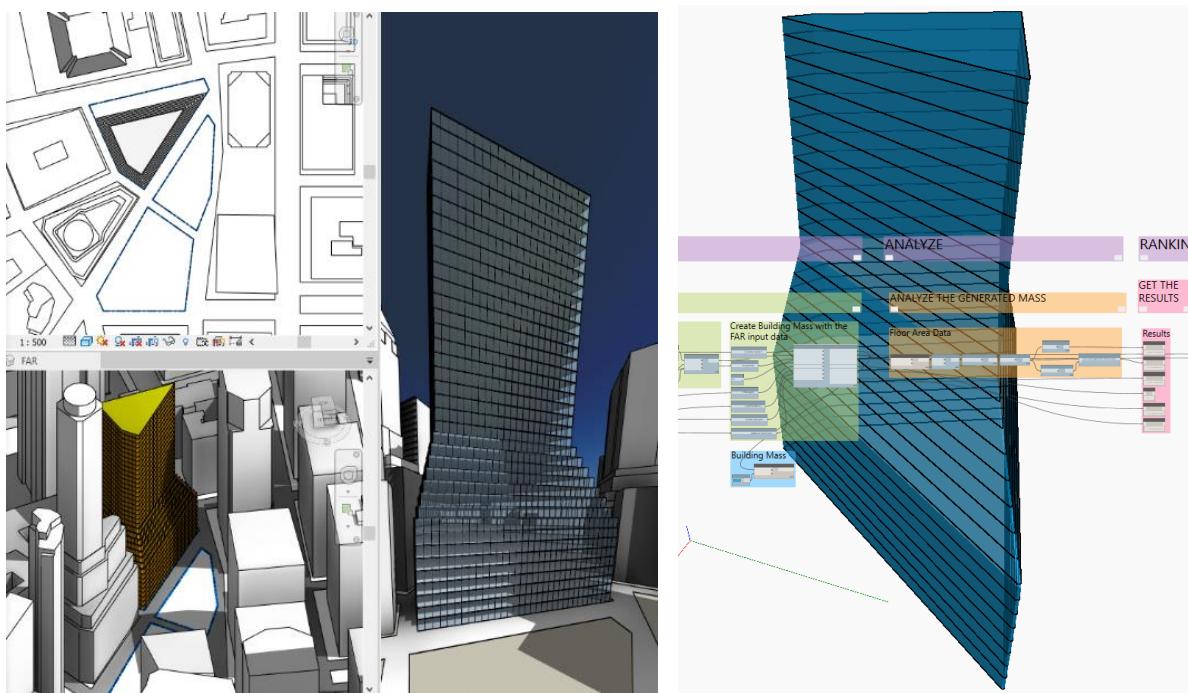
This handout explains more about the cases, workflows, the required packages, and where to find the datasets.

Example 1: Conceptual Tower Mass

Description

This script allows a user to extract Revit geometry and data, run a set of optimization routines on it, explore results, make an informed decision, and return that data to the full BIM environment as Revit elements to continue on with the project development.

Evaluate massing options for a building in an urban site and optimize for the number of floors, floor area, and façade area. Evaluate the optimal designs in their urban context. The scoring is based on a given FAR (Floor Area Ratio).



Packages

The packages that need to be installed before running the script:

- Project Refinery:
install from <https://beta.autodesk.com/key/RefineryLanding>
- Custom Nodes:
Building.ByPlazaSiteFAR.dfy (included in the dataset)

Workflow

This script has already been set to pull site information from the included Manhattan.rvt file. However, it can also be run outside of Revit in DynamoSandbox and in Refinery because the "Data.Remember" node has encapsulated the essential data that was pulled from Revit.

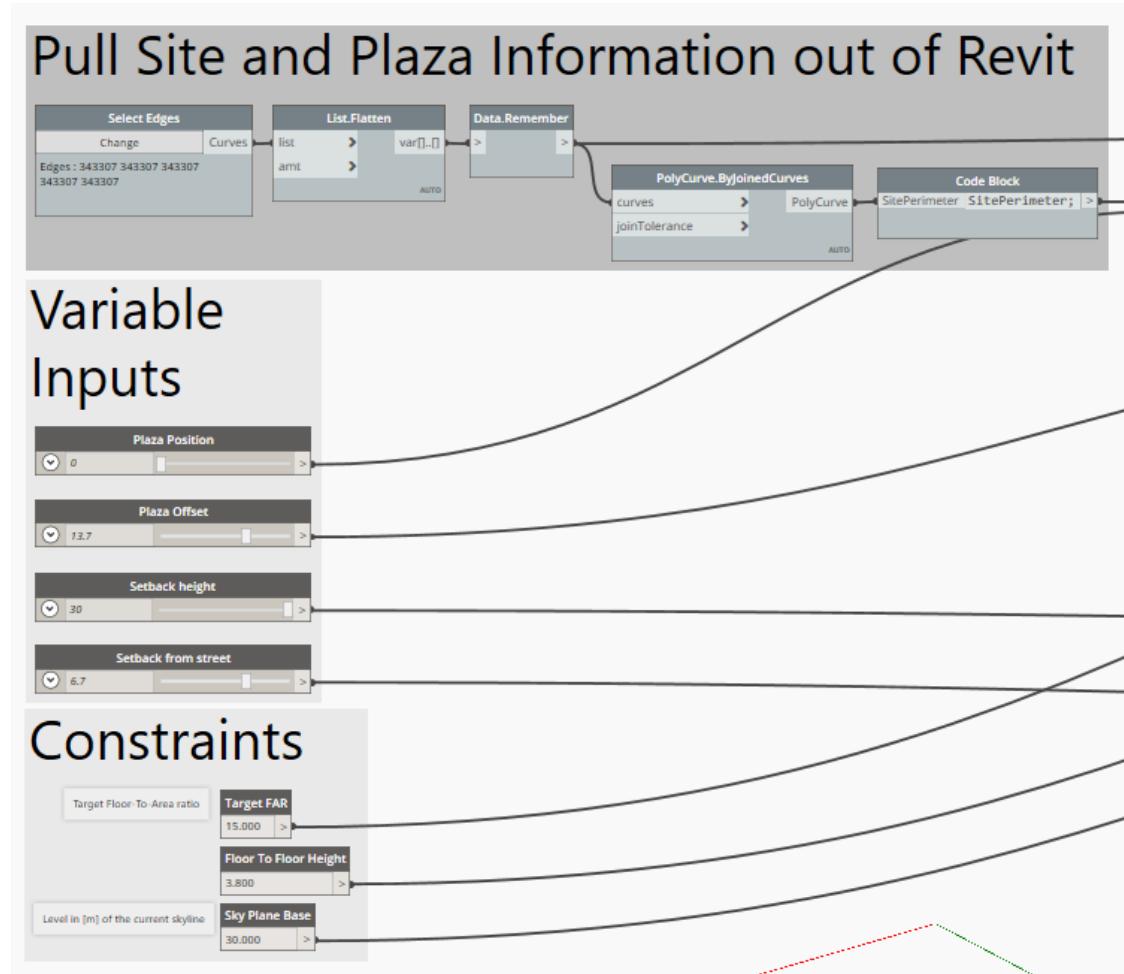
You can try our this same workflow on any Revit file that you can select a closed loop of model lines from, or generate the set of closed lines in Dynamo without Revit.

Zoning regulations cities stipulate a number of rules governing setbacks from street level and from a visible plane about 25 m above ground. While buildings have a certain allowable square footage for a given site, they are allowed more if the building grants access to a public plaza space. The custom node Building.ByPlazaSiteFAR has encoded some of these rules and can be opened and inspected. The user can manipulate these inputs to get the right balance of total area, exterior envelope and other considerations.

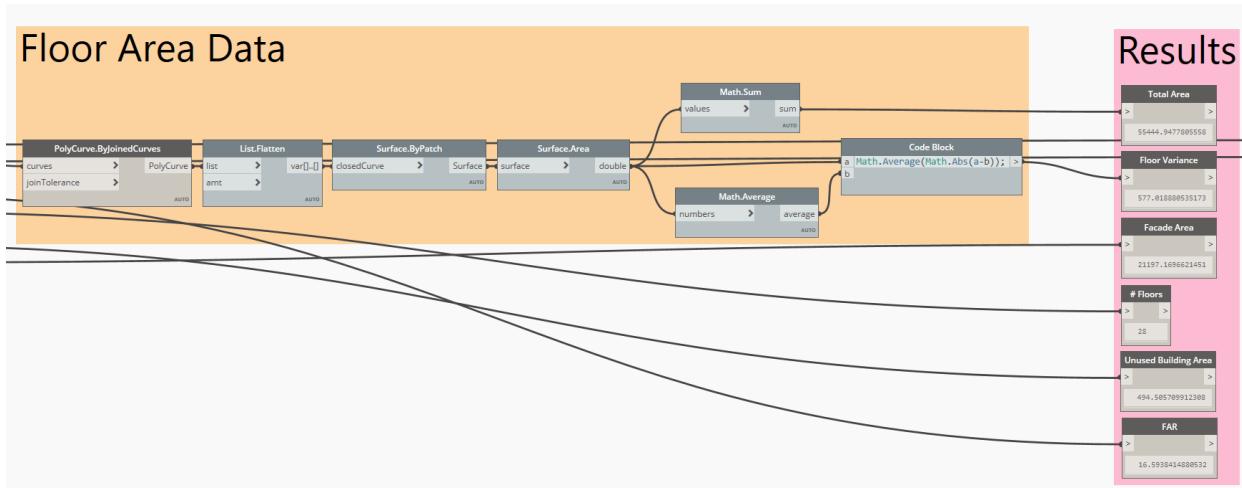


Dynamo Script Overview

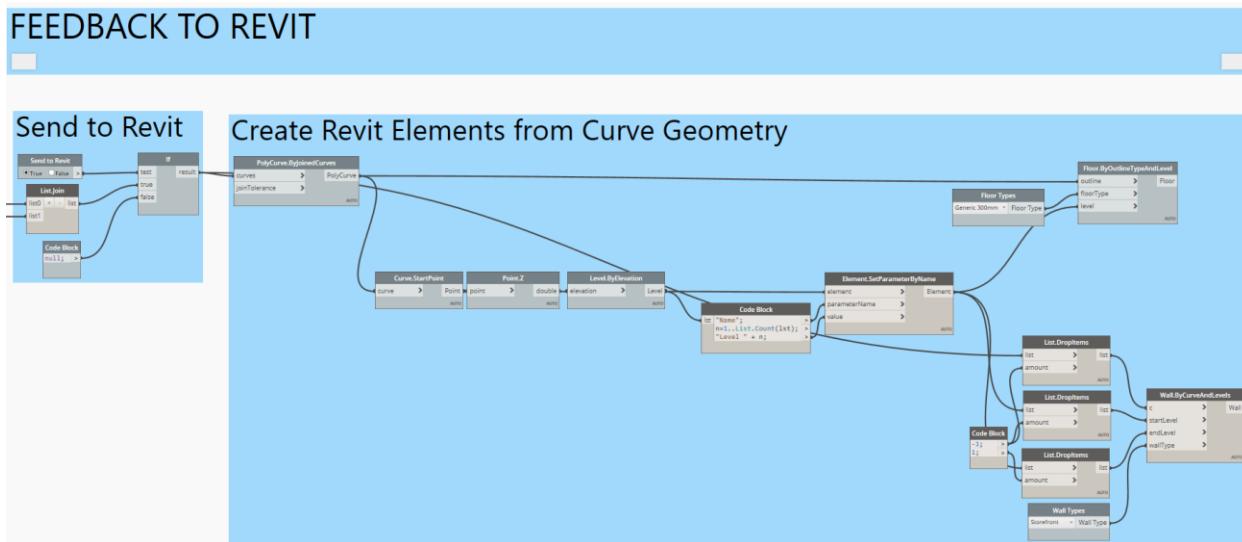
Edge lines in the Revit model are used to define a site boundary in the "Pull Site and Plaza Information out of Revit" group. This data is used to create the footprint of a proposed building. A Plaza Offset slider controls how much space is reserved for public used.



Manipulating this input will give various configurations of final building form with different trade offs for Total Area, Floor Variance (how different each floor is from an average), Facade Area, number of floors, and number of area that are still allowed by code but not used.



When a desired design is found, user can set "Send to Revit" to True, which then creates Floors and Curtain Walls.



Dataset

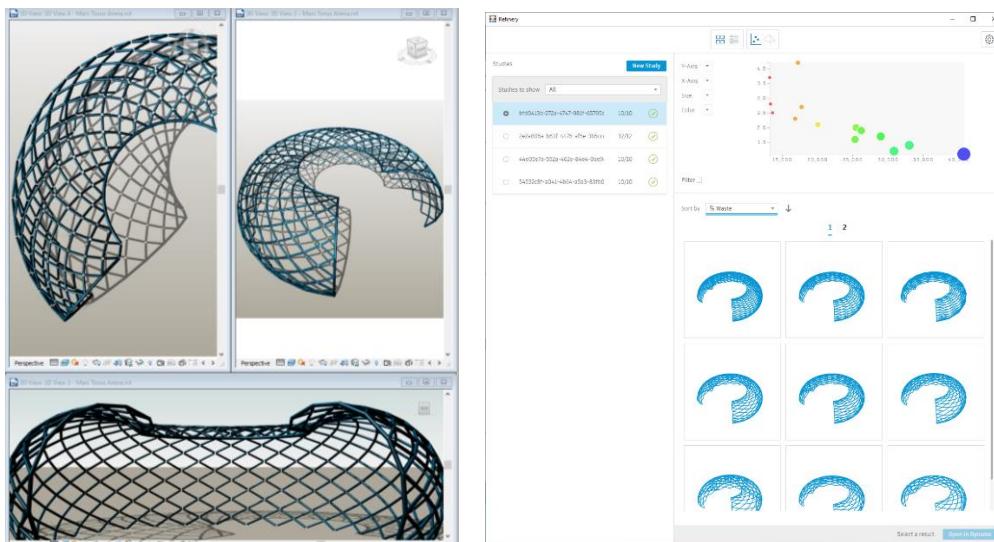
The dataset for this example can be downloaded below.



Example 2: Structure Waste Optimization

Description

This graph creates the conceptual design of the “Mars Torus Arena”, based on swept surfaces and diagrid creation. The optimization of the design is evaluated based on cost for bar cuts, joint connections, material usage and waste. The cut optimization and waste is done with the “First Fit Decreasing” bin packing algorithm. The allowable waste percentage is a measure for acceptable designs.

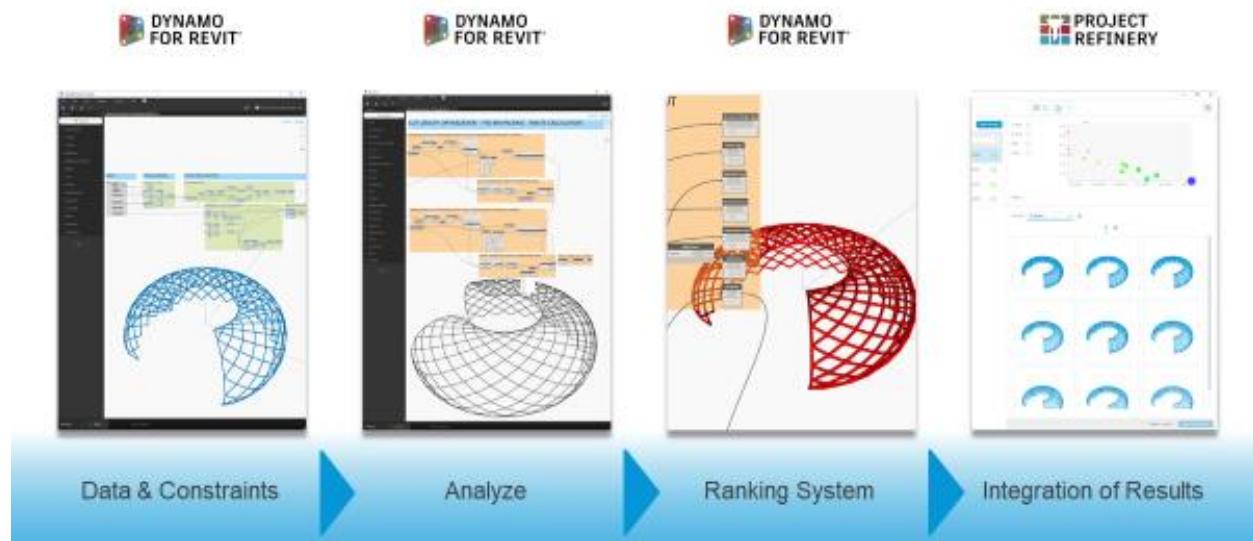


Packages

The packages that need to be installed before running the script:

- Project Refinery
install from <https://beta.autodesk.com/key/RefineryLanding>
- BIM4Struc.Productivity
This package contains the “FFD Bin Backing” algorithm
- Custom Nodes:
Mars Torus Arena Diagrid Creation.dfy (included in the dataset)

Workflow



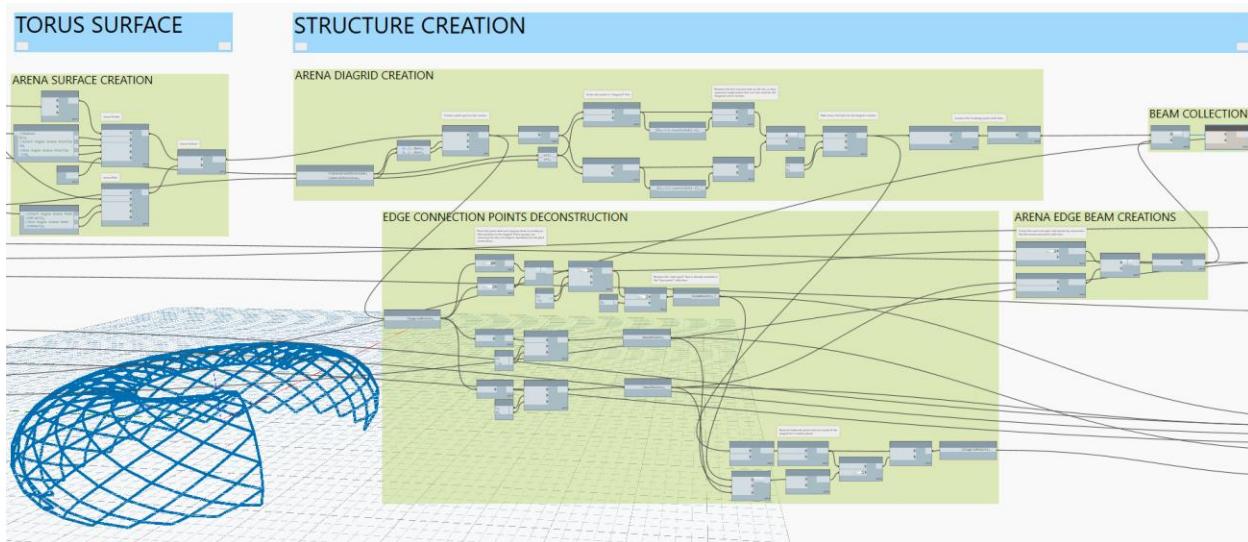
The input data is defined at the start of the script in Dynamo. Using the custom node for the “Arena Diagrid Creation”, a parametric grid system is generated. The generated lines and points are filtered to categorize them according their location and purpose. This could be improved by using *Dictionaries*.

The filtered lists are then evaluated to count the several connections, number of steel cuts and the resulting lengths a FFB Bin Packing algorithm is working to define the stock length assignment with the least waste.

With the “Send To Revit” option, the final result can be integrated with Revit.

Dynamo Script Overview

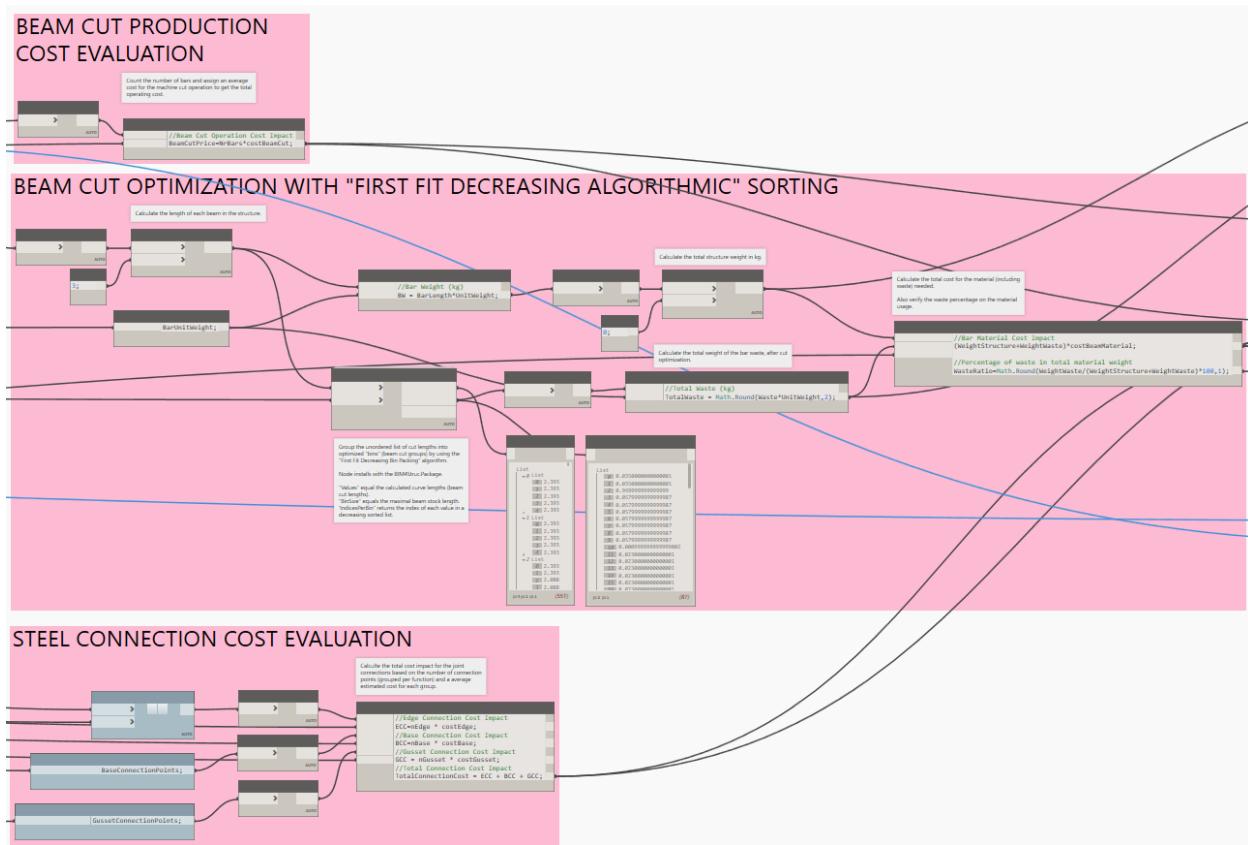
First, a computational model is setup by means of nodes and custom nodes. This will create the framework for the geometry that needs to be evaluated.



The generated structure is evaluated on constructional and cost objectives.

The evaluation is done for multiple topics:

- Cost for cutting beams
- Structure Weight
- Waste percentage (defined with the FFD Bin Packing algorithm)
- Steel Connection Cost



More Information

More information on this example can be found on these AU Classes:

- *ES119852 - Dynam(o)ite Your Steel Design @ AU Las Vegas 2017*
[Class Recording](#)
[Presentation](#)
[Datasets](#)
- *Optimization of Structural Designs with Dynamo @ AU London 2018*
[Presentation](#)
[Datasets](#)

Dataset

The dataset for this example can be downloaded below.



Example 3: Light Distribution Optimization

Description

This Light Layout Optimiser prototype is built for use with Refinery and creates and analyzes lighting positions on a floor layout.

Choose the floor and ceiling face from your Revit model.

The script will place "lights" below the ceiling and an array of points on the floor. It will then ray cast every light to every floor point (taking into account obstacle geometry) and add up the number of unlit floor points.

Packages

The packages that need to be installed before running the script:

- Project Refinery
install from <https://beta.autodesk.com/key/RefineryLanding>
- BIM4Struc. LightDistribution
This package contains the node for the conceptual light analysis.

Workflow



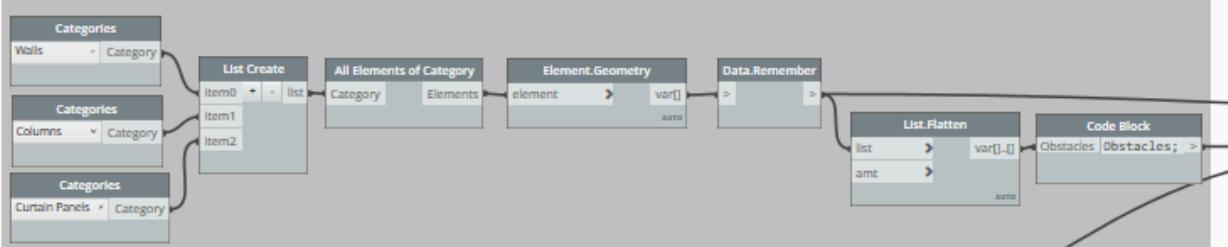
Choose the floor and ceiling face from your Revit model.

The script will place "lights" below the ceiling and an array of points on the floor. It will then ray cast every light to every floor point (taking into account obstacle geometry) and add up the number of unlit floor points.

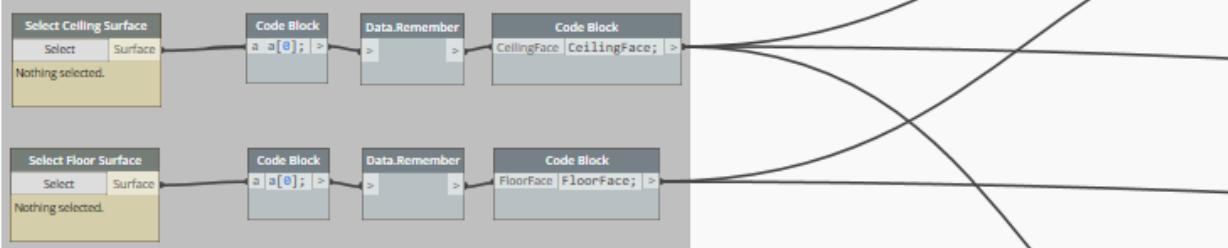
Dynamo Script Overview

From Revit you select the obstacles, the ceiling where the put the lights on and the floor on which the light intensity needs to be measured.

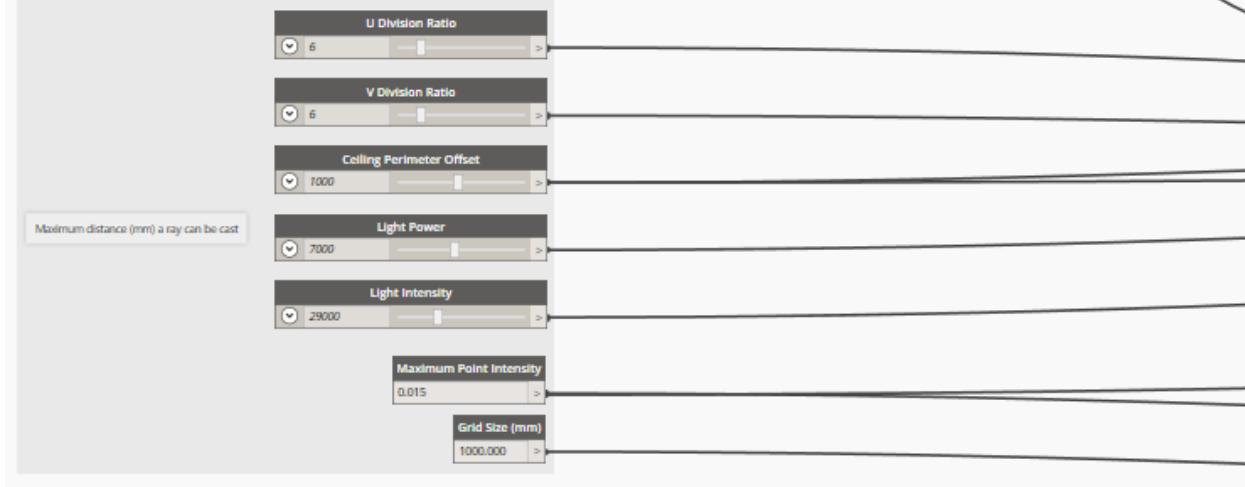
Obstacles Definition



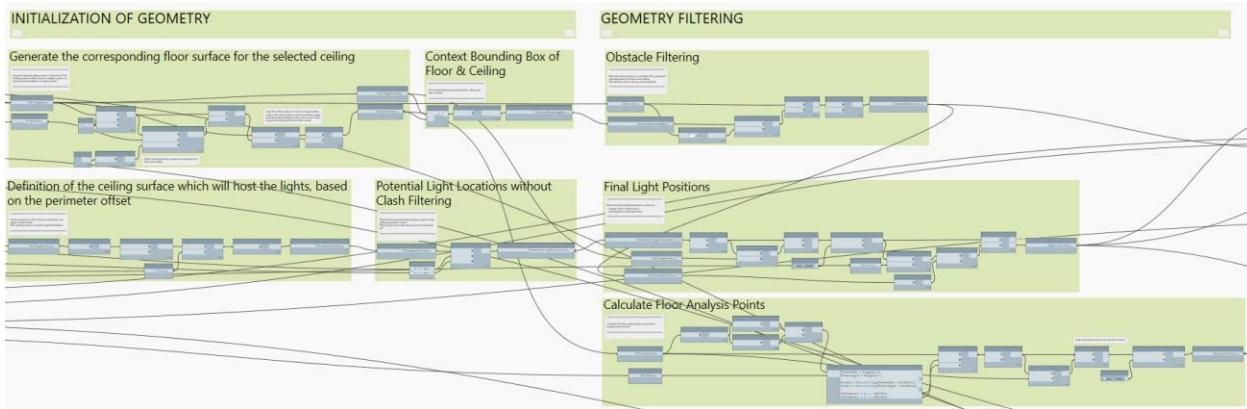
Floor & Ceiling Selection



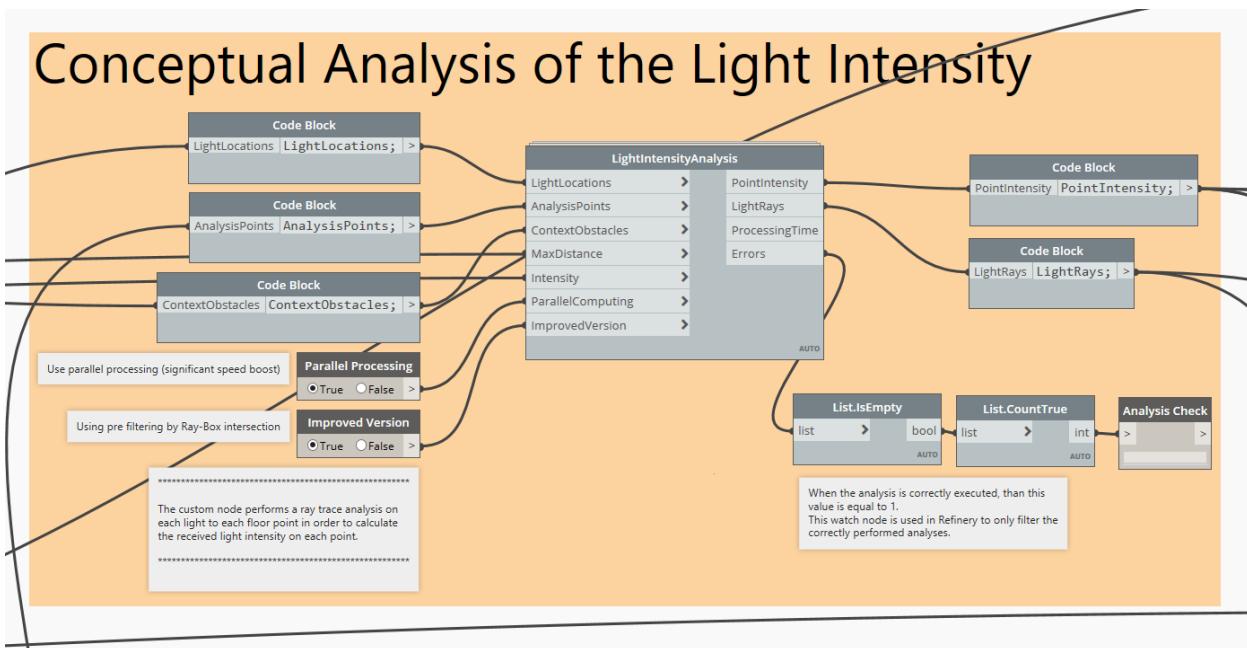
Lighting Variables & Constraints



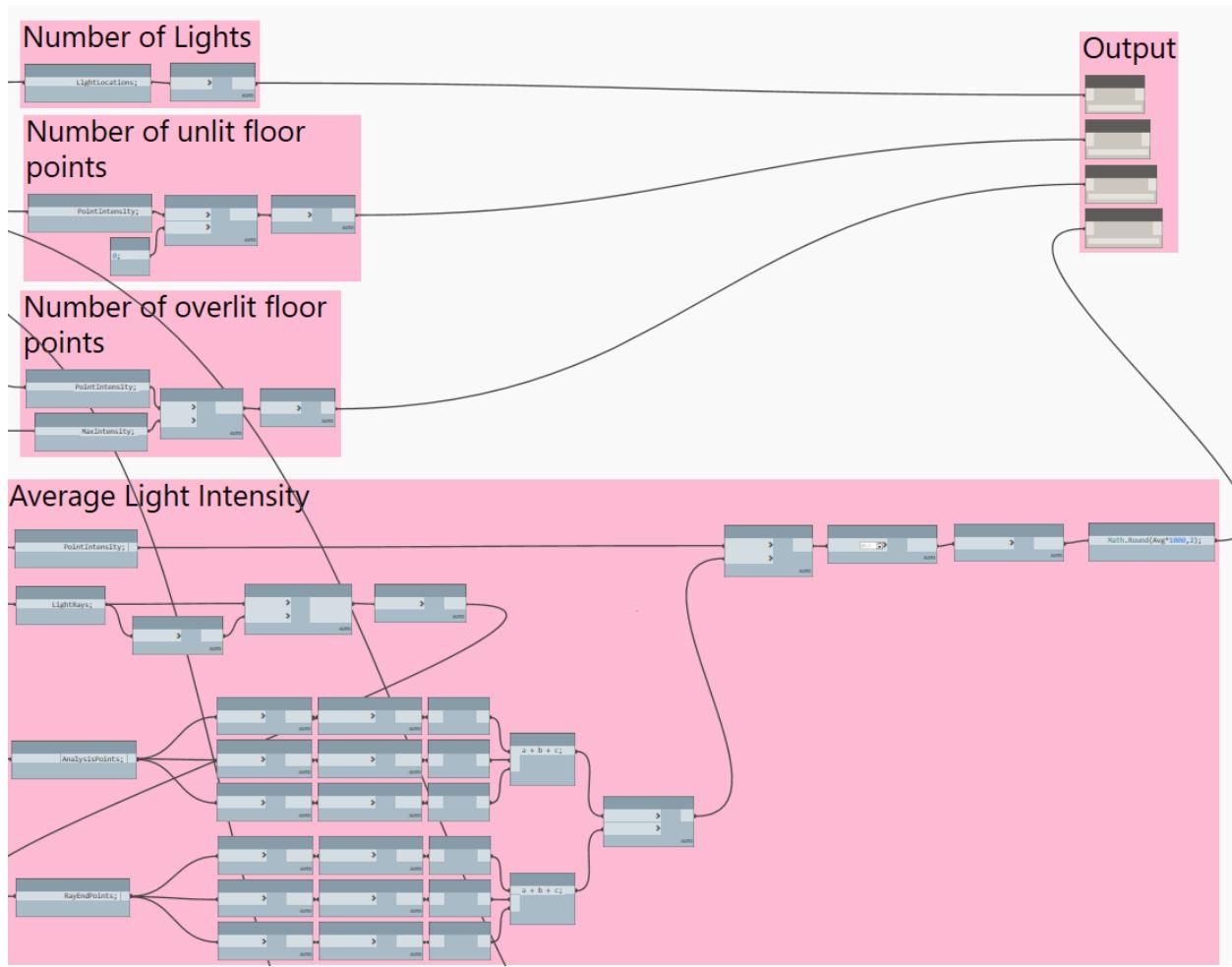
The U and V Distribution ratios define the number of lights in each direction on the ceiling surface. The Light Power and Intensity are used to analyze the lighting intensity.



The light positions are defined based upon the U-V distribution and the obstacles. Every point that is intersecting with an obstacle or not intersecting with the ceiling are filtered out.



The LightIntensityAnalysis node from the BIM4Struc.LightDistribution package performs the conceptual analysis on the points towards the floor analysis points.



The results are evaluated in separate and simple mathematical calculations and can be visualized further in the script.

Credits

Special thanks and credits to Jared Linden, Digital Applications Developer at Hoare Lea and Radu Gidei from Matterlab for contributing to this example.

Dataset

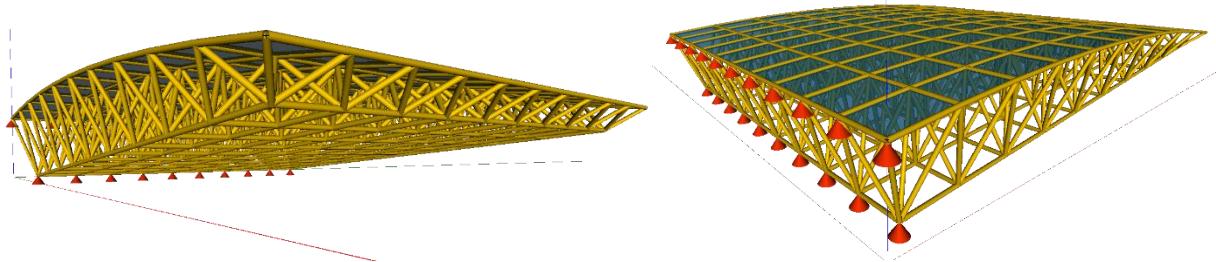
The dataset for this example can be downloaded below.



Example 4: Spatial Truss Optimization

Description

In this case study a conceptual analysis is performed for the deformation of a spatial truss structure for a cantilever roof.

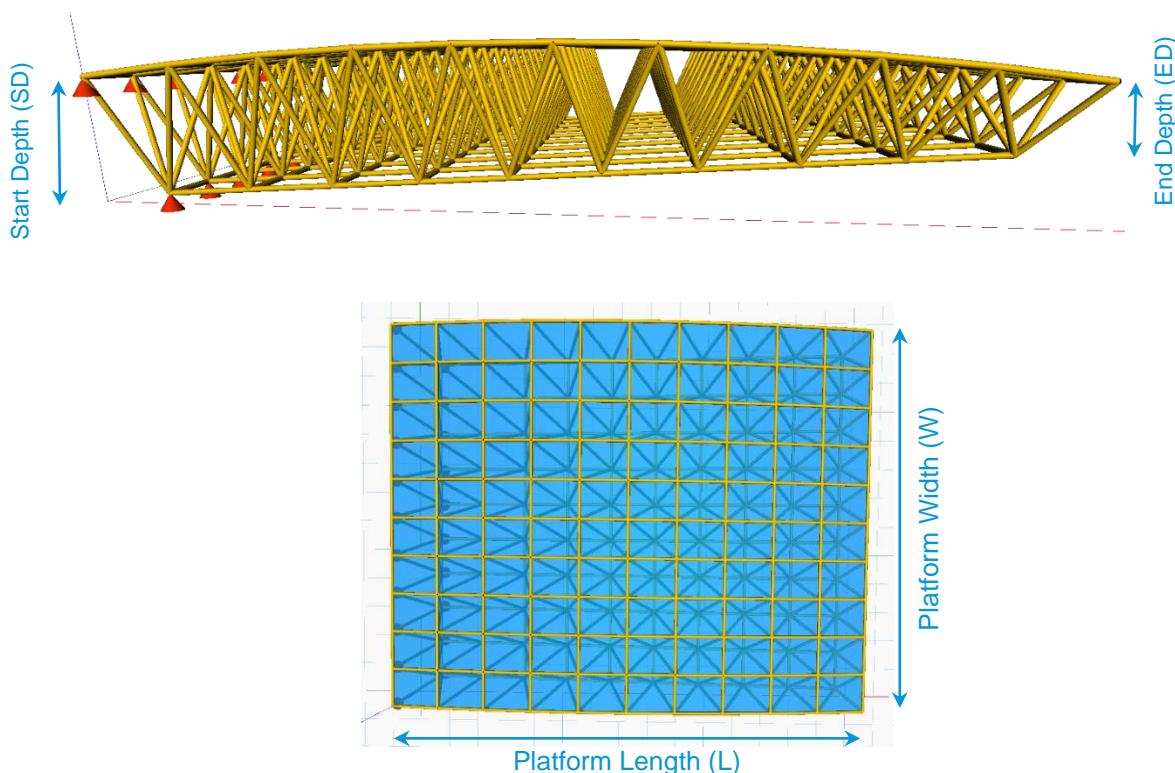


The optimization problem consists of finding the best truss configuration with three objectives:

- Maximize Platform Area
- Minimize Deformation
- Minimize Structure Weight

The configuration of the truss can be changed, by varying these inputs:

- Height of the truss at start
- Height of the truss at end
- Truss Divisions = number of panels/squares along the width



Packages

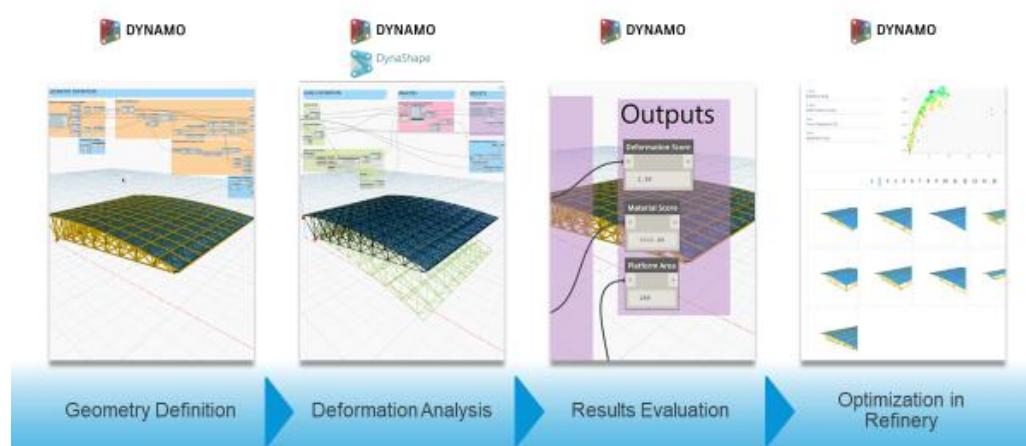
The packages that need to be installed before running the script:

- BIM4Struc.Productivity
This package contains Quad Panels node.
- Project Refinery
install from <https://beta.autodesk.com/key/RefineryLanding>
- DynaShape
Dynamo package for constraint-based form finding, optimization and physics simulation.
Installation instructions: <https://forum.dynamobim.com/t/dynashape/11666>

Learn more about the package from this AU Class:

<http://au.autodesk.com/au-online/classes-on-demand/class-catalog/classes/year-2018/dynamo-studio/aulon32162#chapter=0>

Workflow



Learn more in this class at Autodesk University 2018:

BES224265 - Structural Dynam(o)ite: Optimized Design and Fabrication Workflows with Dynamo

[Class Recording](#)

Dataset

The dataset for this example can be downloaded below.

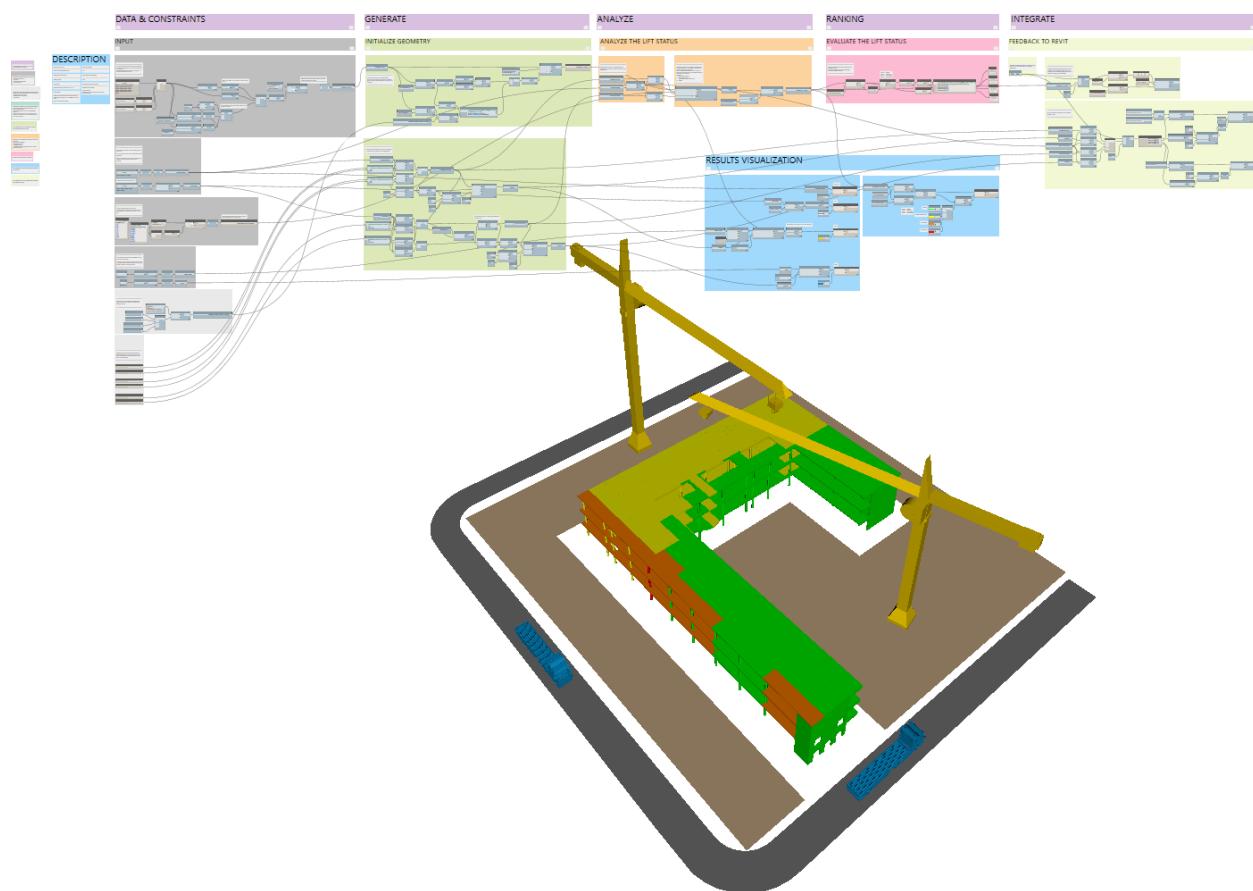


Example 5: Tower Crane Positioning

Description

It is important for a contractor to identify the optimal number and location of tower cranes. This helps avoiding conflicts between several cranes. Possible hoisting problems can be detected before the construction gets built. And finally, the contractor saves time and cost by not having an overload of cranes on site.

This script allows you to evaluate construction elements in Revit, based on their weight and distance to a multiple tower crane and delivery truck setup.

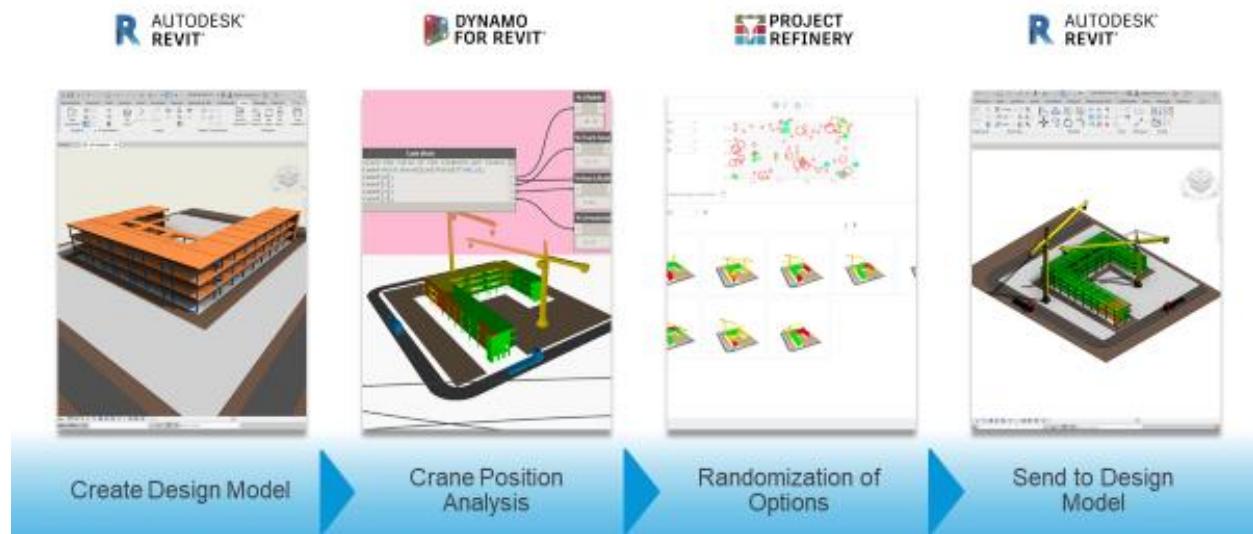


Packages

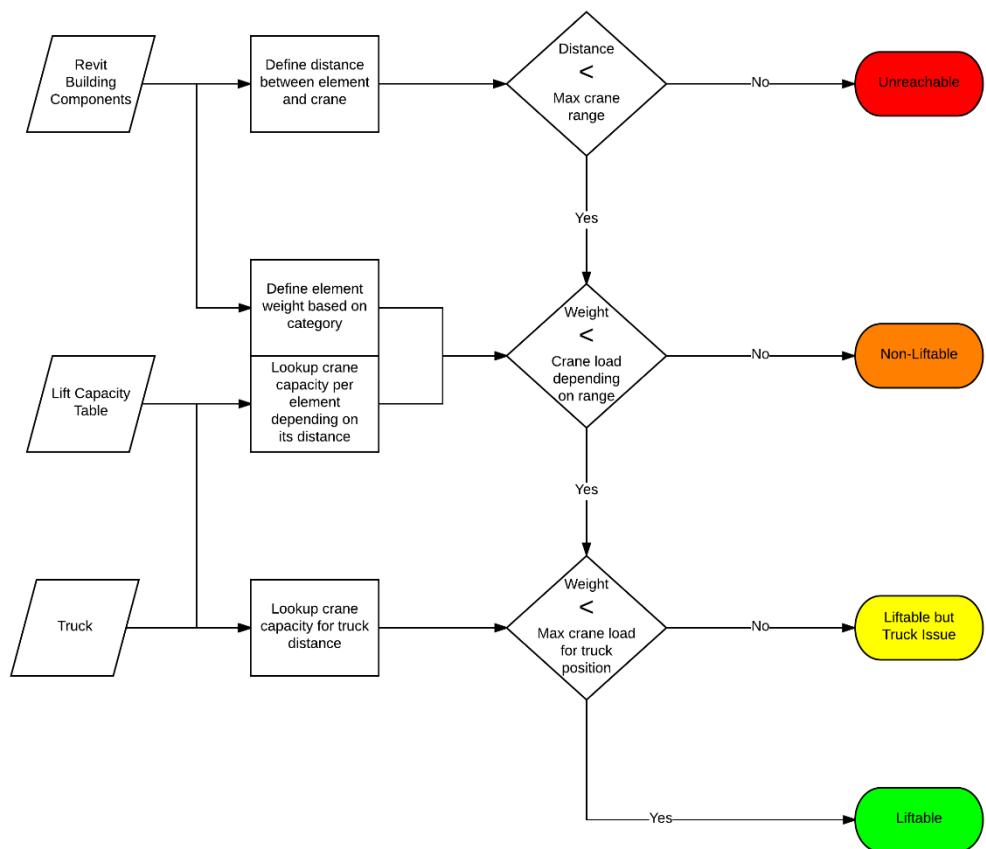
The packages that need to be installed before running the script:

- Project Refinery
install from <https://beta.autodesk.com/key/RefineryLanding>
- BIM4Struc.CraneAnalysis
This package contains the node for the conceptual lift analysis.

Workflow



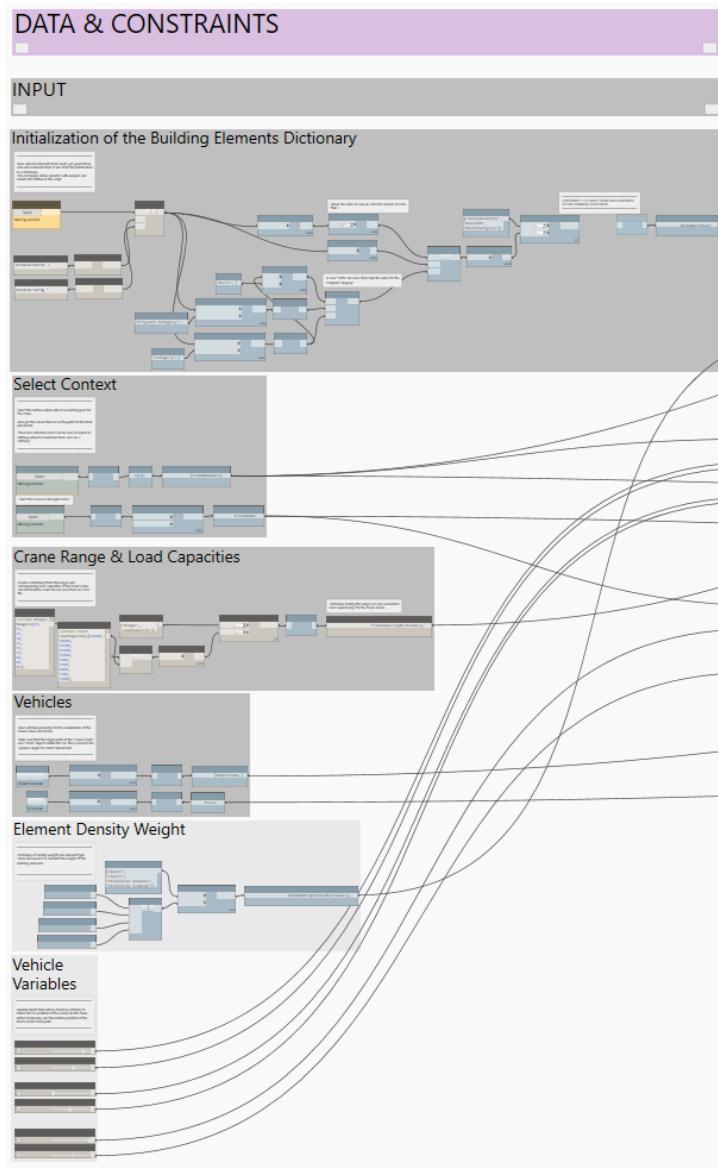
The analysis of the range and capacity of a tower crane can be analysed in many ways. In this case the analysis is based on a simplified method described in the flowchart below. This method calculates the Lift Status of each element depending on its location relative to the tower crane and truck and its weight.



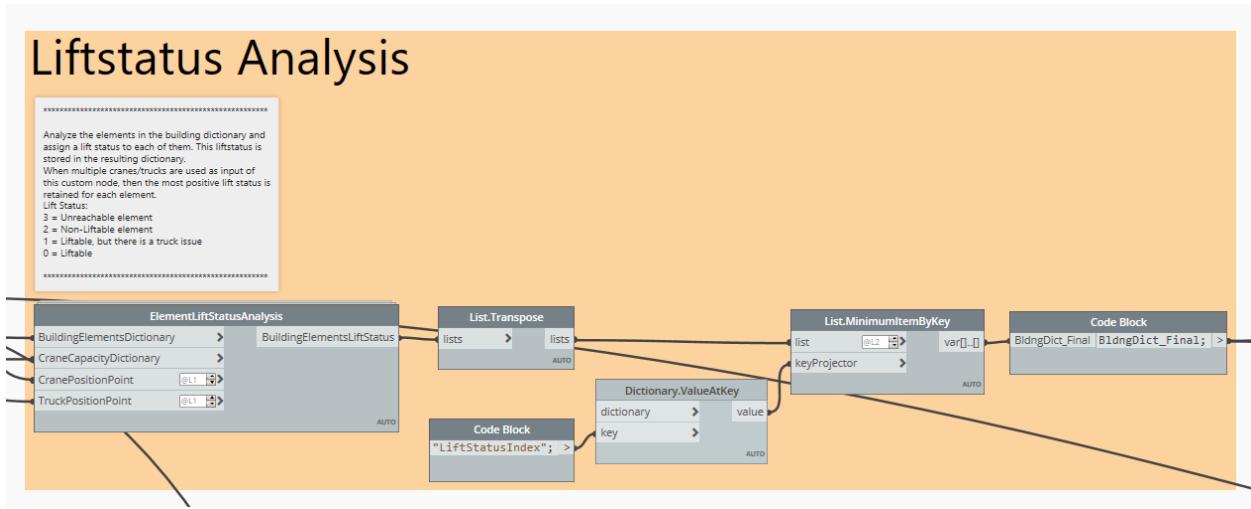
Dynamo Script Overview

The main inputs of the script are:

- Building Components: A selected set of Revit elements (floors, walls, structural framing, parts ...), which need to be lifted on the construction site.
- Lift Capacity Table: a list of values representing the loading capacity of a tower crane depending on the hoisting range.
- Truck: this is also called the Supply zone. In this example the supply zone is represented by a truck in the Revit model.



The Building Components geometry and properties are stored in a Dynamo Dictionary. During the analysis of the elements, this dictionary is updated. This makes it easier to filter the elements according their Lift Status.



More Information

For more information, watch the recording of this class that I did at Autodesk University 2016 in Las Vegas:

CS21553 - Construction Dynam(o)ite—Explode Productivity with Dynamo

[Class Recording](#)
[Presentation](#)
[Datasets](#)

Dataset

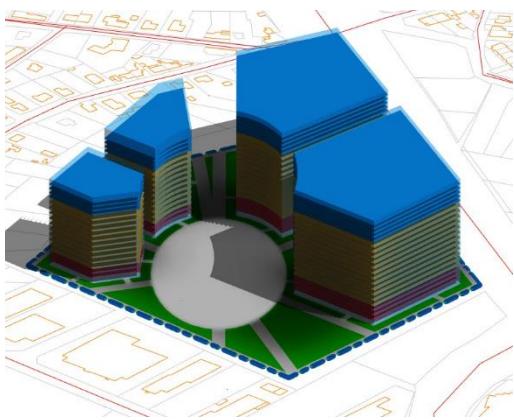
The dataset for this example can be downloaded below.



Example 6: Urban Planning

Description

In this Refinery example it is possible to perform multiple space planning scenarios. An existing site is used to do urban planning and search for the optimal distribution of buildings, forecourt area and plaza area depending on the position of the plaza and the main roads. The solutions generated are measured on environmental, adjacency, visibility, site usage and building profit scores.



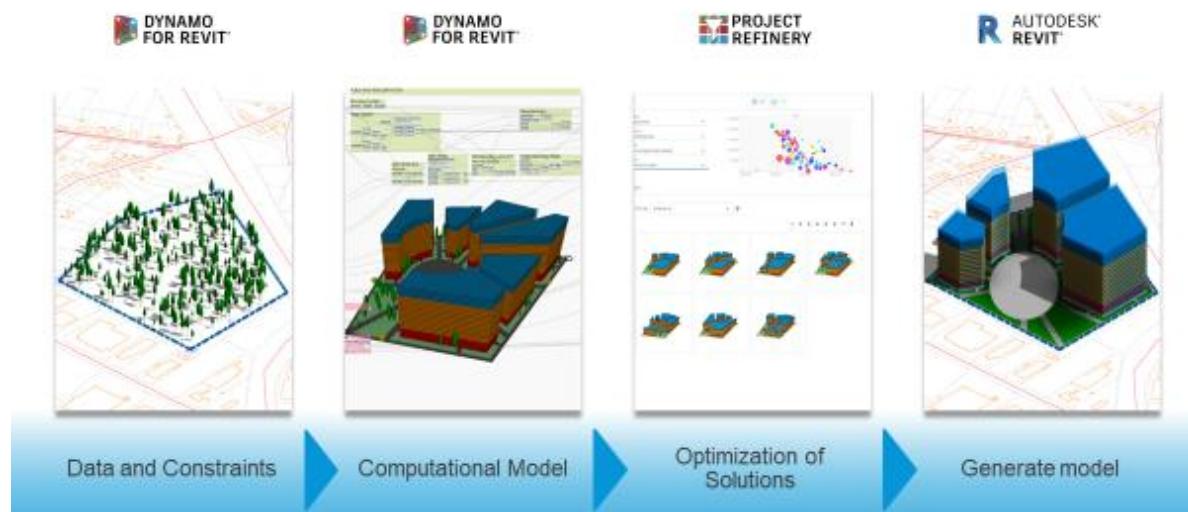
In another part the building program can be optimized by searching for the best solution for the program allocation and measure this with possible revenue for the buildings as well as building footprint analysis.

Packages

The packages that need to be installed before running the script:

- Project Refinery
install from <https://beta.autodesk.com/key/RefineryLanding>
- SpaceAnalysis
Learn more about the this package from the link below:
<https://www.keanw.com/2019/03/the-space-analysis-package-for-dynamo-and-refinery-is-now-available.html>

Workflow



How to use this script:

1. Select the Revit elements for the site, x/y references and trees
2. Run the script
3. Export to Refinery & Run Refinery (View menu > Refinery)
4. Search for the best solution
5. Set the run method in Dynamo on "Automatic"
6. Unfreeze the "Send To Revit" boolean in the "Sync With Revit" section
7. Select your solution in Refinery

The evaluation of the design is based on a few criteria:

- Environmental impact:
 - how many trees are saved?
 - maximize the forecourt area
- Accessibility analysis
 - Minimize the adjacency of the building entrances to points of interest
 - Maximize the entrance visibility from the central square
- Site analysis
 - Maximize the building footprint
 - Verify the building area deviation
 - Evaluate the plaza area
- Building analysis
 - Maximize the total floor area
 - Regulate the cost and revenue

Dataset

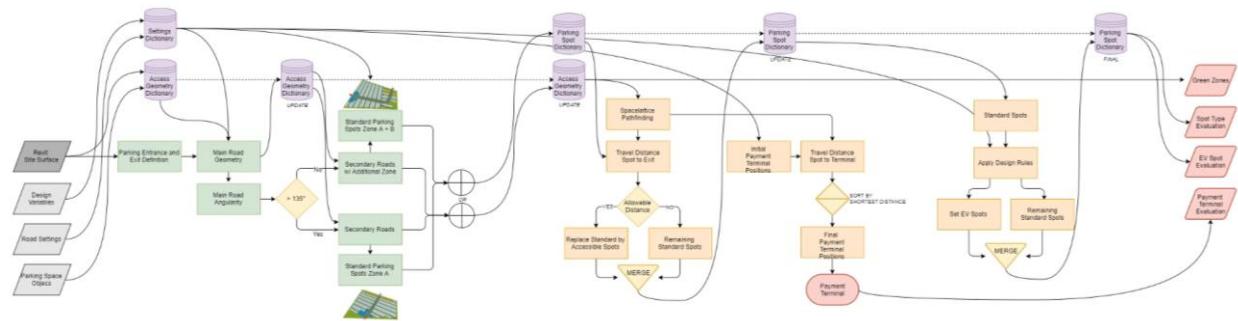
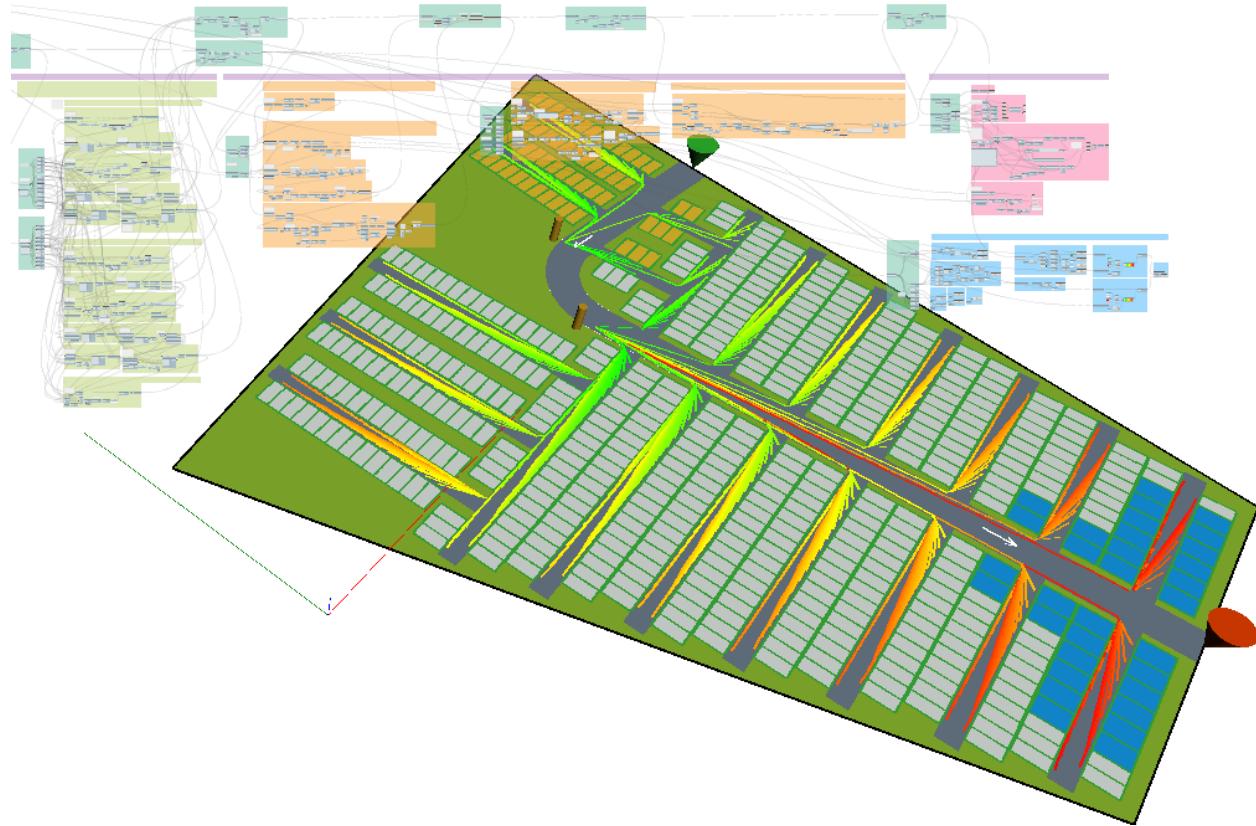
The dataset for this example can be downloaded below.



Example 7: Parking Layout

Description

This script contains a workflow to automate the creation of a parking lot, based on a given site boundary. The workflow consists of multiple processes in order to optimize the layout with Project Refinery.

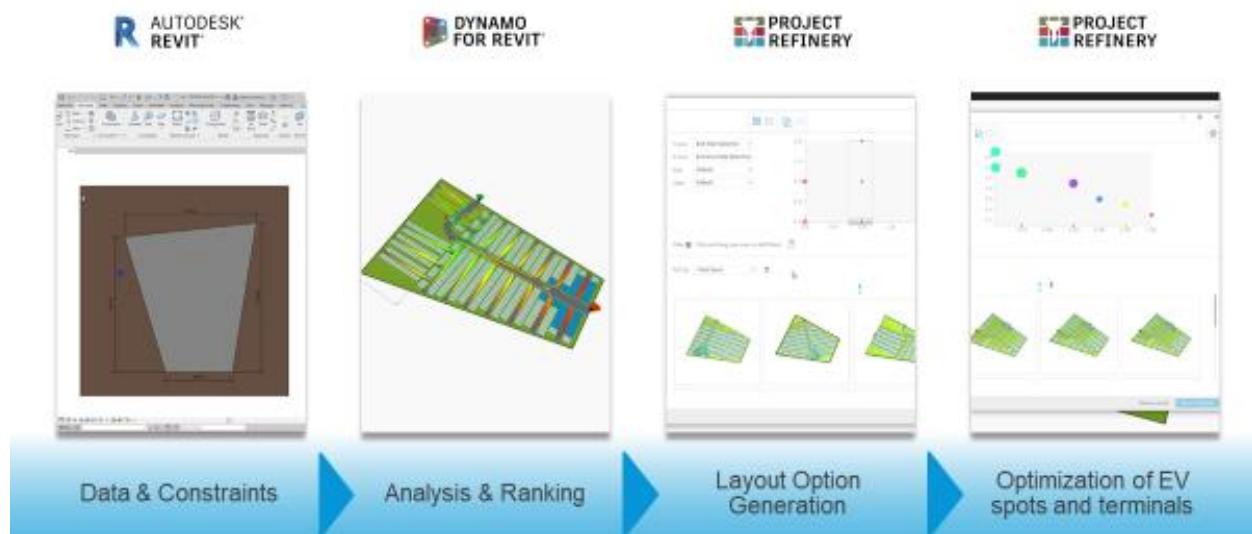


Packages

The packages that need to be installed before running the script:

- Project Refinery
install from <https://beta.autodesk.com/key/RefineryLanding>
- SpaceAnalysis
Learn more about the this package from the link below:
<https://www.keanw.com/2019/03/the-space-analysis-package-for-dynamo-and-refinery-is-now-available.html>
- BIM4Struc.ParkingLayout
Package that contains nodes for this script to automate the parking spot placement and road creation.

Workflow



This workflow allows to search for the best orientation of the main road and connecting secondary roads. Then the parking spots are placed. The SpaceAnalysis package is used to calculate the travel distances from a parking spot to the parking exit point. With these results the best placement for accessible spots are defined. In a second part, the payment terminal positions are defined with the SpaceAnalysis package to have them placed optimally on travel distances.

Another optimization that can be executed in a second run is the placement of spots for "electrical vehicles". The placement can be based upon the concentration of the spots to avoid heavy infrastructure costs or to maintain diversity of types of spots in a parking row.

The site is divided in two zones, with their own properties.

The data and geometry storage and transfer through the script is performed mainly with Dictionaries.

The result is a layout with defined roads (dark grey), standard spots (light grey), accessible spots (blue) and EV spots (orange).

The objectives of the optimization are:

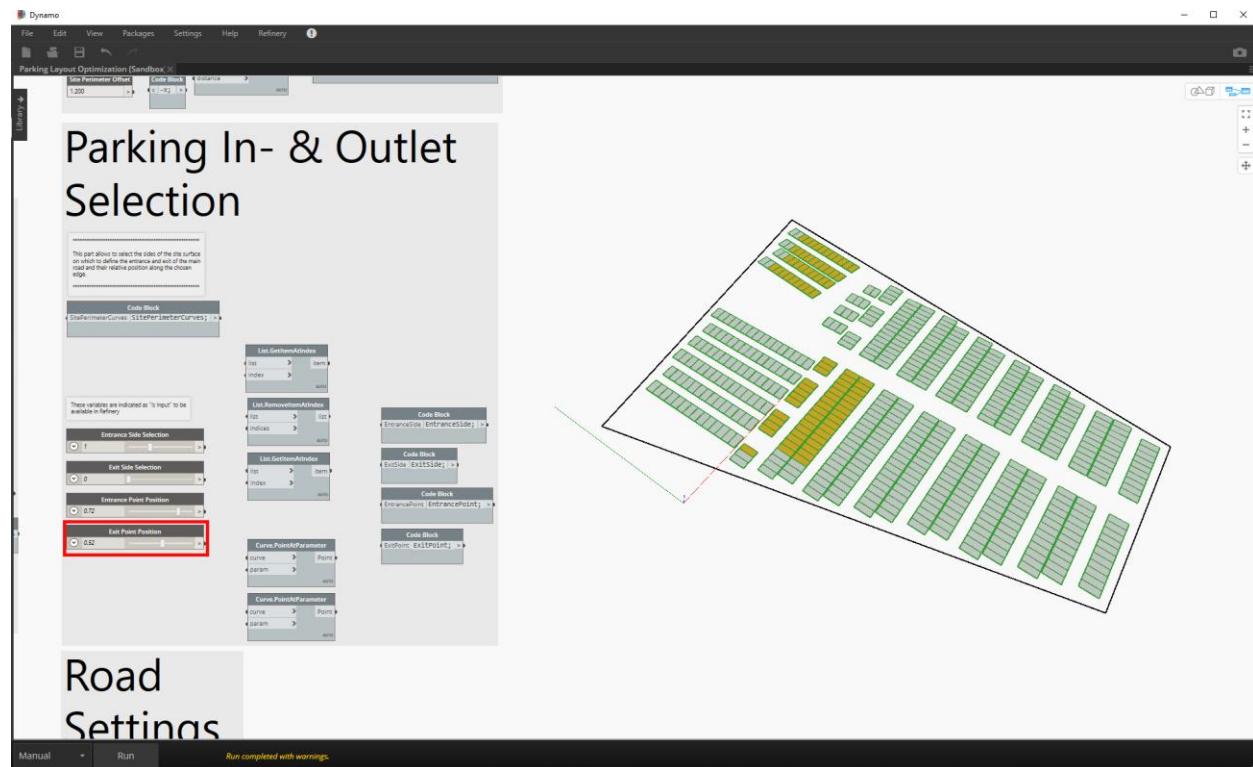
- Layout of main roads, secondary roads
- Number of parking spots
- Assignment of accessible spots
- Concentration of spots for electrical vehicles
- Green zones
- Walking distances to payment terminals

The script makes use of dictionaries that are updated during the progress of the script. This makes it possible to easily track the parking spots, their locations and geometries.

Known Issue

Problem:

In some exceptional cases, the analysis is not performed and you get a result like this below.



Cause:

The cause of this is the accuracy of the main road placement. For some exceptions the "Surface.SubtractFrom" node doesn't execute well in the Green Zone Generation group.

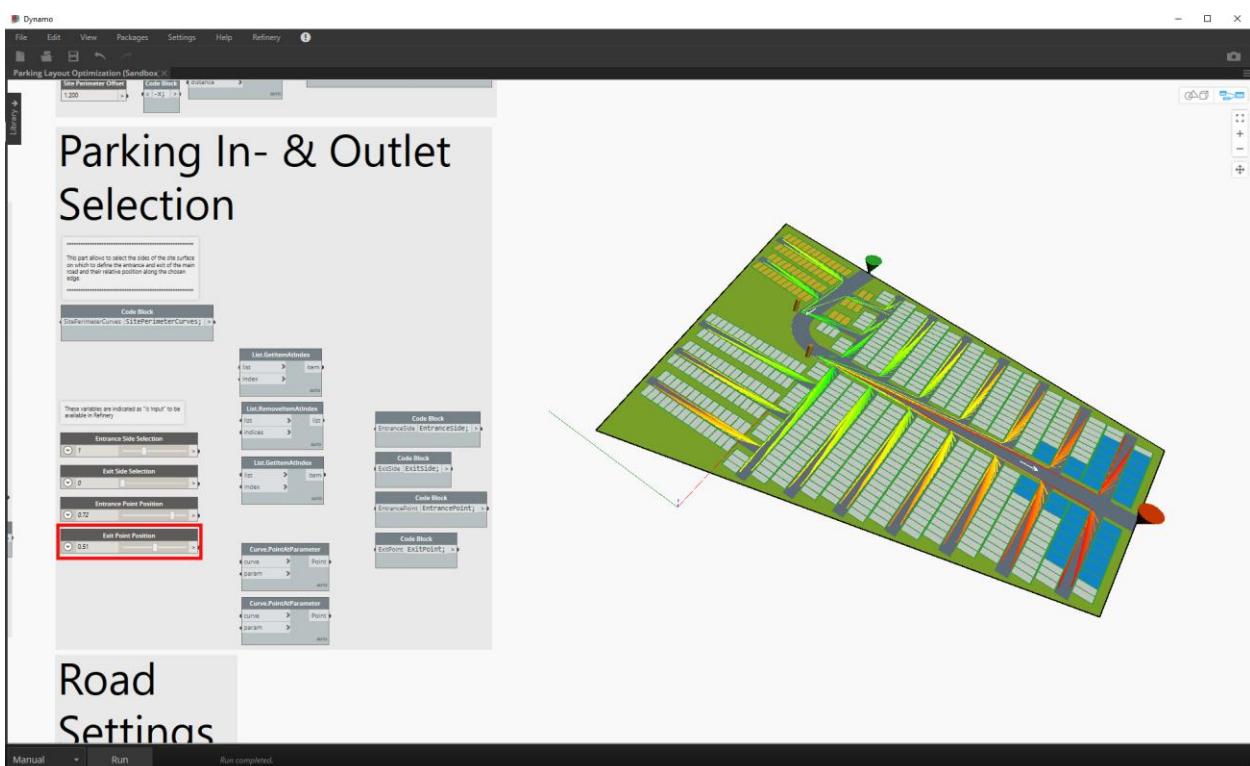
GREEN ZONES

Green Zone Generation



Solution:

Change the position of the entrance or exit point slightly and rerun the script.



Dataset

The dataset for this example can be downloaded below.



Downloadable Materials

All materials for this class can be downloaded on the folder link below.
There you will find all **datasets**, the **presentation** in PPTX format and the **handout**.



Other references

Article:

<https://www.radicomapro.ru/ryedktzij/stroytelstvo/kapitalnoye/diter-vermiulen-autodesk--so-vremenem-generativny-66989.php>

“Demystifying Generative Design” e-Book:

<https://damassets.autodesk.net/content/dam/autodesk/www/solutions/generative-design/autodesk-aec-generative-design-ebook.pdf>



More Generative Design Classes?

You want to learn more about how generative design is being used by your peers to change the way they approach design?

Then surely explore the Autodesk University Online Learning catalog:

<https://www.autodesk.com/autodesk-university/au-online?query=generative+design>

In this class, I often refer to classes I teach at Autodesk University. All presentation material, handouts and complete datasets can be found on this link:

<https://revitbeyondbim.wordpress.com/2018/09/25/autodesk-university-class-presentations-and-datasets/>

The article is updated regularly with other classes I will teach.