With the support of the Erasmus+ Program of the European Union Strategic Partnerships N° 2021-1-SE01-KA220-VET-000028000

Noise Modelling

Assignment with solution

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License

Version

Version 2.0

Date: 2025-04-29

Learning outcomes

At the end of this assignment, the learner is expected to be able to

- Extract data from repositories with BIM data and GIS data.
- Transform (reformat, convert, clean and merge) GIS and BIM data according to specifications provided by noise modelling software.
- Load merged BIM and GIS data into noise modelling software
- Execute noise simulations and evaluate its results.

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Expected Workload

1 assignment, 32 classroom hours, 2 ECTS (ECVET)

Abstract

The aim of this assignment is to demonstrate data some fundamental issues when integrating BIM and GIS data, in this case in a noise modelling context.

Expected competences when entering the lecture

- Basic knowledge in BIM and IFC.
- Basic knowledge in GIS data processing.
- Basic knowledge of QGIS

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Revision History:

Revision	Date	Author(s)	Status	Description
0.1	2024-12-13	A. Östman	Final draft	Assignment ready for QA review
1.0	2024-12-18	A Östman	Final version	Updates based on comments by reviewers
2.0	2025-04-29	A Östman	Final version	Updated EU logo and disclaimer. Edited by T. Näslund

Contents

Assignment task

A significant part of the population is exposed to noise from traffic and exposure increases, partly due to increasing urbanization and traffic growth. A WHO study has shown that noise is affecting sleep and cardiovascular and metabolic function. Reducing noise is one of the targets of the EU's Zero Pollution Action Plan and the Environmental Noise Directive (END).

The END demands all EU member states to map the noise levels in larger cities. These noise maps are not based on direct measurements of noise. Instead, they are based on a detailed noise propagation model called CNOSSOS. There is an open-source tool developed for that purpose, a tool we intend to use in this assignment. The data used in modelling traffic noise consists mainly of data about traffic on the roads and data about buildings. The buildings obstruct the noise propagation, but they are also the places where people live or work and get disturbed. GIS tools are often used for preparing the data input to the noise modelling software. In case where large reconstructions are planned, the proposed changes in the physical environment might only be available as BIM models. To be able to evaluate the impact of the new constructions, the BIM data needs to be merged with the GIS data about existing facility, to facilitate new noise modelling. The results of such a new noise modelling may require a redesign of the designed reconstructions.

Our study area consists of a small part of the city of Zagreb. For this assignment, a new building will be built in this area. It should be stressed that this scenario is artificial, meaning that as far as we know, there are no such changes planned by the city of Zagreb. The new building has just left the architects desks and is available as a BIM model. You task is to evaluate the effect the new building will have on the noise levels within its neighbourhood.

The data we will be using are enclosed in the zip archive of this assignment. They have the following origins.

1. Office building from Karlsruhe Institute of Technology: https://www.ifcwiki.org/index.php?title=KIT_IFC_Examples
2. The GIS data from the Geohub of the city of Zagreb, https://geohub-zagreb.hub.arcgis.com/

Software Installation

3. In this exercise, we will use QGIS for data preparation and visualisation, FreeCAD for BIM modelling and NoiseModelling for modelling the noise propagation from traffic.
4. Install QGIS from https://qgis.org/da/site/, if not already done. This tutorial is based on version 3.34.4.
5. Install plug-ins for Open Street Map, see https://www.qgistutorials.com/en/docs/downloading_osm_data.html for more detailed instructions.
6. Install FreeCAD from https://www.freecad.org/downloads.php.
7. In case you are new to BIM software, have a look at the tutorials coming with the software.
8. Install the NoiseModelling software, version 4.0.5 or later, from https://noisemodelling.readthedocs.io/en/latest/.
9. To familiar yourself with the NoiseModelling software, you may load the training files. Follow the tutorial at https://noisemodelling.readthedocs.io/en/latest/Get_Started_GUI.html.

Data requirements

10. The noise modelling software needs at least three different types of input data, namely a building layer, a traffic layer, and a layer with receiver points. In this assignment, we will prepare the building and traffic layers in QGIS, while we will prepare the receiver layer in NoiseModelling software. If required, you can prepare the receiver layer also in QGIS, but the NoiseModelling software has pre-installed functions for generating this layer.
11. The emission model of the implemented road traffic model is the CNOSSOS-EU model. Users can choose coefficients specified in the Noise Assessment Directive 2015/996 (https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015L0996) and its amendment 2019/1010.
    a. The letter “L” means “noise”
    b. “Ld” then means noise during days, “Le” during evenings, “Ln” during nights and “Lden” during days, evenings and nights
    c. The NoiseModelling software is based on the Noise Directive, stating that the EU member states shall report the number of citizens affected by high noise levels. For this reason, the number of persons living in each building may be included in the modelling.
12. Each layer needs to be loaded into the noise modelling software, where it will be stored in a table.
13. To examine the required content and naming of the tables, do as follows.
    a. Drag the “Noise_level_from_traffic” icon on the left sidebar to the “Builder” canvas.
    b. Click on an item on the left part of the “Builder” canvas and you will see its explanation in the right-hand panel. Mandatory elements to be specified are the table names of roads, buildings and receivers.
    c. Click on the “Buildings” item and the names and content of the required data is printed in the right-hand panel

The table must contain:
***THE_GEOM** : the 2D geometry of the building (POLYGON or MULTIPOLYGON)*
***HEIGHT** : the height of the building (FLOAT)*

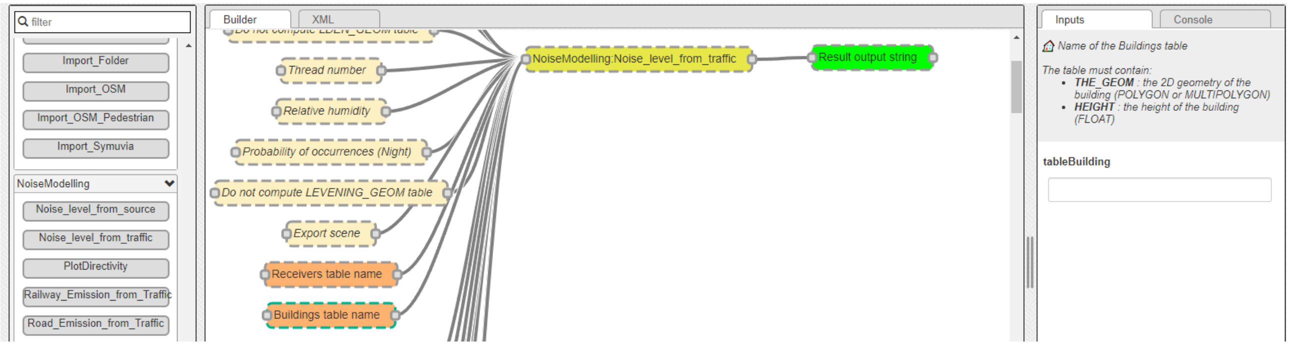

Figure 1: Main canvas of Noise modelling software

d. Examine in a similar way the details of the required properties of the roads and receiver layers

Data preparation

Prepare buildings layer.

14. Open QGIS and load the GeoPackage file with building data over Zagreb, named Zagreb_geopackage.gpkg. Select the zagreb2 layer.
15. Load the open street map as a background map, by using the OpenLayers plugin in the Web tab.

If everything is OK, you should have a screen looking something like this.

Figure 2. Study area in Zagreb

16. Observe that the reference system for the building data set is EPSG:3765. This information is needed when loading the data into NoiseModelling.
17. Select a building and inspect its attributes. The height of the building is set in the attribute named “Z_Delta”.

OBJECTID	698
Godina	2008
HOK5_NOM	5J22_35
LOD	LOD1
Izvor	aerofotogrametrijsko snimanje
Z_Min	115,9717
Z_Max	120,8904
SArea	65,5284343489
Volume	24,2368081682
Z_Delta	4,918700000000001
GDi_OID	
Koristenje	D5- Školska
Status_koristenje	NULL
Analitika_koristenje	Javna i društvena
Skupno_koristenje	Javne i društvene površine

Figure 3. Structure of Building attributes

18. According to the specification of the NoiseModelling software, the attribute specifying the height of the building should be named "HEIGHT". Create a new column with that name and copy the value in column "Z_Delta" to "HEIGHT". Make sure the column type is decimal value.
19. The geopackage file is in 2D only, but NoiseModelling needs 3D layers. Run the command "Assign Z-Value" and assign the z-value "0.0" to each building. However, the ground elevation of each building is also specified in the attribute "Z_Min". But since we don't know the elevations of the roads, we cannot use this information. Instead, we must work with 2D geometries in 3D space where all buildings and roads are assigned z=0.0 (decimal value, some modelling tools are sensitive to the data type).
20. The NoiseModelling software can, in version 4.0.5, read GIS formats like geojson and shape (shp). Export the building layer to one of these two file formats.

Prepare roads layer

21. The next step is to open the roads layer. This layer is extracted from the roads database provided by the city of Zagreb. To reduce data processing time, the road layer has been

clipped along the boarders of the area of interest. Load the data set named "ClippedRoadsSpeed".

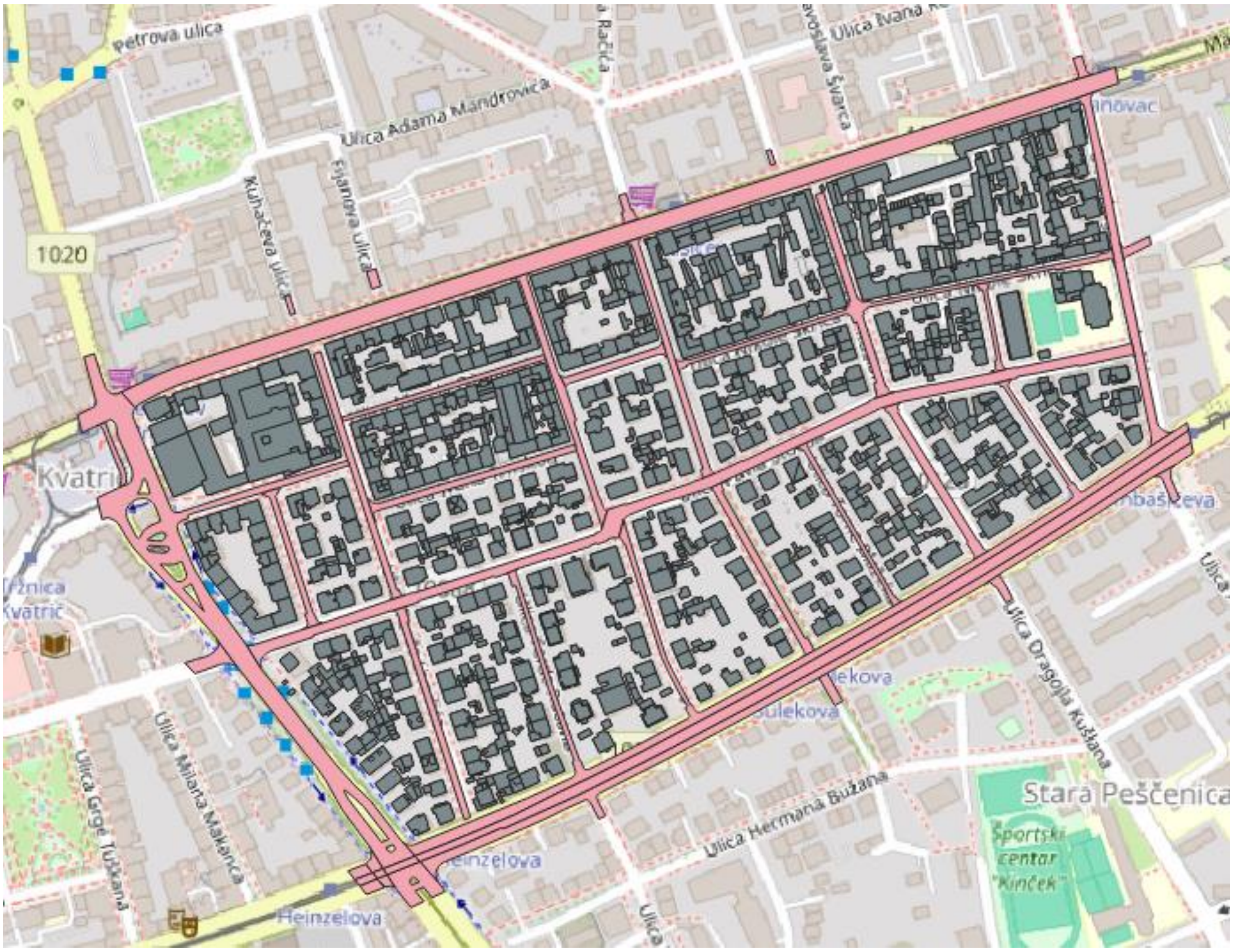

Figure 4. Study area with clipped roads

22. For noise modelling, the roads layer should at least have information about the number of vehicles per hour and their average speed. Additional information may also be provided to increase the accuracy of the noise modelling. The information about the vehicles may be separated into different types of vehicles and for different periods of the day (D, E and N).
23. Unfortunately, there is no traffic information available about the roads. Instead, traffic data from another city have been imported and merged with the Zagreb data. We have here two different types of vehicles, light vehicles (LV) and heavy-duty vehicles (HV).

24. Inspect one road object by clicking on it using the information button. You the notice the following
    a. The geometries consist of complex polygons.
    b. Each polygon represents the edge of the road, not the centrelines where the cars (noise emitters) are supposed to drive.
25. In the NoiseModelling software, noise emission points will be generated along the road segments. In the best case, we should use the centrelines of each lane in the roads. But in our dataset, the road segments correspond to the edge of the road, not the centreline. This is quite common in many urban databases. We will not adjust for it in this assignment.
26. De-complex the road polygons by using the command “Multipart to singlepart”.
27. Convert the road polygons to road lines by using the command “Polygons to lines”.
28. Assign a proper z value to the road lines by using the command “Assign Z-value”. Since the road layers will be used for noise emission points, where the noise is created by vehicles, a good z-value could be 0.5 meters.
29. Save as shape file

Run Noise Propagation Modelling

30. Open the NoiseModelling software.
31. Load the building layer by
    a. Drag the “Import_File” process to the canvas.
    b. Enter the filename of the file to import in the Path field.
    c. Enter a suitable name of the database table to be created, for instance “Buildings”. Try to avoid national letters, only English letters A-Z and a-z.
    d. Run the process by pressing “Run Process”

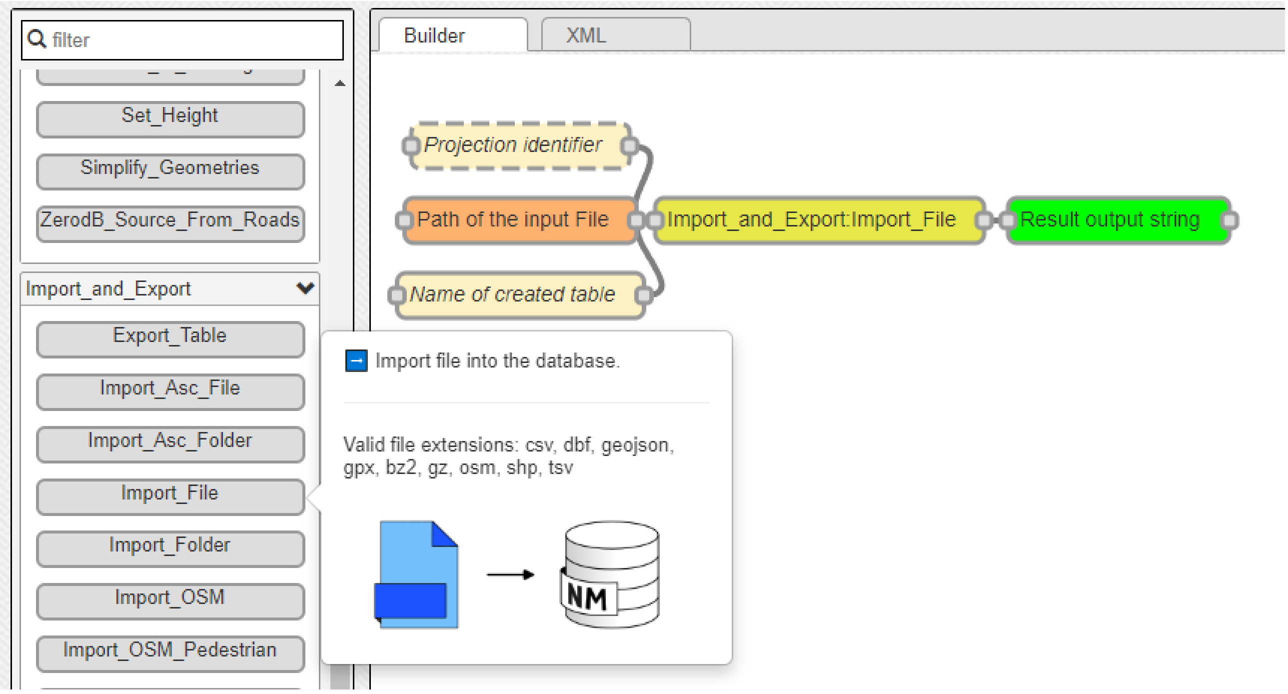

Figure 5. Importing files to NoiseModelling

32. If the building layer is imported successfully, Run the “Display_Database” process, or “Table_Visualization_Data”. The first command only displays the column names while the second command display the first 10 rows of the table. Verify that the data and column names from the shp/geojson file have been imported properly by comparing column names with the corresponding names in the shp/geojson file.
33. Load the road layer in a similar way.
34. The next step is to prepare the receiver layer, using built-in functions in the NoiseModelling software. Go to the “Receivers” section at the bottom of the panel on the left-hand side.

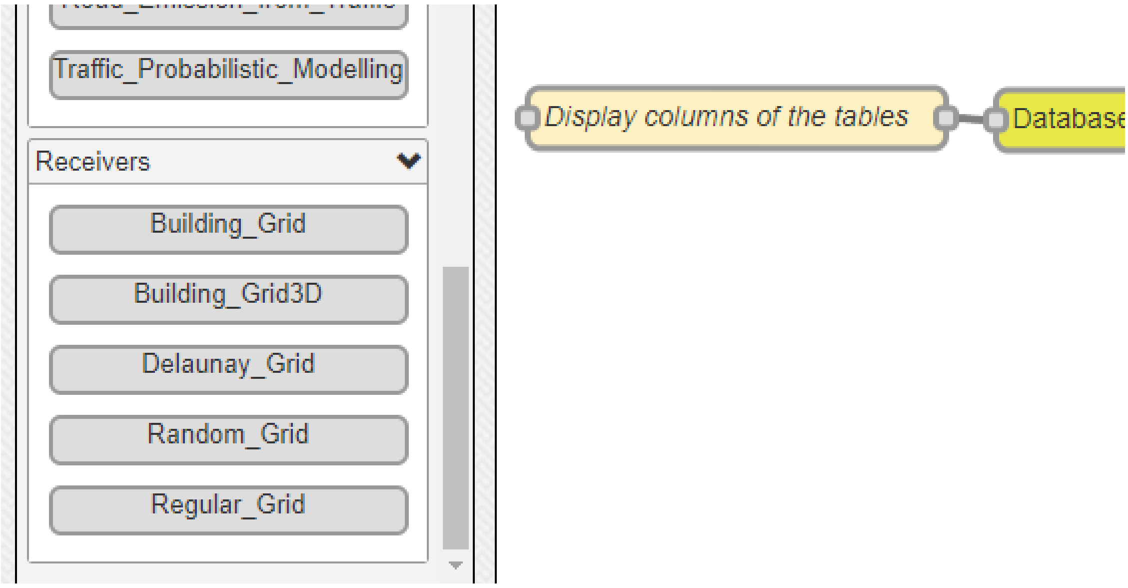

Figure 6. Building receivers grid panel

35. Depending on the type of noise analysis to be made, different patterns of receivers may be generated. A receiver is a point where the noise is to be calculated. If one is aiming to estimate the number of persons affected by high noise levels, one of the Building Grids may be of interest. In our case, a noise map is to be produced. This means that a regular grid would be fine.
36. Drag the “Regular_Grid” process to the main panel. There are several parameters you can enter here. Review their meaning but you can keep the default values if you wish. The only thing you must enter is the name of the building table. The modelling software will create a fence around the area of interest and then generate a regular grid inside this fence, based on the content of the building table.
37. Run “Display_Database” or “Table_Visualization_Data” once more and examine the tables and columns being created.
38. Now it is time to run the noise propagation model. Drag the “Noise_level_from_traffic” process from the left-hand pane (just above the “Receivers” processes) to the main panel.
39. To run this noise propagation, several parameters can be specified. You may leave most input parameters as default, but you must specify the table names of the buildings, roads and receivers.
40. Export the LDEN_GEOM table as a .shp file by using the process “Export_Table”.

Prepare a Noise Map

41. Go back to QGIS and open the LDEN_GEOM shape file. It should look something like this

Figure 7. Output grid file

42. Inspect the attributes of a few grid points, using the “identify object” command. If everything is OK, you should have attributes related to noise levels of different octave bands (from 63 Hz up to 8000 Hz). There are also two generalised noise parameters, LAEQ and LEQ. LEQ stands for Equivalent Continuous Sound Pressure Level and it represents the total sound energy being logged, or in our case being modelled. This parameter is the most used parameter in legislation, noise studies etc.
43. Create contour lines of the LEQ values, for instance by using the Contour plugin in QGIS. Modify the cartographic appearance according to your own preferences, for example by using line width, color or other visualisation settings. The noise map may look something like this.

Figure 8. Noise map

44. Open FreeCAD and load the file “AC20-Institute-Var-2.ifc”. You should then be able to view the new office building, see figure 9

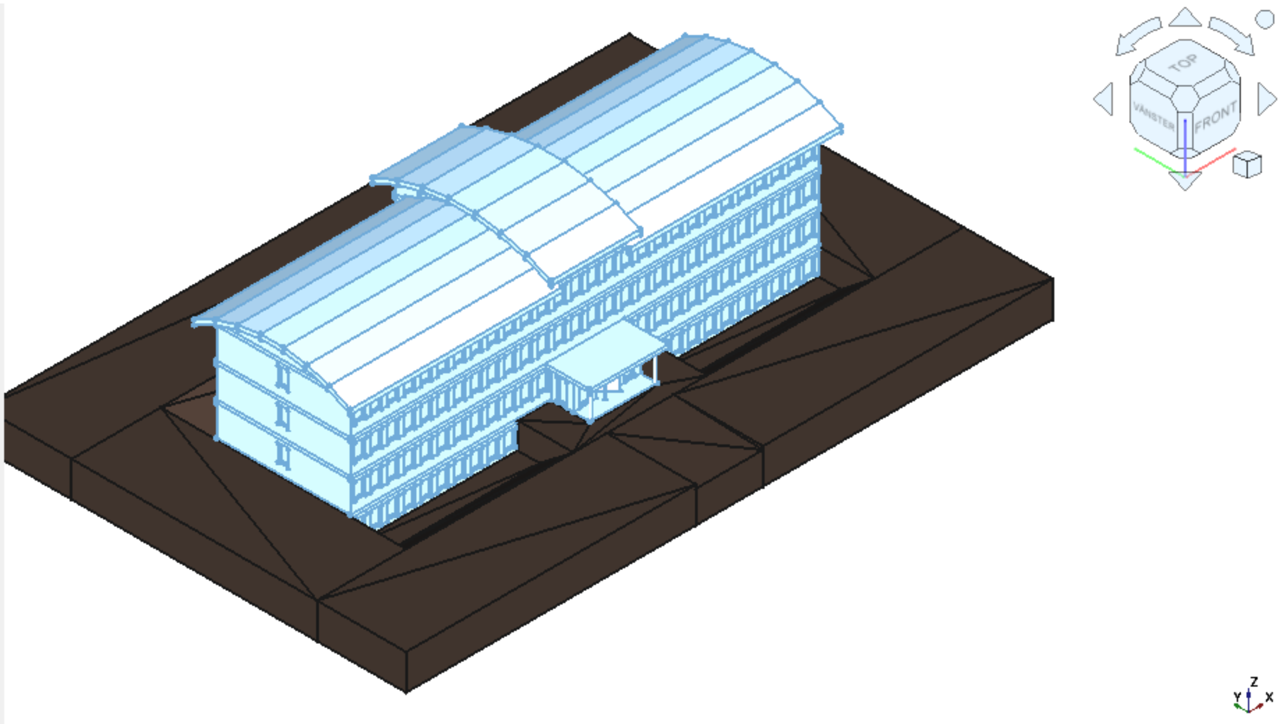

Figure 9. Our new office building as viewed in FreeCAD

45. Our building data for the noise modelling consists of the footprint (outline) of the building and its height as an attribute. The BIM model is much richer in information, so we need to clean it up a little bit. There is much redundant information in the BIM model, which we don't need for our noise modelling. We can do such a cleaning in the BIM environment or in the GIS environment, but in this case I prefer to do it in a BIM environment.
46. Before cleaning up, we should do some measurements. Measure the height and size of the building, for instance by using the measure tool. I got the height to 12,17 m and the size to around 44 x 14 meters.
47. We only need the building outline (footprint) for the noise modelling, and the height we just measured. If we export the entire building, then we need to do a lot of cleanups in QGIS. It is easiest to export only the outline of the footprint of the building. Explore the building components using the FreeCAD software and select the component(s) that correspond to the footprint. I selected the component "Projekt Beurogebeude – Gelaende 0815 – Beurogebeude – Dachgeschoss – Decke-002". Please note that there is a hole (an inner ring) in this component.
48. Then it is time to export the selected BIM components. There is a jungle of different formats, but we should use a format which can be read by QGIS. DXF is such a format, although it is only for 2D. Select the component you wish to export and export it as a DXF file.

Prepare the new building layer

49. Since you cannot edit DXF files directly in QGIS, you must convert it to shape, for instance by using the plugin "Another DXF Importer / DXF2Shape Converter". Convert and import the DXF file into QGIS and open it. Since the BIM model is not using geographic coordinates, the building is situated close to (0,0). Zoom in to the layer with the imported DXF file, see figure 10.

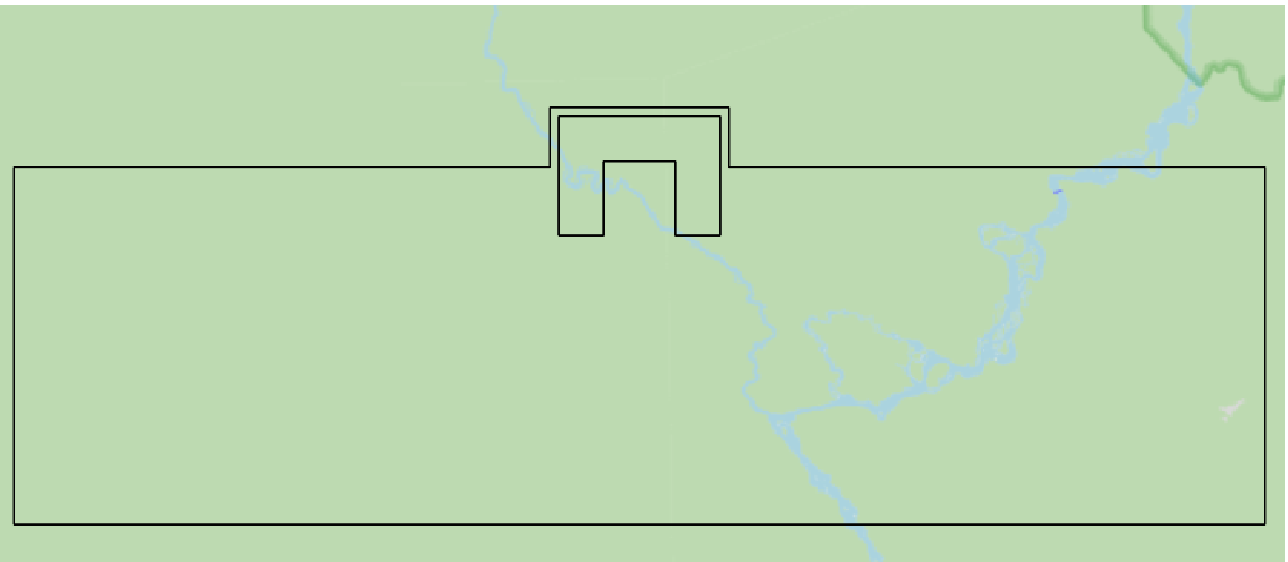

Figure 10. Extracted BIM model, imported into QGIS.

50. We should now check our import. Unless you have used a better footprint than I had, we notice that our data also include the hole we observed earlier. In addition, if we measure the size of the building, we notice that the size is around 44 * 14 km. There is a conversion error where millimetres (main unit in BIM) are converted into meters (main unit QGIS). This means that our cleanup consists of the following steps
51. Delete the hole by using QGIS editing tools.
52. Re-scale the new building, for instance by using the tool “Geoprocessing toolbox – Vector geometry – Affine transformation”. Assign the scale factor 0.001 for the x, y and z-axis. I also recommend you that the filter setting in “Algorithms properties” ignores not valid geometries. Check the new size of the building after the affine transformation.
53. Create a 3D polygon of the building. The following commands may be used
    a. Repair geometries
    b. Densify the lines
    c. Polygonise
    d. Assign z-value

54. Move and rotate the new office building and place it in the area it is supposed to be located see green building in figure 11.

Figure 11. New office building inserted at its expected location.

55. Merge the two building layers (the old one and the new one), for instance by using the command “Union”. Set the height attribute of the new building to the height you measured in the BIM model (12,17 m in my case). Export the new layer as a shape file.
56. Rune the noise simulation once more, but now with the new building included in the building data set.
57. Export the noise grid in the same way as before and create a new noise map. Display the old and new noise maps side by side and compare the differences. You can now see the effect a new building has on the noise propagation, see figure 12

Figure 12. Noise maps, before and after inserting a new office building.

Discussion topics

- The process we have applied in this exercise is often called “Extract-Transform-Load” (ETL). There are specialized software packages addressing this type of workflow, for instance FME (Safe software), HALE Studio (wetransform) and several others. Classify the different operations you have carried out in this assignment as “Extract”, “Transform” or “Load”. Which ETL-processes do you think can be automated through scripting using specialized ETL software?