

CANTIERE User Guide

This document contains the user guide for the 1.0 beta version of CANTIERE. It provides information regarding the system requirements, the functionalities of the tool and the suggested settings for the correct use.

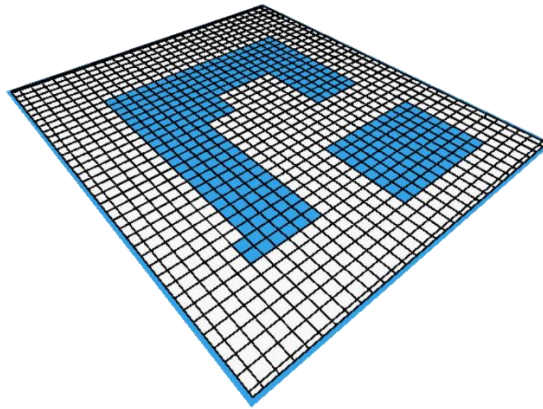


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General notes

CANTIERE optimizer was developed to support the complex task of construction site layout planning. It is capable of producing high performance construction site geometry alternatives by using a generative design optimization. The performance of the site layout is evaluated considering the *time* needed for the site activities, the *cost* of the operations on the site, the *safety* of the site and the *quality* of the end product and of the working environment.

The simplicity of the inputs needed for the optimization and the integration with more design software such as Revit, Rhino/Grasshopper and SketchUp, make CANTIERE an agile tool to use at the early design stage. This gives the possibility to the designers to have feedback on the buildability of the design, which is often a parameter considered only later on in the design process.

CANTIERE comes as a folder containing the scrips to set the inputs of the optimization (Revit IS and SketchUp IS) and two versions of CANTIERE optimizer (Revit 2021 and earlier versions).

System requirements

The Autodesk Revit license is required for the use of CANTIERE, **Dynamo Revit** was used as development platform and **Generative Design for Dynamo** is used as optimization engine.

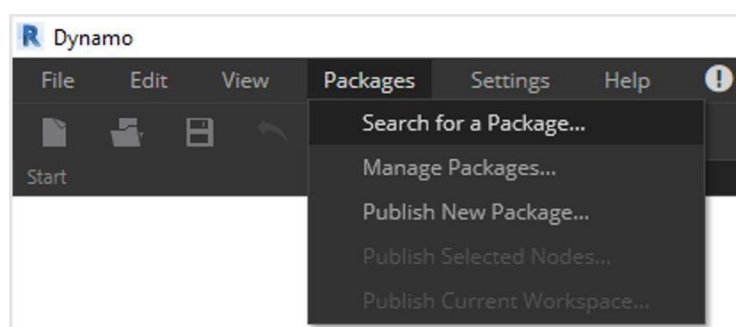
For the tool to work correctly, make sure that Dynamo Revit *version 2.1 or above* and Refinery *version 0.62.2* (if you are using Revit 2020) or Generative Design for Dynamo *version 1.1.0* (if you are using Revit 2021) are installed in your computer. Dynamo for Revit is automatically installed in Revit since the version 2020. Generative Design is automatically installed in Revit 2021 and it is automatically included in Dynamo. If the current version of the software in your computer is older, update it using the Autodesk Desktop App.

If you have an older Revit version, Dynamo can be downloaded from the community on <https://dynamobim.org/>. If you are using Revit 2020, Refinery can be downloaded from <https://feedback.autodesk.com/key/RefineryLanding>, where you have to sign up to be part of the Autodesk community.

Dynamo can be launched from the Revit interface, in the “Visual Programming” tab of the “Manage” menu.



Before starting to use CANTIERE, it is necessary to download the packages that were used to develop the Dynamo flowchart. Open Dynamo and find the voice “Search for a Package...” in the “Packages” menu.



Make sure your computer has an internet connection and download the following packages:

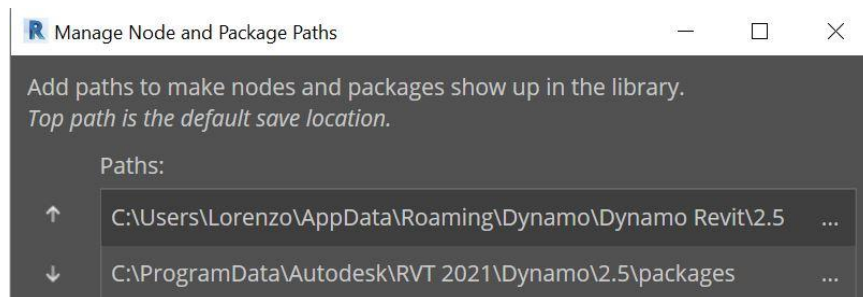
- LunchBox for Dynamo (version 2018.7.6)
- Refinery Toolkit (version 1.1.0)
- SketchUpForDynamo (version 1.5.4)

Furthermore, since the latest version of *Speckle for Dynamo* is only available through the website, go to <https://speckle.systems/>, create a Speckle account (if you do not have it already) and download the version 1.7.0 or above.

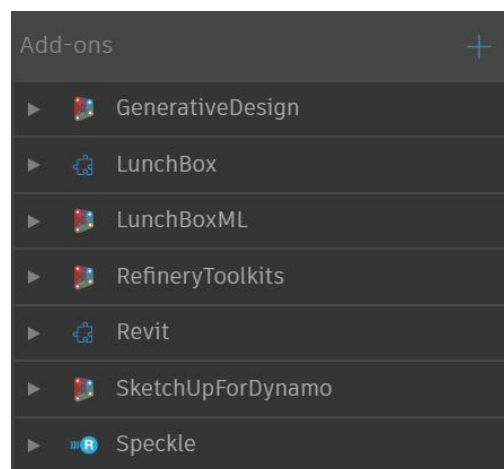
The correct installation of the packages can be checked by opening “Manage packages” from the “Packages” menu.



If they do not appear, check if the path where they have been saved corresponds to the one that Dynamo uses to load the packages. This can be found in the “Settings” menu, at the voice “Manage Node and Package Paths...”. The paths can be changed or added to the list.



If the settings are correct, the new nodes and packages appear in the Library, at the bottom left of the Dynamo environment, under the tab “Add-ons” and the Generative Design and Speckle tabs are shown on the main toolbar.



CANTIERE is now ready to be used.

Before the optimization is run, CANTIERE optimizer needs to receive data to use as input. The data can be sent by the user independently with a Speckle data stream (either from another Dynamo script or Grasshopper for Rhino) or by using one of the integration scrips available in the CANTIERE folder.

Revit IS

This script was developed to translate the elements of a BIM model into inputs for the optimization. The inputs for this algorithm are selected by the user in the Revit model in order to import them into Dynamo. The needed inputs are: the topography of the site (mesh), the building to be built, the obstacles on the site (optional) and the accesses to the site.

Inputs

Select Topography
Change Element
Element : 265906

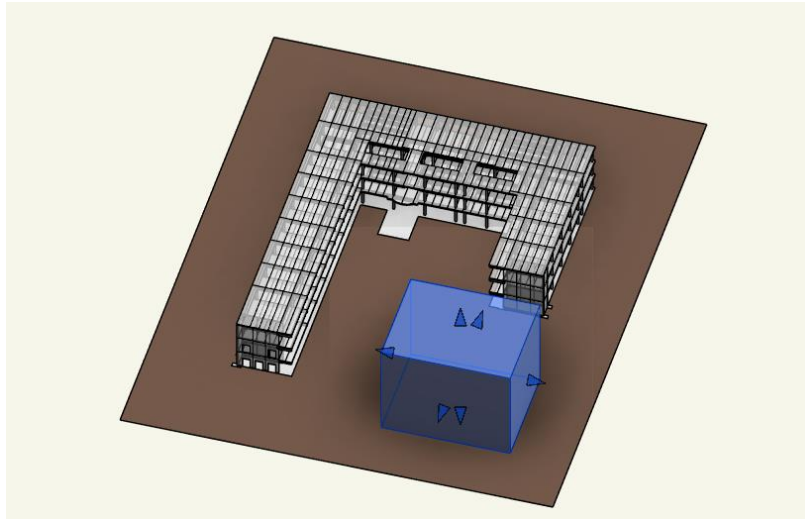
Select Building
Change Elements
Elements : 122477 122478 122479
122480 122481 122482 122483
122484 122485 122486 122487
122488 122490 122491 122492
122493 122494 122495 122496
122497


Select Obstacles
Select Element
Nothing selected.

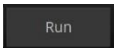
Define Site Access
Change Point
Point on Element : 265906

Define 2nd Site Access (optional)
Select Point
Nothing selected.

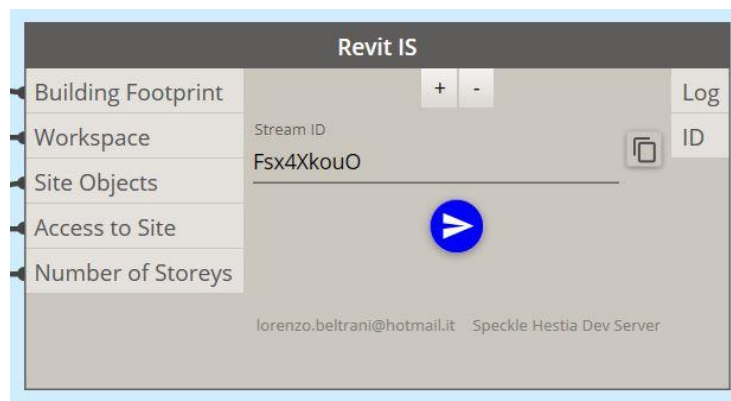
Press to select elements from the Revit model or to make a new selection (if previously selected). You can select either one or multiple element from the Revit model.



In the case of the definition of the accesses to the site,  allows to place a point on a surface. Therefore, click on the topography to define the access. The point should not be on the edge of the topography but inside the surface (the point will be transferred to the edge automatically by Revit IS).

Press  to run the script and to send the data through the Speckle sender.

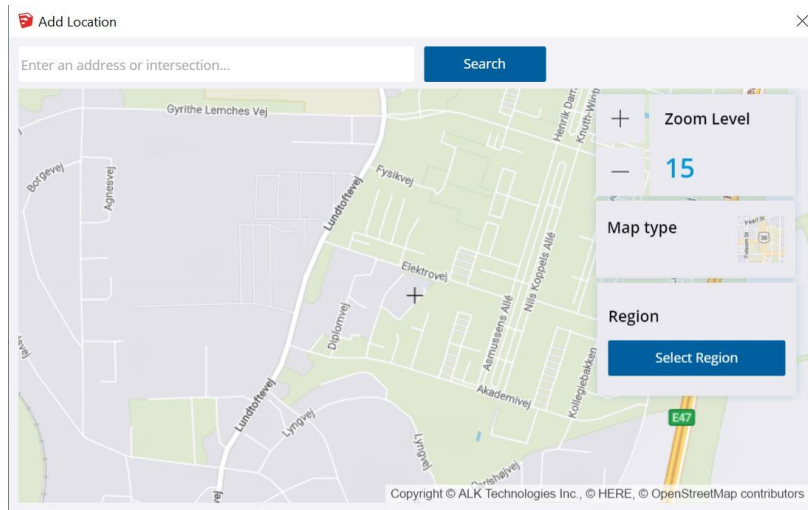
Opening the script for the first time, the sign in to Speckle is required. Once signed in, a *Stream ID* is automatically generated in the Speckle sender at the right end of the script. The *Stream ID* will be requested from the receivers in CANTIERE optimizer, therefore, remember to copy it before closing the script.



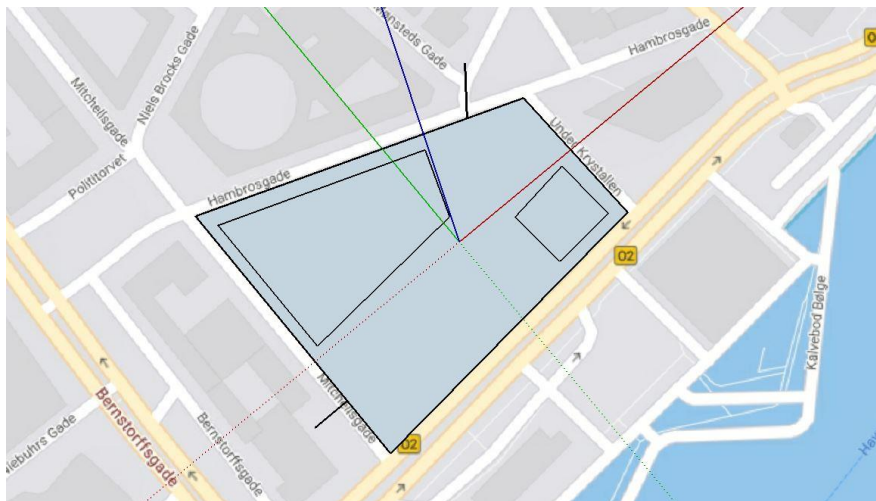
SketchUp IS

The integration with SketchUp was developed to give the user the possibility of quickly drawing a construction site on a map and evaluating the buildability of the proposed concept.

To send the inputs to CANTIERE optimizer for the optimization, firstly the user needs to design a simple SketchUp model. In the SketchUp environment, open the window “Add Location”, from the “File” menu and choose the area where the building of your project will be built.



Once the map is inserted in the model, use the pen tool to draw in the following order: the boundary of the construction site, the footprint of the building to be built, the obstacles (if present) and the access(es) to the site. For defining the access, you need to draw a line from the actual access on the boundary of the site to any point outside of the construction site.



Save the model and close SketchUp. At this point, SketchUp IS can be launched through Dynamo. Here, the only inputs required are the saved SketchUp model and the number of storeys of the building to be built.

Inputs

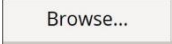
File Path

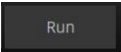
Browse... >

..\Building 357.skp

Number of Storeys

4.000 >

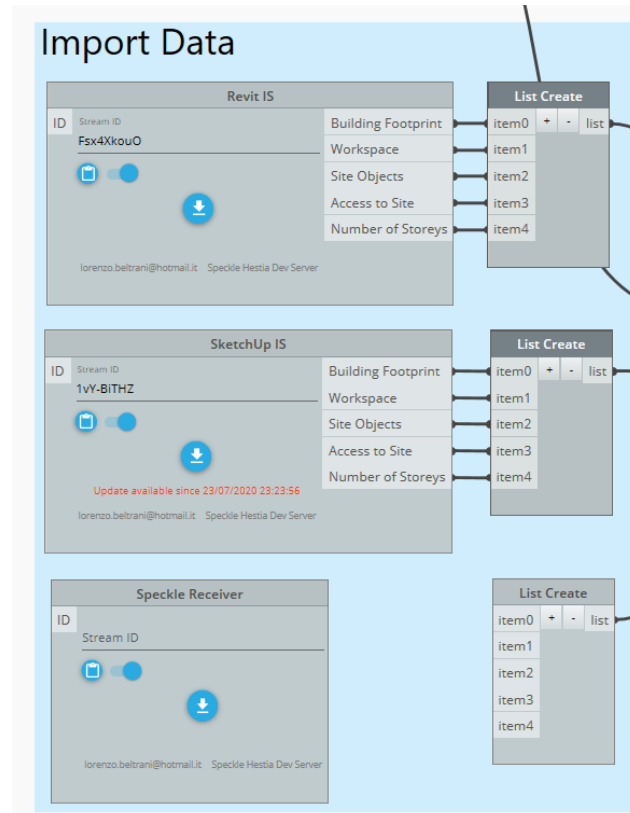
Press  and find the saved SketchUp model to load it into Dynamo and define the number of storeys.

Press  to run the script and send the data through the Speckle sender.

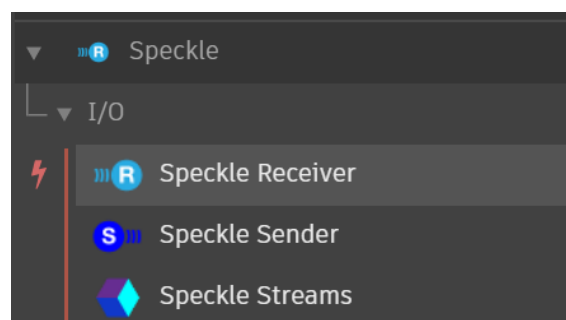
Remember to copy the Speckle sender' *Stream ID* before closing the script.

CANTIERE optimizer

When the inputs for the optimization are sent, they are received through Speckle receivers in the main script: CANTIERE optimizer. You have the possibility of getting inputs from three receivers. When you open CANTIERE optimizer, there are two default Speckle receiver nodes and a blank one. Paste your *Stream ID* in the third receiver and connect the received data to the list next to it, exactly as it is done for the other two receivers.



If you want to have more streams and easily switch among them, the default receivers can also be replaced by new receivers where you can paste more *stream IDs*. To do that, delete the nodes and search for a new receiver in the Add-ons section of the Library.



A Speckle sender is also included by Default in the script so that the geometry result of the optimization is saved in cloud and can be received by another script.

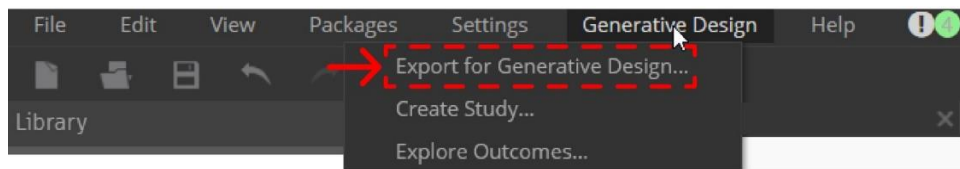
The inputs for CANTIERE optimizer are: *Input source* (use 3 to use the receiver in which you pasted the stream ID), the *Cell size*, which determines the accuracy of the generated geometry through setting how fine or coarse the grid should be, and the *Budget* in millions of Danish Kr.

Inputs

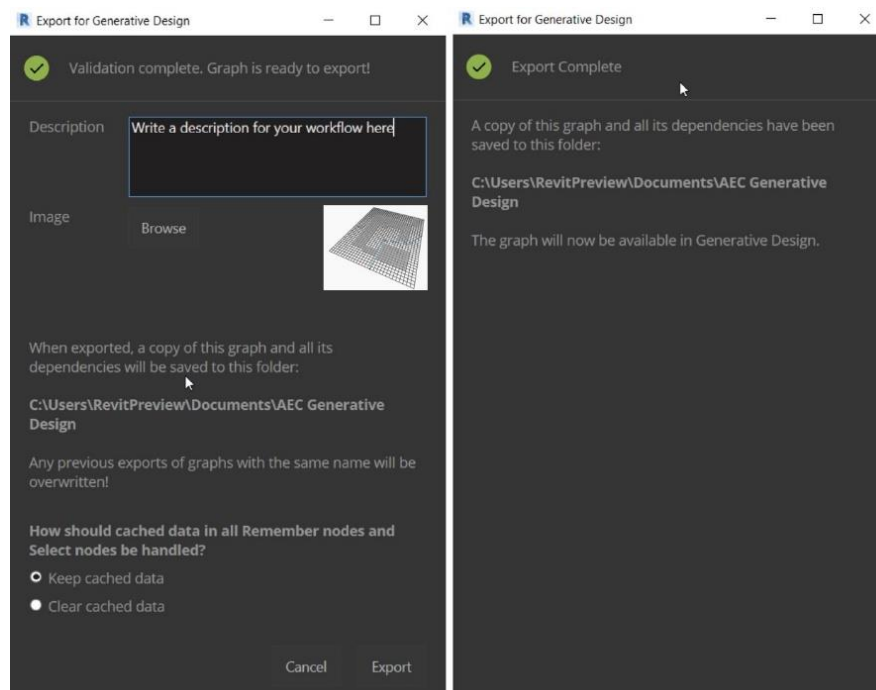
Input source	3
Cell size (mm)	8000
Budget (Mln dkk)	100

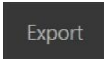
Press  to run the script.

Once the run is complete, open the window “Export for Generative Design...” from the “Generative Design” menu of the toolbar.



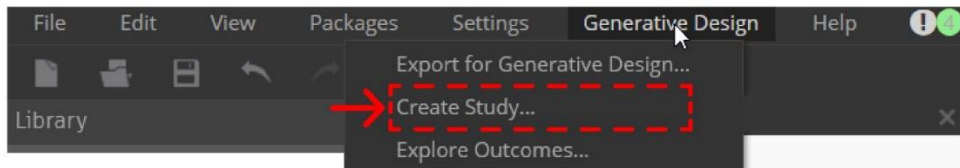
Here you can write a description of the optimization you want to make.



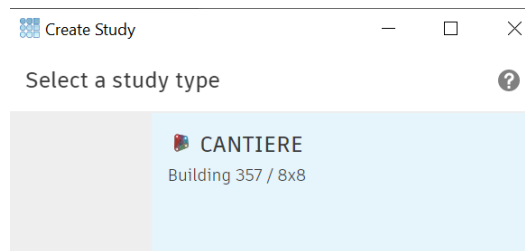
Keep the selection on “Keep cached data” and press 

A message saying “Export complete” should appear as shown in the picture above.

At this point, **Generative Design** can be launched by pressing on “Create study”.



Select “CANTIERE” in the list of the study types.



Select the variables that you want to use for the generation of geometries.

Set all the goals to “Maximize”.

Choose the constraints for the acceptability of the result. The scores go from 0 to 10, exception made for the **% of covered footprint**, which goes from 0 to 100.

Type the size of the population to generate and the number of generations along with any number to use as a seed for the optimization.

Choose variables		Set constraints	
<input checked="" type="checkbox"/> Crane Position	0 to 1000	<input checked="" type="checkbox"/> % of covered footprint	Min 75 Max
<input checked="" type="checkbox"/> Material Position	0 to 1000	<input checked="" type="checkbox"/> TIME score	Min 5 Max
<input checked="" type="checkbox"/> Material Area Shape	0 to 1000	<input checked="" type="checkbox"/> COST score	Min 5 Max
<input checked="" type="checkbox"/> Number of Cranes	1 to 2	<input checked="" type="checkbox"/> SAFETY score	Min 5 Max
<input checked="" type="checkbox"/> Temporary Facilities Position	0 to 1000	<input checked="" type="checkbox"/> QUALITY score	Min 5 Max
<input checked="" type="checkbox"/> Temporary Facilities Shape	0 to 1000	<input type="checkbox"/> OVERALL score	Min Max
<input checked="" type="checkbox"/> Percentage of Covered Area	0 to 50		
<input checked="" type="checkbox"/> Number of Container Layers	1 to 3		
<input checked="" type="checkbox"/> Site Path Points	0 to 1000		
<input checked="" type="checkbox"/> Crane Size	20000 to 60000		

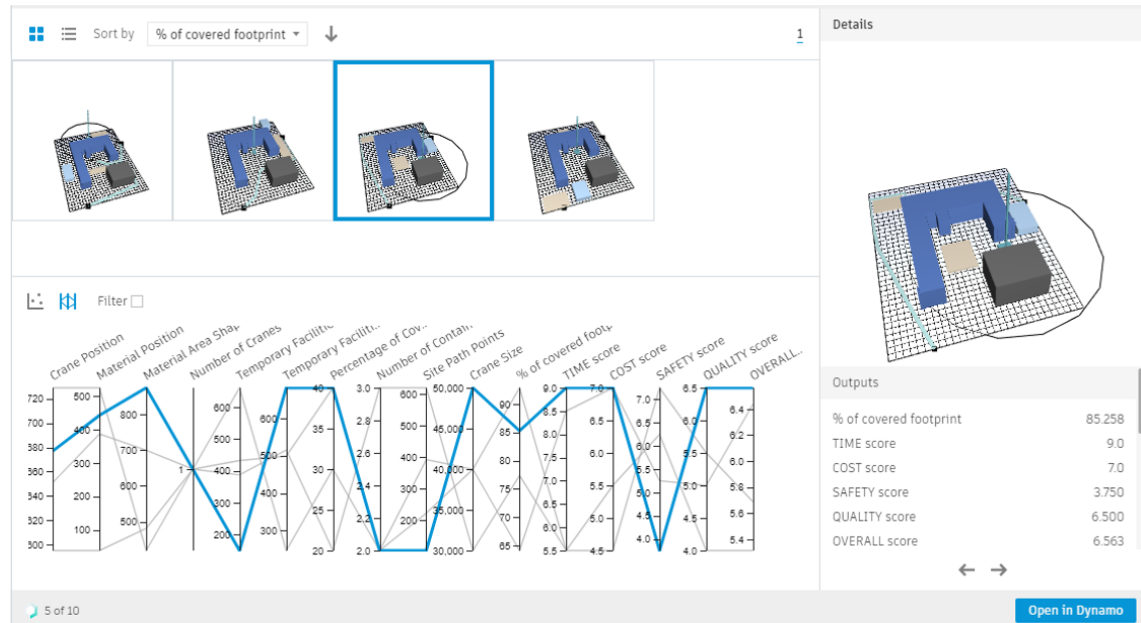
Set goals	
<input type="checkbox"/> % of covered footprint	<input type="radio"/> Minimize <input checked="" type="radio"/> Maximize
<input checked="" type="checkbox"/> TIME score	<input type="radio"/> Minimize <input checked="" type="radio"/> Maximize
<input checked="" type="checkbox"/> COST score	<input type="radio"/> Minimize <input checked="" type="radio"/> Maximize
<input checked="" type="checkbox"/> SAFETY score	<input type="radio"/> Minimize <input checked="" type="radio"/> Maximize
<input checked="" type="checkbox"/> QUALITY score	<input type="radio"/> Minimize <input checked="" type="radio"/> Maximize
<input checked="" type="checkbox"/> OVERALL score	<input type="radio"/> Minimize <input checked="" type="radio"/> Maximize

Generation Settings	
Population Size	100
Generations	10
Seed	1

Once all the settings are done, **Generate** press at the bottom of the window to start the optimization.

The results of the optimization are visualized through a *design grid* view, where the models are visible and sortable by inputs or outputs, and through a *parallel coordinates* chart, where the results can be filtered by the scores that the geometries obtained in each optimization goal.

Each solution can be selected and the detailed are visualized on the right side of the Generative Design interface.

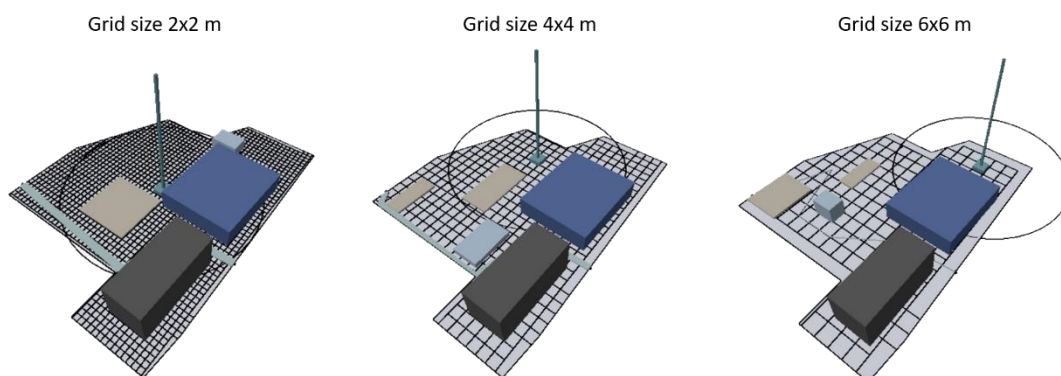


Once the solution has been chosen, either record the inputs to obtain it or open it directly in Dynamo pressing [Open in Dynamo](#)

Recommendations

By testing CANTIERE in multiple scenarios, some guidelines for the correct use of the tool have been identified.

- 1- Before starting the optimization with Generative Design, it is recommended to set the **grid size** in order to obtain an accurate result within an acceptable computing time. The balance is found when the number of cells constituting the grid is in the range of 300 – 1000. This means that the bigger is the construction site, the bigger should be the size of the cells.



- 2- During the creation of new study in Generative Design, it is suggested to set the minimum of the **% of covered footprint** in a range between 70 and 80. This is to ensure the output of a solution in which the crane covers the majority of the building footprint, but still keeping a large enough population that allows the genetic algorithm to work correctly. Similarly, to keep a balance between performance and diversity in the generated population, it is suggested to set the minimum acceptable value for the other optimization goals not higher than 5.

Set constraints			
<input checked="" type="checkbox"/> % of covered footprint	Min	75	Max
<input checked="" type="checkbox"/> TIME score	Min	5	Max
<input checked="" type="checkbox"/> COST score	Min	5	Max
<input checked="" type="checkbox"/> SAFETY score	Min	5	Max
<input checked="" type="checkbox"/> QUALITY score	Min	5	Max
<input type="checkbox"/> OVERALL score	Min		Max