Construction of Sound Models Using Freely Available Data

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Bachelor's thesis
November 2014
Environmental Engineering

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ABSTRACT

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Environmental Engineering

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Bachelor's thesis 34 pages, appendices 12 pages

December 2014

Creating a Sound Map requires an Environmental map and a Source Model. Digitizing environmental maps requires time and the time required depends on the size of the map. It would be easier to import readymade maps as many national survey authorities provide map data publicly. The aim of this thesis was to check the viability of importing freely available data to create environmental map for sound model creation

Finland was used as a model and different types and formats of data was tested to conclude the optimal format for different objects required for environmental maps. Software SoundPLAN 7.2 was majorly used for the task with minor usage of ArcGIS. Las2txt was used to translate LAZ data to ASCII.

ASCII was optimal format for terrain and surface points, Buildings and roads were best imported as ESRI or DXF formats. LAZ was required and used after translated to ASCII for building and structure height when it was unavailable in ESRI or DXF metadata. National Map data were the most reliable followed by Open source where self validation is required before use. The process of importing freely available data to create environmental maps was found to be possible for any part of the world with varying level of convenience depending on the data available and overall the method was found to save considerable time compared to manual digitization of data.

Key words: sound model, open source data, soundplan, national map data, road traffic noise

CONTENTS

ABBREVIATIONS AND TERMS

ESRI	Environmental System Research Institute
GIS	Geographical Information System
CAD	Computer Aided Design
ASCII	American Standard Code for Information Interchange
I	Intensity
L	Sound Intensity Level
p	Pressure
Pa	Pascal

1 INTRODUCTION

Maps and map data are easily available today as government as well as private sectors conduct different type of area mapping and publish them. Huge variety of map sources is found online. The data sometimes can be overwhelming. The aim of this thesis is to assess the viability and convenience of using these freely available map data available to create a map model and noise models.

There are plenty of software suites available, which map and model sound, in the market including some open source software. These types of software have basic environment mapping support. A general way of mapping the environment is by tracing polygon on top of a bitmap map. The task is convenient for a small area but conducting this in a large scale can be time consuming. Usage of readily available data can streamline the process of modelling and mapping huge areas as quickly and conveniently as the computing power available.

Data for Environmental maps can be obtained from National Map data, created and published by a government body or Open Source. Open Source Data as the name suggests are open sourced i.e. data is created and distributed by individuals which are made available for free and cannot be sold. The data can be created and published by anyone within a specified format and used without limitation. Openly Created data can be edited and republished with the only requirement of citing the original data. (What is Open Source, Bit Blueprint Aps)

Environmental Map Data are available in a range of formats. The most common ones are: American Standard Code for Information Exchange (ASCII) data which contains elevation, terrain, geological and anthropogenic structures; Esri (Originating from Arc-Suite) files which are line and polygon data which contain buildings, roads and area data; and AutoCAD drawing files which are similar to Esri but are created in AutoCAD.

Apart from these there are also laser scanned grid data which contains the laser scanned surface data.

The data available are mostly in clusters and needs to be sorted and filtered before it can be used. A range of third party software like ArcGIS can be used, but not necessary, to manage the data clusters. These data have codes and can be further divided into small manageable packets when sorted based on the codes.

2 SOUND THEORIES

2.1 Measurement of Sound

Sound is measured as Intensity. Intensity is defined as Power acting per area.

$$I = \frac{Power\ (watts)}{Area\ (square\ meter)} \quad \text{Equation 1}$$

The S.I. units of Intensity are W/m^2 (watts per square meter). At mid range frequencies, human beings can hear a wide range of intensities. It ranges from threshold of hearing $I_0 \approx 1 \times 10^{-12} W/m^2$ to threshold of pain at $\approx 10\ W/m^2$. The intensity level is measured in decibel scale (dB). The scale is set such that at the threshold of hearing, the sound intensity is zero dB. (Knight, 2008)

$$L_I = 10 log_{10}\left(\frac{I}{I_0}\right) \text{ dB} \quad \text{Equation 2}$$

L_I = Sound Intensity
When I=I_0 (threshold of hearing), L_I = 0 dB
When I = 10 W/m^2(threshold of pain), L_I = 130 dB

For Sound Power Level,

$$L_W = 10 log_{10}\left(\frac{W}{W_0}\right) \text{ dB} \quad \text{Equation 2}$$

L_W = Sound Power Level

When W=W_0 (threshold of hearing), L_w= 0 dB

W_0 = 10^{-12} W or 1pW (picowatt)

Similarly, The sound pressure at threshold of hearing p_o = 2.0×10^{-5} Pa. The decibel scale relative to sound pressure level is represented as:

$$L_p = 20 \log \frac{p}{p_o} \ dB \qquad \text{Equation 3}$$

When p= p_0 (Threshold of hearing), L_p = 0 dB

L_p = Pound Pressure Level (Tammertekniikka, 2002)

2.2 Sound Attenuation

Attenuation is the process of gradual loss of intensity. Sound loses intensity with the increase in distance from the source. A Point source emits spherical waves uniformly in all direction. The noise intensity at a distance r for point source depends on power of the noise source (W) per surface area of a sphere with the radius r. (Knight 2008)

$$I = \frac{W}{4\pi r^2} \quad \text{Equation 4}$$

The intensity of the source decreases inversely with the square of the distance.

$$\frac{I_1}{I_2} = \frac{{r_2}^2}{{r_1}^2} \quad \text{Equation 5}$$

A line source emits cylindrical wave and its intensity decrease linearly as the distance from the source increases.

$$\frac{I_1}{I_2} = \frac{r_2}{r_1} \quad \text{Equation 6}$$

Translating Equation 4 to sound levels

$$L_p = L_w - 20\log r - 11 \ \text{(dB)} \qquad \text{Equation 7}$$

If the sound is directional, additional directive index affects the sound pressure level. Directive index (DI) is the difference between the actual sound pressure and the sound from a non directional point source with the same sound power. (Lamancusa, 2009). An Omni-directional sound source has a Directive index of zero.

$$L_p = L_w - 20\log r - 11 + DI\ (dB) \quad \text{Equation 8}$$

2.3 Sound Propagation in Real Atmosphere

There are many factors that deviates sound propagation from a spherical model including, absorption of sound in air, deviation due to meteorological conditions, ground absorption and barriers.

$$L_p = L_w - 20\log r - 11 + DI - A_{abs} - A_E(dB) \quad \text{Equation 9}$$

Where, A_{abs}=atmospheric absorption (dB)

A_E= Excess Attenuation (dB)

Excess attenuation is the total attenuation in addition to that due to spherical divergence and atmospheric absorption. The total Excess attenuation accounts for many effects such as weather, ground, turbulence, vegetation and barrier.

$$A_E = A_{weather} + A_{ground} + A_{turbulence} + A_{barrier} + A_{vegetation} + \text{Any other effects} \ldots \quad (\text{dB}) \text{ Equation 10}$$

Each of the quantities are either determined experimentally or calculated for limited number of analytical cases. (Beranek et al, 1971)

2.4 Sound Propagation Models

There are different standards used when modelling sound. Following is a list and description of few commonly used sound models.

2.4.1 ISO 9613: 1996

"ISO 9613 describes a method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level" (ISO 9613). A-weighting is the process of accounting for the relative loudness perceived by humans from equipment read value. This is done because the equipment also accounts for low audio frequencies which are inaudible to humans (Knight, 2008). ISO 9613 is applicable to road or rail traffic, industrial noise, construction activities and many other noise sources. This model is the basis of most of the other models of outdoor sound propagation like Harmonoise, Nord2000 and CoRTN88. The following attenuations are taken into account:

Geometric divergence
atmospheric absorption
ground effect

reflection from surfaces
screening by obstacles (ISO 9613-2:1996).

2.4.2 Calculation of Road Traffic Noise CoRTN88:

CoRTN88 model was published by Her Majesty's Stationery Office in 1988. The model incorporates L10 (18 hours) and L10 (1 hour). They are the value of sound level exceded for 10% of time in 18 hours period and 1 hour period respectively. The model also accounts corrections for : Mean Traffic Speed and Percentage Heavy Vehicles, gradient, distance, ground absorption, barriers, angle of view, low traffic flow,opposite facade and retained cut. It is recognized in the U.K. and Australia.

2.4.3 Harmonoise Noise Prediction Algorithm

Harmonoise Prediction Algorithm calculates attenuation by considering the combined effects of ground and air absorption; ground effect; shielding by topography, buildings and barriers; atmospheric refraction or atmospheric scattering. This system calculates attenuation not calculated by the ISO 9613 (Bulen, 2012). Modified versions of this model is used and recognized in Australia and New Zealand

2.4.4 Nord 2000

The Nordic noise prediction method or Nord 2000 is a standard introduced by Danish Environmental Protection Agency for strategic mapping of road and railway noise. This standard include source models for road and rail traffic in the third octave bands from 2h Hz to 10 kHz. The method was in development and in use in the early 1970's and early 80's. The Nord200 currently in use was created and used since 2006. It is designed to be used with different weather classes and nine weather classes are published for the calculation in these different weather classes, although they have to be run separately. Nord 2000 model also takes eight different types of ground surface ranging from very soft (mossy surface) to very hard (dense asphalt), although only soft and hard are used for sound mapping (Nord 2000). The Nord 2000 is used and recognized in the EU.

3 DATA SOURCES

Data are freely available online. Many countries like Finland and Denmark have a National Public Data Library of geological data available at The Finnish National Land Survey site (Maanmittauslaitos) and Danish Geodata Agency (Geodatastyrelsen) respectively. The data available includes topographical, line, polygon, bitmaps as well as laser grid scan. The level of detail of data available depends on the country. Developed countries like western European Countries, United States of America, Australia, Japan, and Singapore have more detailed data compared to developing countries. Some developing countries like Nepal have most of their survey data available only in paper format and hence National Map cannot be found on the internet.

Apart from the National Sources, several Open source data are also available. Open source data are created by the people for the people and is free. These data cannot be sold but can be used without limitation. The only drawback is that it is not guaranteed by any authority because of the nature of its origin but it can be guaranteed by a trusted review or up-loader. Unlike National Public data which are guaranteed by the National Institute it was created, open source data can be incorrect. It is rare but possible. It is up to the user to validate the data. List of freely available data is listed in the Appendices.

4 PROCEDURES

Creating a sound model requires few basic entities. First an environmental map is required and an area is defined in the environmental map where the noise model will be created. A terrain model is required to define the terrain. Then the structures on the map are needed. Roads, 3D model of buildings, bridges and other structures are required in the map. Noise source also needs to be defined. Roads traffic, building noise, trains etc are the noise sources. To model these, further data is required, for example road traffic, building noise type etc. Once all these are obtained, a noise modelling software can be used. All the parameters are to be input in the software and the software makes calculations and outputs a noise model based on a sound propagation model. The output noise model can be in a chart, list or pictorial format. (Mughal, 2014)

The map data i.e. roads, buildings etc can be obtained online if available or else needs to created. There are many programmes capable of creating environmental maps. Mapping software like GIS which can be used to create maps is available. Software like SoundPLAN also come equipped with mapping module.

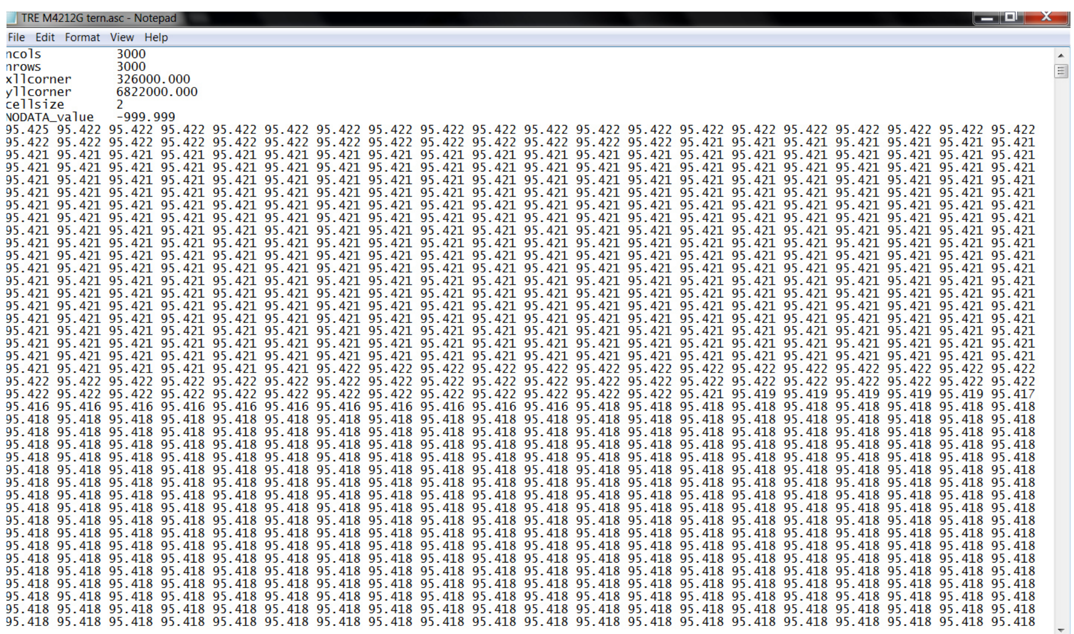
4.1 Obtaining Map Data for Environmental Maps

Map data are needed for environmental map creation. Map data are available in various formats. The format to choose depends on the availability of data and the programme that is used to create noise models and its import capabilities. The following are the type of environmental map data which were found.

4.1.1 ASCII

ASCII stands for American Standard Code for Information Interchange. It is a system which encodes 128 characters (upper and lower case English alphabets, numbers, punctuation marks and symbols) into 7 bit binary integers which is the raw format for any digital data. The ASCII codes which contain map data are available in text file format containing raw coordinates. (ASA X3.4-1963)

Terrain data is very commonly available as ASCII files. The terrain is represented as dots similar to pixels in which each point has a co-ordinate and a height assigned to it. Each point when rendered represents a point of terrain and all the points in unison represent a terrain when interpreted (Figure 2). The resolution of the data available varies according to the origin of the data. Although ASCII data are text files, due to the sheer amount of data inside the file pertaining information on its location in 3-dimensional space and the amount of points in the data, ASCII files are generally huge ranging from tens to hundreds of megabyte as demonstrated in Figure 1. Terrain data in ASCII codes from that National Land Survey of Finland was used in SoundPLAN in this report as seen in figure 2.


TRE M4212G tern.asc - Notepad

File Edit Format View Help

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ncols         3000
nrows         3000
xllcorner     326000.000
yllcorner     6822000.000
cellsize      2
NODATA_value  -999.999
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Figure 1 Raw ASCII data from Finnish National Land Survey as a text file viewed in Notepad.

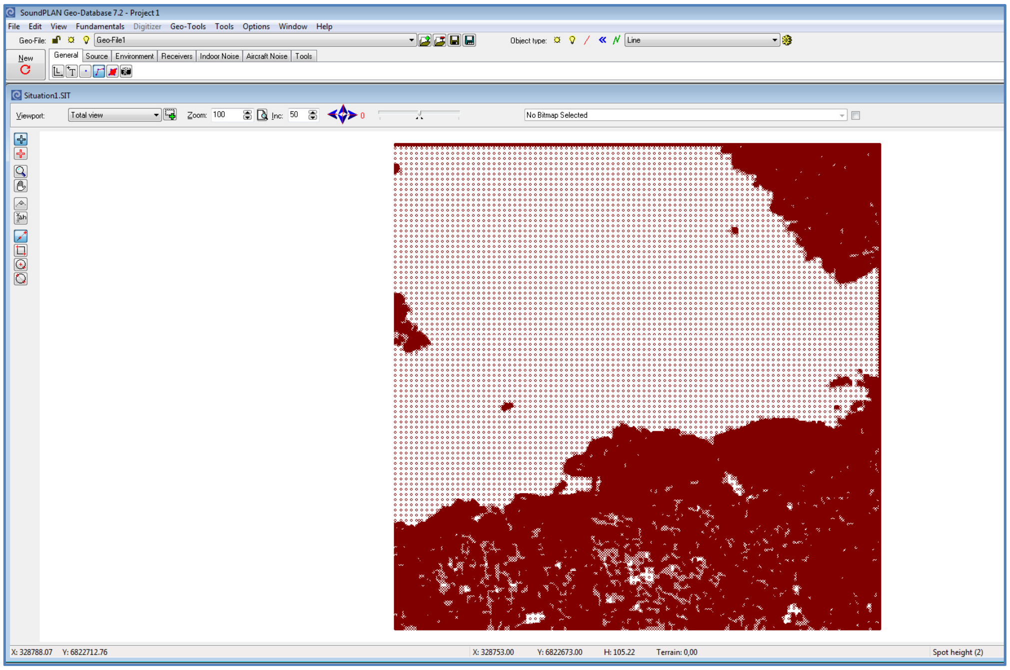

Figure 2 ASCII data interpreted as terrain in Soundplan 7.2

4.1.2 ESRI

ESRI (Environmental System Research Institute) file and file systems are proprietary of ESRI, provider of Geographic Information System (GIS) software and geographic data and geographic data management software. ESRI files are group of files containing point, linear, polygon and area data accompanied by individual sets of meta- data which contains further detailed data (explanation) of each point, linear, polygon data.

Mostly used ESRI data during the creation of sound model were linear and polygon data which represented roads and areas such as building areas, parks, parking lots and water bodies. ESRI data available online from National Land Survey of Finland (NLS) constitutes of huge grid ($400km^2$) and a large number of individual object in the data (thousands), which needed to be sorted and filtered before it could be imported for map making and sound map making purposes. Sound modelling through software was conducted within a small area about 5 – 10 km^2 or less and the data found were in grids of 20-40 km^2. Hence the sorting and filtering was necessary so the simulation and rendering process would run smoothly and only necessary results were demonstrated.

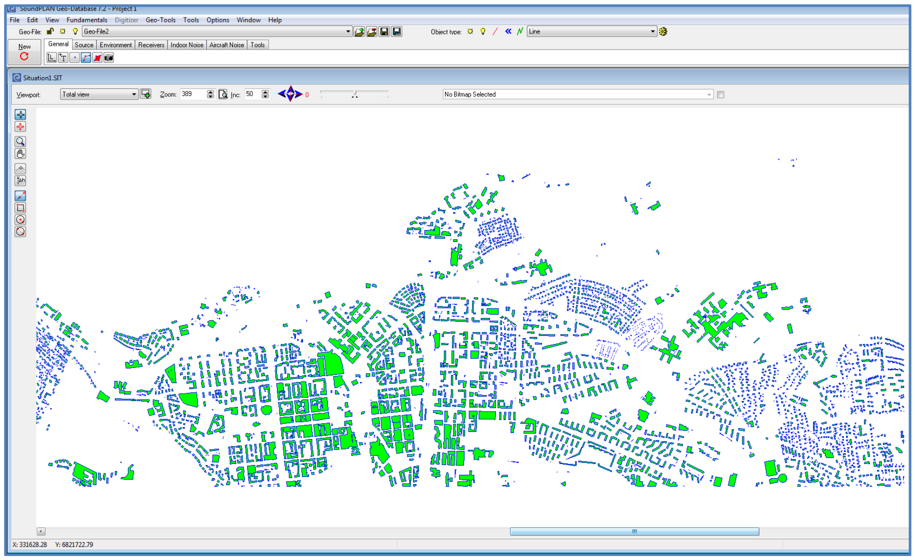

Figure 3 ESRI polygon shape file containing buildings in SoundPLAN 7.2

Management of ESRI data is essential before it can be used hence, programmes like ArcGIS can used for data management before the sorted data is uploaded for sound modelling (Figure 6). ArcGIS provides flexibility in data management. For most of the mapping, native windows file explorer was used to sort and manage ESRI data. ArcGIS was only used in cases where very selective data needed to be imported like roads of exactly 2m in width. This function cannot be done only by file explorers and ArcGIS or similar programmes needs to be used.

4.1.3 AutoCAD DXF

AutoCAD (Auto Computer Aided Design) is proprietary software from developers Autodesk and DXF (Drawing Exchange Format) is the file system of the software.

DXF files are similar to ESRI files in a way that they both have point, linear and polygon data. DXF files also carry data of roads and areas (building areas, zones, parking lots, water bodies) as well as some complex 3D structure of human creation as well as natural land formations. The availability of data as .dxf or ESRI depends on preference of the person or institute that created the data. Danish Geo-data agency has their building and building height data available as dxf file.

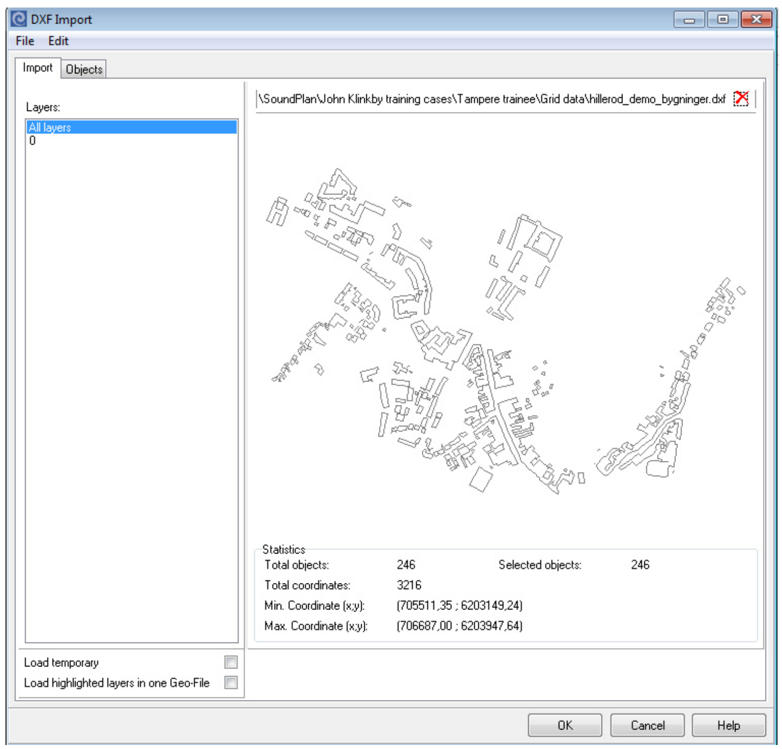

Figure 4 DXF building file upload screen in SoundPLAN 7.2

4.1.4 LAZ

LAZ or Laser Scanned Grid data are the data generated from Lidar scans. Data contained in it are surface point data from a laser scan. Most sound modelling software including SoundPLAN doesn't come equipped with LAZ data interpreter. In such condition, third party software is used to translate the data into ASCII terrain data and then imported. Laz2txt, a free programme was used to view and convert Lidar data to ASCII data as seen in Figure 5.

The data contains surface point data and is used to calculate object height of buildings, road placements, bridges and other significant structures. Building heights of Finland were calculated in SoundPLAN 7.2 by calculating the difference between the surface points of LAZ data and the topography.

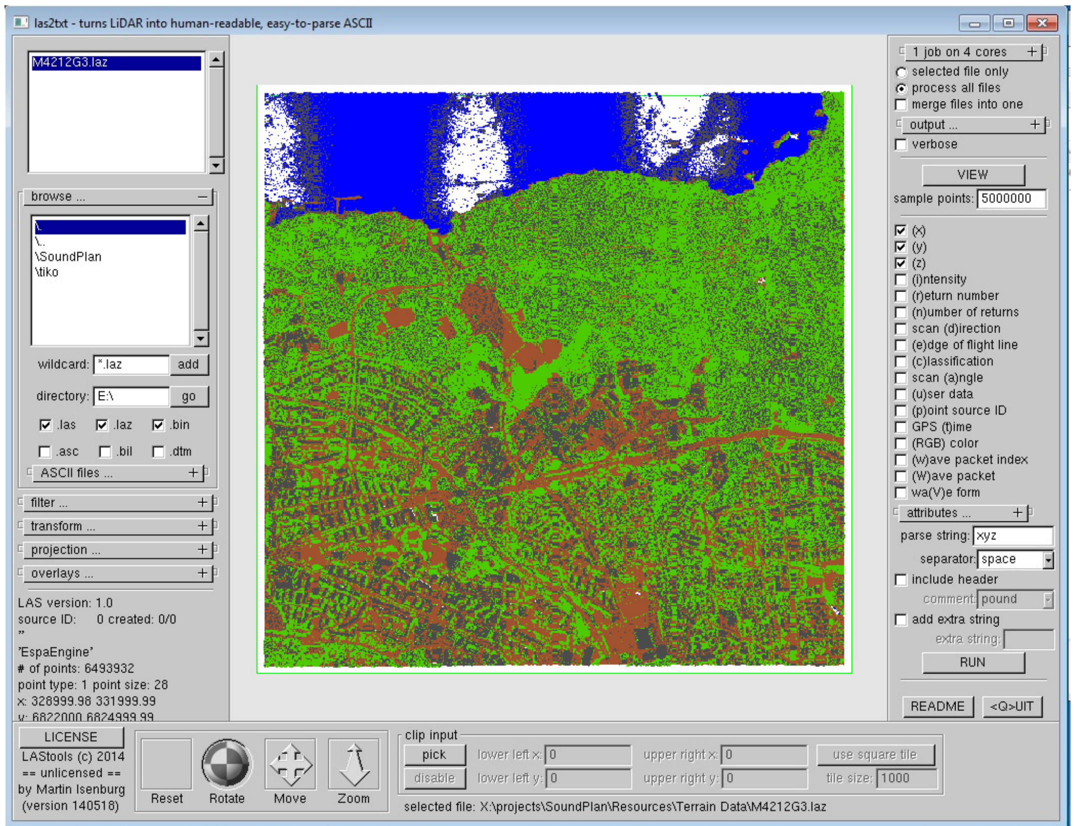

Figure 5 LAZ data with a Lidar viewer las2txt

4.1.5 Bitmap

Bitmaps are the pictorial representation of an area as a map. These maps are available in picture format (jpeg, bmp, and tiff). These maps can be used as the basis of environmental mapping before sound modelling. The bitmaps can be used as layover maps before other structures like roads and required buildings are imported. On smaller scale scenarios, bitmap can be used as starting point and other structures can be traced over it. In these cases, structures are not imported rather they are created by sketching over the bitmap using mapping software or with the mapping module of the noise modelling software where available.

Bitmaps are image files and first need to be calibrated in order to use it in accordance to the co-ordinate systems. Calibration is the process of fitting the map in position so that any point within the map is identifiable with the used co-ordinate system. This is done automatically through complimentary auto-calibration file or manually with 3 or more points and inputting the co-ordinate system of the points. There is always the possibilities of error with manual calibration hence auto-calibration is recommended.

Auto calibration files are geo-location file which consist of co-ordinate values of certain pixels of the bitmap which is used to place the whole map within the co-ordinate system. Bitmaps in this report was only used as a base map for environmental map creation.

4.1.6 Google Earth™ Maps

Google Earth™ is proprietary software of Google. The software has free as well as paid license. Certain Software Packages including SoundPLAN contains modules that allow direct import of terrain and maps from Google Earth although the version used in this model didn't. Google Earth has extensive worldwide data of terrain and structures in various resolutions and accuracy. Google Earth Maps, because of its sheer size of data can have some inaccuracies. In most cases the object and the terrain is fused resulting in hilarious pictures. These maps are to be used at one's own risk. Some examples of inaccuracies are presented in Appendix IV.

4.2 Noise Source Data

Noise source data defines the sources of noise. Noise source needs to be defined in order to create accurate noise maps. There are two different ways a source can be defined; point source and line source. Point source originates from a point and propagates as a spherical wave source, line source is the collective noise originating from line and it acts as a cylindrical wave. Noise originating from a point like a windmill is considered point source and noise originating from roads is considered line source.

A noise source can be an existing source as well as a predicted source (future sources). Noise sources data can be present as average amount of noise originating in units (decibels) or when certain parameters of noise source are known. Noise from a road can be represented as average amount of decibels in a time period or it can be represented as flow of traffic. If the type of traffic passing through a section of the road and the number is known, it can directly be input as it is and the software can predict the noise levels. A detailed noise source data contains, average number of different type of traffic (medium or heavy vehicles) passing through an intersection at different time slices. This produces the most detailed noise source model in software like Sound Plan 7.2. In Table 1, necessary data to create a noise profile for a road is present. This data can be input in SoundPLAN which will create a line source model for a road.

SoundPLAN has library of general definition of various types of roads form Scandinavia and Germany. Those data can also be used instead for Noise prediction although detail and accurate data is always results in accurate results.

Table 1 Example of road's noise profile

	Day (7-18)	Night (22-7)
Light Vehicle Volumes	3142	557
Heavy Vehicle Volumes	376	140
Heavy Vehicle %	12	21
Vehicle speed, km/h	95	110

5 GENERAL METHOD OF CONSTRUCTION OF NOISE MODEL

First, the bitmap is loaded into the software, and an area for Noise Map creation is traced around the desired. Next, the terrain is loaded within the created area. A Digital Ground Model (DGM) is calculated from the loaded terrain data. The digital ground model is the software's interpretation of the terrain. Buildings and Roads are inserted next with general attributes assigned to them. These attributes define the profile of buildings and roads. Detailed profile can assigned subsequently although general definition from the library can be used. Detailed building profile is defined by comparison of topography (DGM) with a laser grid scan in ASCII. The difference of height between terrain and laser grid scan data in the zone occupied by the building determines the building height. The process is calculated automatically as long as the terrain data and the laser grid scan data are input in their correct places. This is the extent of environmental map data required for a Noise map. 3D rendered environmental maps are presented in Appendix III

Further data about the source of the noise and placement of barriers can be input next. The sources of noise need to be established through a noise profile. The most common noise sources are roads. A detailed data about the road can be input like in table 1 where available. There are two types of Noise model that can be created in SoundPLAN: Point Source Map, Grid Noise Map. Point Source Map is created by placing receivers in different places and the output shows the different sound level registered at different receivers. A grid Noise Map shows the intensity of sound at all places within the mapped area. 2D and 3D examples of Grid Noise Map are presented in Appendix III.

6 UTILIZATION OF ARCGIS

Esri's ArcGIS is self described as: "A geographic information system (GIS) for working with maps and geographic information. It is used for: creating and using maps; compiling geographic data; analyzing mapped information; sharing and discovering geographic information; using maps and geographic information in a range of applications; and managing geographic information in a database."

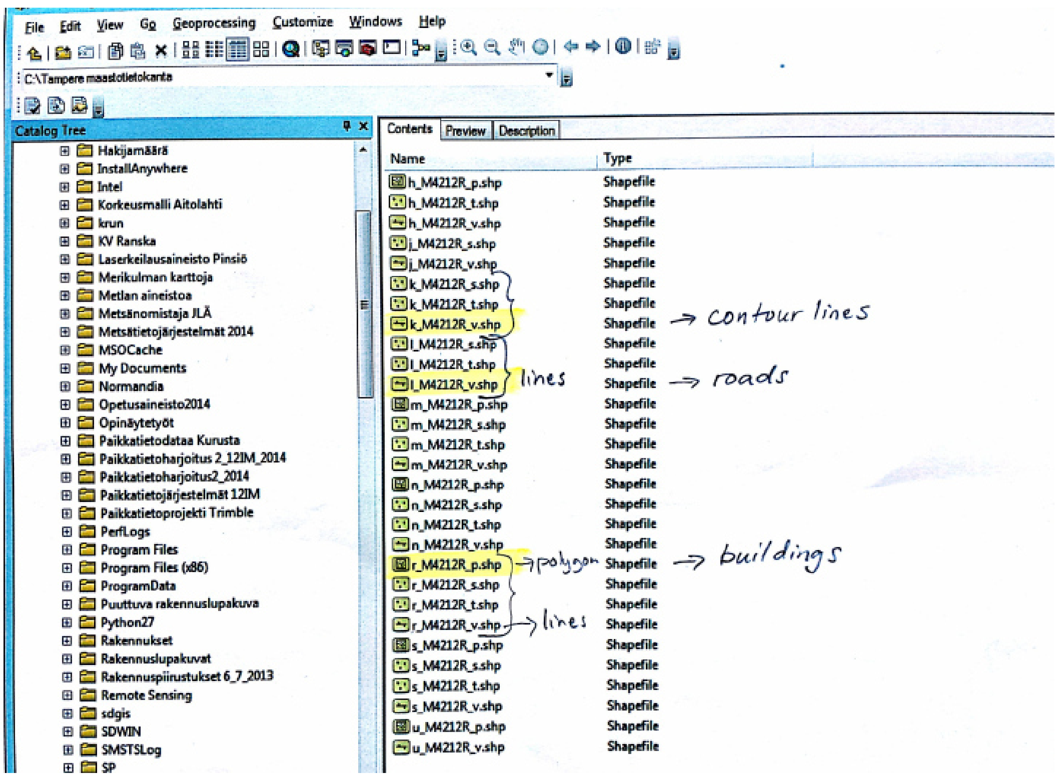

Figure 6 Identification of file clusters in ArcGIS (source: Eeva Sundström)

In figure 6, ArcGIS is used to differentiate between lines, points and polygons. It can also be done with a file explorer (Windows or Macintosh) as long as the codes are recognized. In figure 6, the objects are labelled with a system X_Gridnumber_Y.shp, where lower case string variables X and Y determines the type of data. According to the instructions in the picture, X=r, Y=p represents a polygon file which contains all the building in the grid M4212R and X= l, Y=v represents a line file containing all the roads and shipping routes in the same grid (M4212R).

SoundPLAN is fully equipped with mapping tools and environment maps can be created conveniently within it. ArcGIS, although optional, provides some extra tools which makes mapping easier. SoundPLAN can utilize ESRI files made in ArcGIS hence maps can be created in ArcGIS and uploaded to SoundPLAN if such is preferred. Data available sometimes can be in high clusters, ArcGIS can be utilised as data management software for sorting and selective importing of data. The software (ArcGIS) can access metadata which is the data that describes the objects in the map data such as name and width of a road and number of floors in a building. If these metadata are present, selection and grouping can be done based on it and sorted. This function however cannot be conducted by default file explorers and ArcGIS (or similar software is needed). Examples in the Appendix III were created without the help of ArcGIS.

Data obtained from the Finnish Land Survey contains these metadata as numerical codes. A codebook guide is also available which can be used to find the precise object or type of object. (Maanmittauslaitoksen maastotietokohteet, 2013)

7 COMPARISON OF AVAILABLE SOUND MODELLING SOFTWARE SUITES

There are some other options also available for noise propagation calculation; some free programmes are also available. STAMINA 2.0 and STAMSON 5.1 free programmes which are proprietary of United States and Canada and is free for respective national authority. The programmes only work with 32 bit computers and have limited availability to users outside of North America. Most of the computers today are 64 bit so these programmes have gone out of use and are very hard to find. TNM 2.5 (Traffic Noise Model) is software created by the United States Federal Highway Administration (FHWA, 2014). It is available to download from the FHWA website and can be used but licensing is not free. The programme only accounts for road traffic noise calculation and the algorithm. The input for the programme is limited, only DXF and STAMINA 2.0 files are compatible.

Cadna/(A)coustic and SoundPLAN are commercial software available in the market. Both the software suites were developed in Germany and provide an easy to use Graphical user interface. Both software suites are flexible in terms of input and output. The software come equipped with tools to add and modify input variables. They are also equipped with mapping tools and a library of standards for roads, barriers and vehicles. They both have similar prediction algorithms and according to comparison calculation made by Chung, Karantonis, Gonzaga and Robertsen 2008 and Karantonis, Gowen and Simon, the difference in result is insignificant. The result of the findings showed that SoundPLAN yielded slightly higher decibels that Cadna/A, whereas Cadna/A yielded higher sound behind sound barriers than SoundPLAN. The studies were done in Australia using the Cortn88 prediction method ("Calculation of Road Traffic Noise", London: Her Majesty's Stationery Office 1988.). These studies mention that SoundPLAN model and calculation is more recognized and widely used than the Cadna/A model because it is new. It was also mentioned that SoundPLAN was preferred to Cadna/A because of lack of Nord2000 prediction method in Cadna/A in versions previous to Cadna/A 4.4 (Pedersen, 2013, LinkedIn)

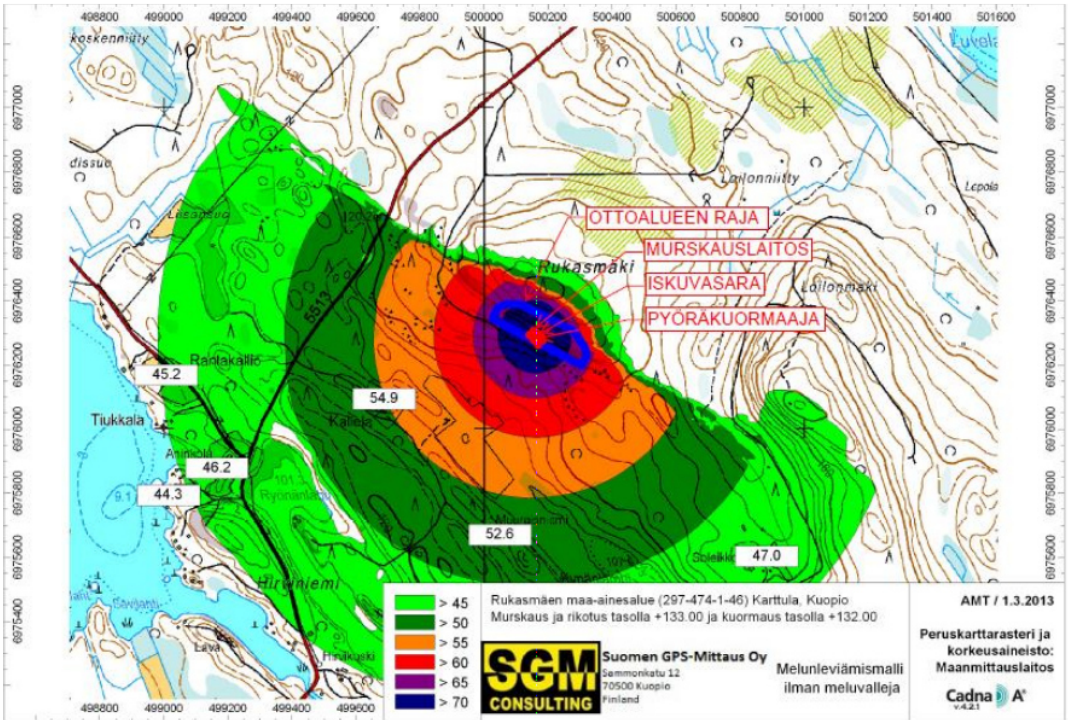

Figure 7 Sound Model Output in Cadna/A (Kirkkonen, 2013)

Table 2 Ranking of Sound Modelling Software

	Cost	Ease of use	Hardware	Input	Speed	Import	Overall
STAMSON 5.1	1 Free	4	4	4	3	4	4
STAMINA 2.0	1 Free	5	4	5	4	4	4
TNM	3	3	1	3	5	3	3
Cadna/A	5	1	1	1	2	2	2
SoundPLAN	4	2	1	2	1	1	1

(Carr, Penton, Li)

Table 2 describes the ranking of different sound modelling software. A score of 1 denotes the best and consecutive number denotes a decrease in ranking than its preceding number. Further explanations of the columns are below:

- **Cost:** General Cost of licensing the product. Software can have different packages and sold separately. The cost also varies on the number of user under the customer and type of usage.
  Although STAMSON 5.1 and STAMINA 2.0 are free, they are not readily available to other outside of their respective local authorities.
- **Ease of use:** Judged on the basis of graphical user Interface and 3d views and ability to run batch calculation (calculation queue) and limits to number of inputs (number of receivers, number of sources)
- **Hardware:** STAMSON 5.1 and STAMINA 2.0 do not run in 64 bit machines which most of the contemporary computers are.
- **Input:** Ability to add and modify data
- **Speed:** Time required for calculations
- **Import:** Ability to import data from other software packages in formats like bitmap, cad drawings (.dxf) or other formats from other modelling software.

Carr, Penton and Li conclude that the best software for Sound Propagation Calculation in light of cost, ease of use, utilization of hardware, input flexibility, speed of calculation and importing options is SoundPLAN.

Apart from these, there are some other software suites capable of Outdoor Sound Propagation Calculation. The list of other less known are listed in table 3

Table 3 List of other Softwares Capable of Sound MOdelling

Acouspropa
IMMI Basic
MITHRA-SIG V3 Light MM Light Module, Module industry
OTL-Terrain Analyser
OTL-Terrain Solver
Predictor-LimA Type 7810
Prelude

8 DISCUSSION/CONCLUSION

Freely available data for environmental maps are available in many formats from many sources. In SoundPLAN, there are optimal formats for certain entities. It was found that the best format for terrain was ASCII codes, best format for buildings (polygon shapes) and roads (line shapes) were ESRI shape files and AutoCAD dxf files. Choosing between ESRI shape files dxf files depends upon the availability and user's personal preference. In most cases, only one of these formats is available from one Source. The data provider may have chosen to create those shape files in AutoCAD or ArcSuite. Building heights are usually available in dxf or ESRI shape files. If they are not available, LAZ data can be used. LAZ data contains the Lidar surface scans and these data needs to be converted to ASCII with third party software and imported. The building heights can be obtained by calculating the height difference between the terrain and a building.

Among the two types of source available, National Map data and Open Source Map data, National Map data should always be the preferred option because of the reliability of National Sources. Open Source data should only be used when National map data is unavailable. Open Source map data should also should be validated before use. The data might of errors and inconsistency in global positioning. Google Maps can also be used to import bitmaps and Terrain data. Although Google Maps are created and backed by Google, care should be used when using this map data. Google maps contain maps of the whole world and due to the sheer size and certain generalised techniques used to create these maps, it should be assumed that not all the areas are checked and validated for accuracy. Accuracy in Google maps depends on the population, location country and popularity of the place. Densely populated areas of a developed country have reliable area maps than rural areas of developing countries. Sometimes open source map data can be more reliable than Google Maps if the publisher is known as a professional or the review in the internet is good. If the publisher of the open source map data can be verified then open source maps should be preferred to Google maps.

Supplementary programmes can be used to make the task more convenient. Software like ArcGIS and AutoCAD can be used to create map data if required. These programmes, although optional, provide an extra level of convenience if one possesses its knowledge. ArcGIS can be used to sort and manage clusters of data. National map data provide GIS topography data which consists of thousands of objects in a folder as well as in a file. ArcGIS can be used to sort these data to a more manageable cluster before uploading to SoundPLAN. This helps free the computer memory for more calculation. Having a huge clump of unnecessary data slows down the calculation process. Hence, selective import of useful data helps speed up the calculation and prevents system clogs.

Utilizing freely available data to create an environmental map model for sound model creation saves considerable amount of time compared to digitising the map. The bigger the map, the efficient it is to import data instead of digitising. An area of 40x40 m^2 can take more than 40 hours to digitise but will take less than an hour to import. The most complicated entity to digitise is the terrain. Terrain can be digitised using contour lines and it takes quite considerable amount of time. Importing terrain should be preferred to digitising. Buildings and Roads can be digitised and is relatively easier to digitise compared to terrain.

It is theoretically possible to create an environmental map of any place in the world and create a sound model of anywhere in the world and is practical for all the countries with public national map data. Any area in Finland and Scandinavia can be effectively mapped within an hour because of the availability of environment map data. This is also true for any country with public national map data available which are listed in Appendix I. Environmental and sound maps for other countries with national map data unavailable publicly can also be created but it might require more effort. There are open source data available for many countries which can be found from Appendix II. If the data required is unavailable, it can be digitised. Terrain data is the only complicated data that is strenuous to create but terrain data is found for almost any corner of the world including underwater. If no such data is found in the open source data base, terrain data from Google maps can be imported. Google maps have terrain data for all land mass, mapped underwater areas including Mariana trench, the moon and some parts of mars.

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United States Federal Highway Administration, 2014, FHWA Traffic Noise Model V2.5 software and manual:
https://www.fhwa.dot.gov/environment/noise/traffic_noise_model/tnm_v25
Accessed: 19/11/2014

What is open Source? A short Video, Bit Blueprint Aps, Filed in Wikimedia Commons. Accessed from:
http://upload.wikimedia.org/wikipedia/commons/transcoded/c/ca/What_is_Open_Source_explained_in_LEGO.ogv/What_is_Open_Source_explained_in_LEGO.ogv.480p.webm

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available online at: http://www.maanmittauslaitos.fi/en/node/4747 (as of 15/10/2014)

Appendix I: List of National Data Sources

- **Australia :** Geoscience Australia
  ga.gov.au
- **Austria:** Bundesamt für Eich- und Vermessungswesen (BEV),
  bev.gv.at
- **Belgium:** Nationaal Geografisch Instituut (NGI) / Institut Géographique National (IGN)
  ngi.be, ign.be
- **Brazil:** Instituto Brasileiro de Geografia e Estatística (IBGE)
  ibge.gov.br
- **Botswana:** Department of Surveys and Mapping
  www.mlh.gov.bw
- **Canada:** Centre for Topographic Information
  http://www.nrcan.gc.ca/
- **China:** 国家测绘地理信息局 / National Administration of Surveying, Mapping and Geoinformation
  sbsm.gov.cn
- **Colombia:** Instituto Geográfico Agustín Codazzi (IGAC)
  igac.gov.co
- **Croatia:** Državna geodetska uprava (DGU) / State Geodetic Administration
  dgu.hr
- **Czech Republic** Český úřad zeměměřický a katastrální (ČÚZK)
  cuzk.cz
- **Denmark including Faroe Islands and Greenland:** Geodatastyrelsen / Danish Geodata Agency. **Data Available:** Terrain, .dxf files with building heights.
  gst.dk
- **Egypt:** Egyptian general Survey Authority (ESA)
  esa.gov.eg
- **El Salvador:** Instituto Geográfico y del Catastro Nacional
  www.cnr.gob.sv

- **Estonia**: Maa-amet / Estonian Land Board
  maaamet.ee
- **Finland:** Detailed data for finland can be obtained from Finnish National Land Survey (Maanmittauslaiutus) website. The range of data is available free and the website is accessible in English, Finnish and Swedish which is accesible at:
  https://tiedostopalvelu.maanmittauslaitos.fi/tp/kartta?lang=en
  Data available: Background map, General Map (multiple scales), Map rasters (multiple scales), Elevation model 2m, 10m, Topogrpahic map raster (multiple scales), Laser gridscan, Orthophoto
- **France:** Institut national de l'information géographique et forestière (IGN)
  ign.fr
- **Germany:** Bundesamt für Kartographie und Geodäsie (BKG) / Federal Agency for Cartography and Geodesy. Maps available excluding 1:5000 - 1:100 000
  bkg.bund.de
- **Great Britain** Ordnance Survey (OS) Northern Ireland excluded
  ordnancesurvey.co.uk
- **Greece:** Γεωγραφική Υπηρεσία Στρατού (ΓΥΣ) / Hellenic Military Geographical Service (HMGS)
  gys.gr
- **Guatemala:** Instituto Geográfico Nacional (IGN
  ign.gob.gt
- **Hong Kong:** 測繪 / Survey and Mapping Office (SMO)
  landsd.gov.hk
- **Honduras:** Dirección General de Catastro y Geografía (DGCG)
  dgcg.ip.gob.hn
- **Iceland:** Landmælingar Íslands (LMÍ) / National Landsurvey of Iceland (NLIS)
  lmi.is
- **India:** Survey of India
  www.surveyofindia.gov.in
- **Indonesia:** Badan Informasi Geospasial
  bakosurtanal.go.id

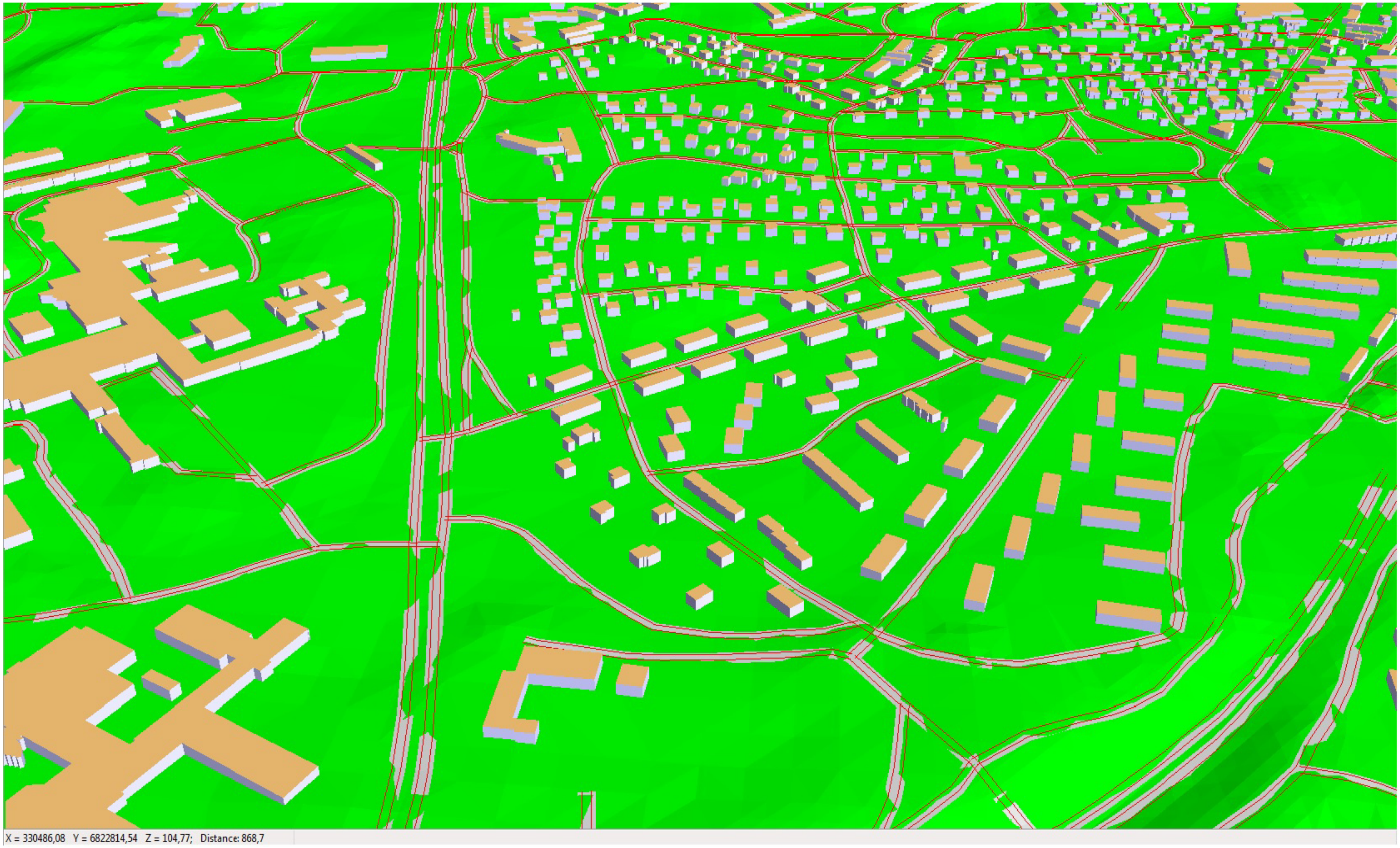
- **Iran** National Cartographic Center
  ncc.org.ir
- **Ireland:**Ordnance Survey Ireland
- **Israel:** Survey Of Israel
  mapi.gov.il
- **Italy:** Istituto Geografico Militare
  igmi.org
- **Japan:** Geospatial Information Authority of Japan
- **Mexico:** Instituto Nacional de Estadística y Geografía (INEGI)
  inegi.org.mx
- **Netherlands:** Kadaster (Caribbean Netherlands not included)
  kadaster.nl
- **New Zealand:** Land Information New Zealand
  linz.govt.nz/
- **Nicaragua:** Instituto Nicaraguense de Estudios Territoriales (INETER)
  ineter.gob.ni
- **Nigeria:** Office of the Surveyor General of the Federation
  www.osgof.gov.ng
- **Northern Ireland:** Land and Property Services
  www.dfpni.gov.uk/lps/
- **Norway**: Statens Kartverk
  kartverket.no
- **Pakistan**: Survey of Pakistan
  www.surveyofpakistan.gov.pk/
- **Portugal**: Instituto Geográfico Português
  www.igeo.pt/
- **Russia**: Federal State Service for registration, inventory and mapping ros-reestr.ru/wps/portal/
- **Saudi Arabia:** Ministry of Municipal and Rural Affairs, General Commission for Survey
  www.gcs.gov.sa/

- **Slovakia:** Úrad geodézie, kartografie a katastra
  www.skgeodesy.sk
- **Slovenia:** Surveying and Mapping Authority of the Republic of Slovenia
  http://www.gu.gov.si/
- **South Africa:** Chief Directorate: National Geo-spatial Information
  www.ngi.gov.za
- **Spain:** Instituto Geográfico Nacional
  www.ign.es/
- **Sri Lanka**: Department of Survey
  www.survey.gov.lk
- **Sweden:** Lantmäteriet
  kso2.lantmateriet.se
- **Switzerland:** Swisstopo
  swisstopo.admin.ch
- **Thailand:** Royal Thai Survey Department
  www.rtsd.mi.th
- **Turkey:** General Command of Mapping
  www.hgk.msb.gov.tr
- **United States:** United States Geological Survey
  www.usgs.gov
- **Uruguay:** Servicio Geografico Militar, Montevideo
  sgm.gub.uy

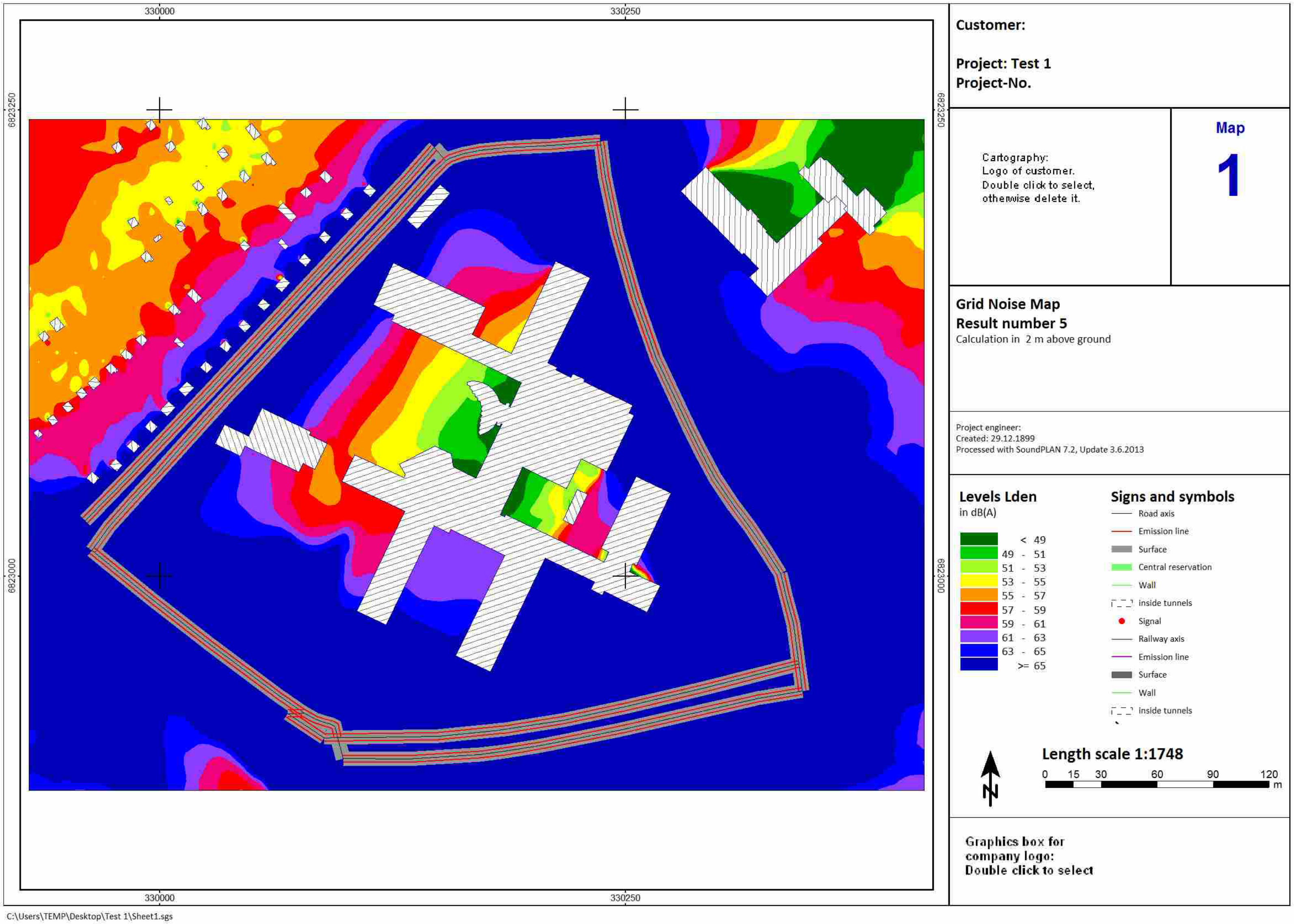
Appendix II: List of Open Data Sources

- Google Earth Maps: Requires installation of Google Earth™ and maps can be exported. Terrain vector, selective buildings and roads data available.
- Open Street Maps : Open source street and building maps
  http://www.geofabrik.de/data/download.html
- Range of free GIS data
  freegisdata.rtwilson.com/
- Worldwide Boundary, Roads, railroads, Elevation.
  www.diva-gis.org/gdata
- Worldwide elevation 90m
  srtm.csi.cgiar.org

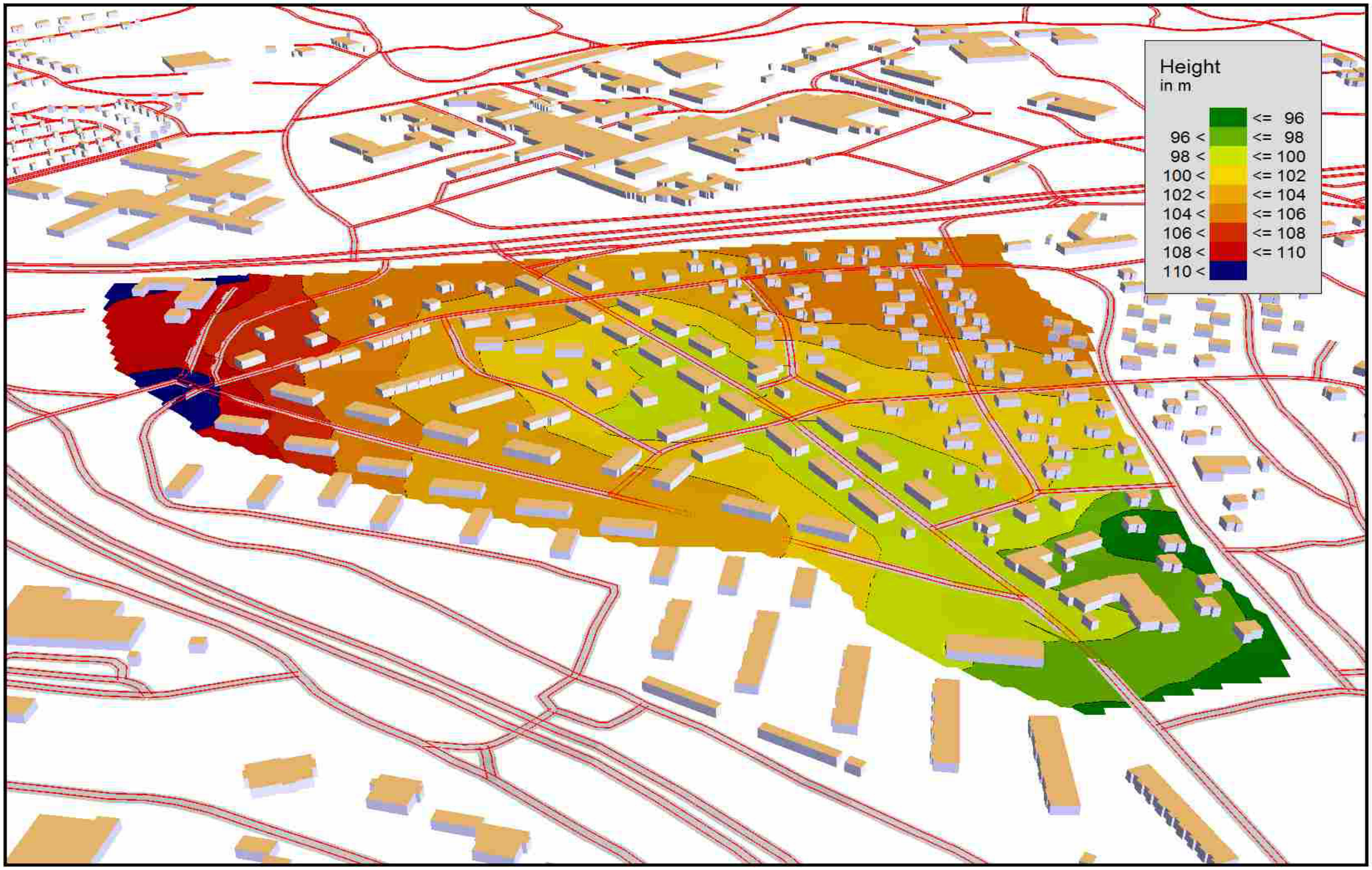
Appendix III: Examples in SoundPLAN 7.2



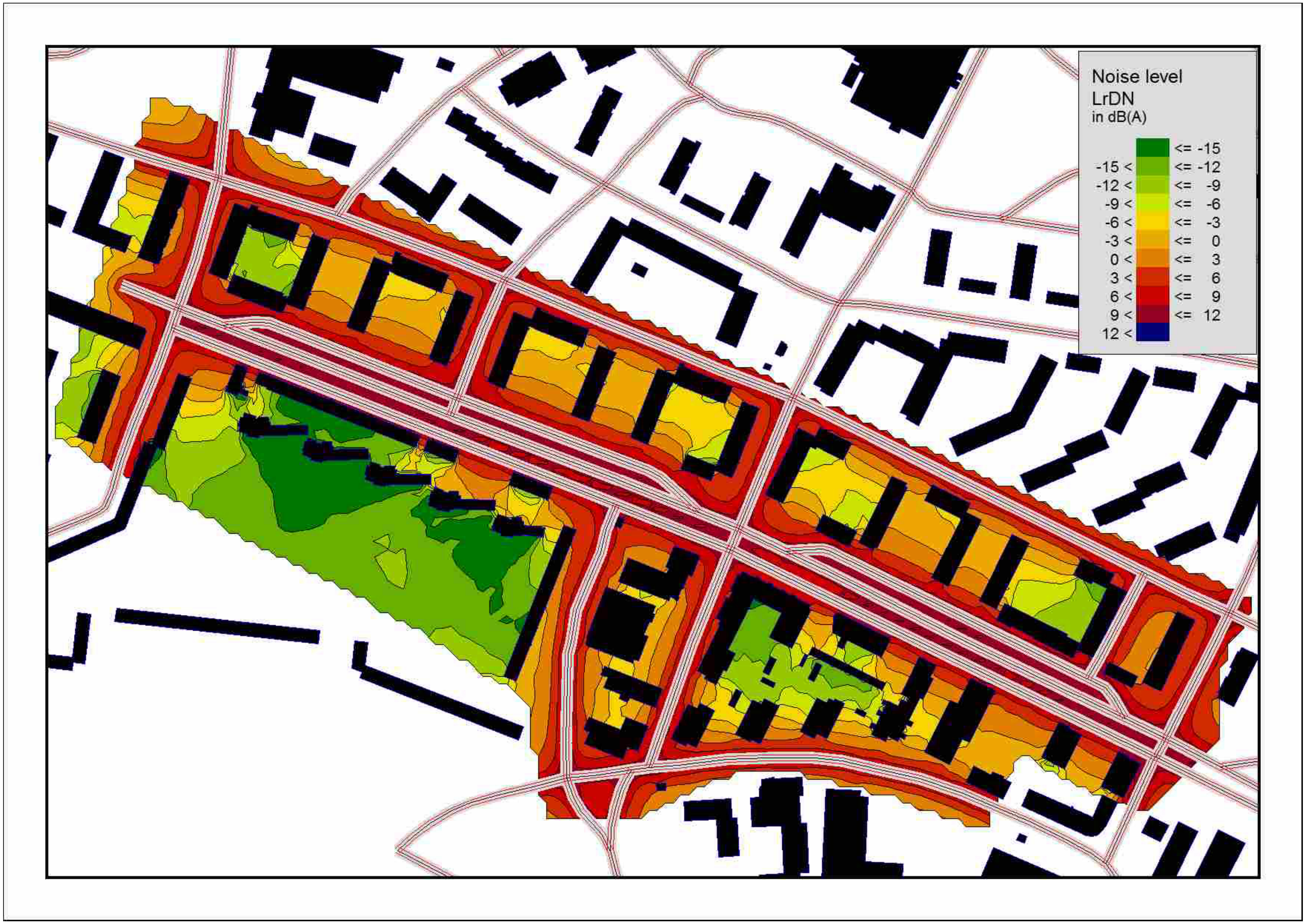
3D Render of Kissanmaa, Tampere in SoundPLAN 7.2



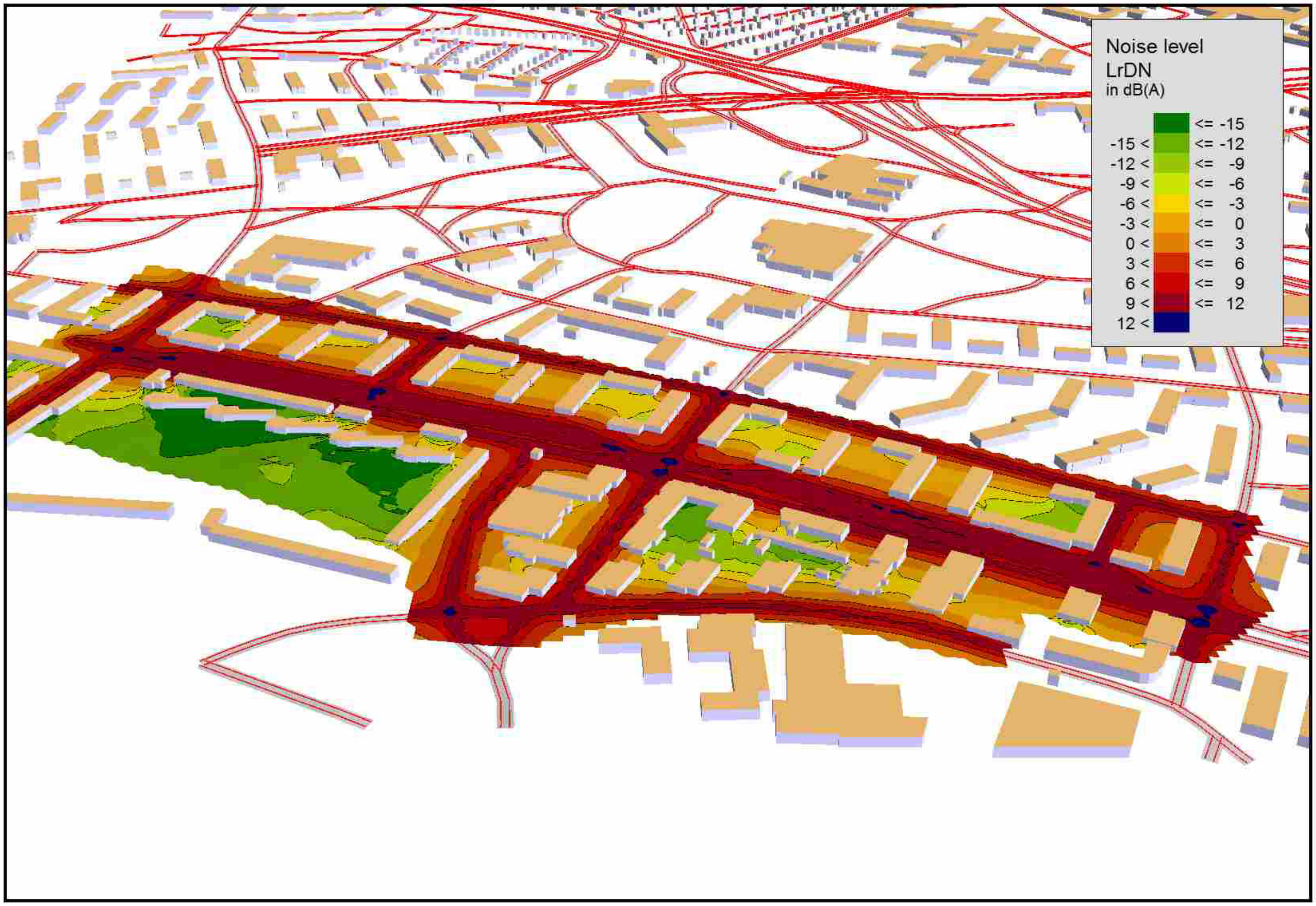
Sound Map from Manually Digitized Environmental Map of Teskontie, Tampere SoundPLAN 7.2



3D view of Kissanma, Tampere with Elevation model Rendered in SoundPLAN 7.2



2d Render with Noise Model (day/night) Kaleva, Tampere, with a relative dB Scale



3D Render with sound map of Kaleva, Tampere, with a relative dB Scale

Appendix IV: Examples of Unreliable Google Maps

(Viralnova)

(Viralnova)