NOISE MAPPING OF LARGE REGIONS - EXTRA BENEFITS

Hardy Stapelfeldt

Stapelfeldt Ingenieurgesellschaft mbH (SIG), Wilhelm-Brand-Str. 7, D 44141 Dortmund, Germany
email: HS@stapelfeldt.de

and

Frank-Christian Zacharias

Thüringer Landesanstalt für Umwelt und Geologie (TLUG) , Jena, Germany

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Environmental noise analysis, especially when used for END noise mapping, will require large and detailed modelling data. Different sources of data provision are involved. Modelling data is not subject to any fixed scheme and thus after 10 years of END extra efforts are still needed to create a homogenous model. Available data get ever more detailed and unveil more data conflicts. In consequence the amount of necessary refinement seems to increase. In support of financial efficiency modelling and calculation shall aim at working on larger regions which produces new challenges in data storage. From the economic point of view one may consider using these models for noise abatement. As abatement considerations shall take air pollution aspects into account it is only logic that the same model shall be fit for air pollution calculation.
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1. Introduction

Looking at the situation in the three rounds of END noise mapping, a trend towards a comprehensive analysis covering large regions instead of single agglomerates can be observed. This helps to make the mapping exercise more efficient and sustainable. The re-use of refined spatial input data for other environmental analysis helps to ensure financial efficiency. The paper will illustrate developments by pointing out example aspects in data refinement and usage for environmental simulation

2. Development of data in volume and detail

2.1 Rise in geometric detail

Watching the last 3 rounds of noise mapping we see a constant rise in size of model data. For round 2 there was a legal demand, as the definition of agglomerates did change as well as the threshold level for relevant major roads.

Nowadays dealing with silent areas is coming into the focus as well and thus model data is needed for a larger portion if not all of the state wide area.

Model data collection is in many countries based on airborne laser or radar scanning producing more accurate data but also bigger in volume. Taking the example of terrain data we see a shift from 10 m grid cell data to 1 m increasing the data size 100-fold. However by converting this data into contour lines which allow an efficient smoothing and data reduction, we need to handle less data and grid data can be kept aside. Other than in some GIS tools efficient smoothing will adapt to the tolerance to the distance of neighbouring contour lines.

For CNOSSOS a ground description will be mandatory as well.

2.2 Increasing number of attributes

For CNOSSOS we can expect further attributes for the emitting object types.

When aiming at parallel air pollution analysis for road objects extra attributes are needed to describe the key emission data. To limit this demand TLUG adapted the information provided for pollutant emission in the HBEFAS (Handbook of emission factors) to the car fleet mix representative for the German state of Thuringia. Finally the typical acoustic parameters, such as road category, speed, percentage of HGV are required plus “level of service” which to a limited degree coincides with the traffic flow parameter. Further differentiation for this parameter are aggregated in lump sum assumptions per road category.

As a trend we can find extra attributes now introduced with no genuine simulation purpose but purely for data management. Examples are:

- DATS Starting date of object existence
- DATT Termination date
- LINAGE Original data provider
- USER User in charge of latest modification (used for record keeping)
- MODI Logging of significant modifications, entry separate by “-“
    - E.g.: -VMA-VMN-DTM:REP-
      With –DTM:REP- meaning: Digital Terrain Model resulted in Replacement of vertexes

Another trend that increases demands on data storage is the idea to keep track on validity time of objects, such that a single data set will keep track of model data development. A noise calculation can then be instantly performed for any given period to show developments over the time in various aspects.

2.3 Increase in project size

Finally project area size is increasing as contracting practice is changing or regional or state authorities take of the job of EU noise mapping for their county or country.

We are now talking about data size that exceeds the storage addressing space of 32-bit Windows systems while using single files per object type, a hurdle that might be overcome by using 64 bit systems. However file loading or data selection from files will get cumbersome and using a data base for managing large sets of geo-spatial seems logic.

One technical approach is to store model data in a geo-database, example give ORACLE or Postgres/PostGIS based. The later solution is used in the ODEN system for environmental simulation, within which a web-based GIS interface allows many users to share central data and use their local knowledge to improve a central data pool. As a benefit for each participant (community) the user is allowed to perform noise and air pollution, e.g. for noise abatement analysis.

In Germany the states of Thüringen and Hessen now apply this system. For Nordrhein-Westfalen (NRW) the state environment authority and IT-NRW (IT support) as well developed a web-based graphic user interface on ESRI technology to support joint data refinement by the communities. This system will however not support any simulation.

Communities showed good response in the refinement process. The data size the NRW project is in the range of 100 GB, mainly due to a detailed terrain and about 10 Mio. buildings.

For simulation purpose the acoustic software will work on a comparatively small region. For reason of calculation speed model data needs to be kept in memory. Also the calculation time in many aspects will rise to the square of model size. Thus it is still feasible to read in model data for calculation from files. In the case of ODEN LimA uses SHAPE files and for NRW the database exports CityGML files via WFS-T.

It should be mentioned that in general it is still manageable to handle large data sets in files. In project work this is typically done by splitting the model region in 10 x 10 (km) tiles.

Even being in the 3rd round of mapping, we find that original data supply is far from optimal for acoustic purposes and setting up a coherent model from different sources for such large data sets is a challenge. For roads for instance one will have to combine information from 3 data sets using separate geometries:

- Ordnance survey data providing road geometry
- Traffic volume from traffic simulation
- Speed limit data from navigation system suppliers

Many other refinement tasks come on top and the processing time for data pre-processing might well exceed the time for noise mapping calculation. Again a model processing based on tiles helps to speed up most of these refinements by using e.g. up to 100 automated GUI processes, to modify data based on LimA macros. Though a data base can support such parallel processing as well the approach is very straight forward when processing file based data.

3. Data refinement

Next it will give a few examples of such refinement processing which in all cases was based on LimA macros, as macros help in tedious geometry and attribute manipulation work and keep risk of human errors small as well as speed up processing by allowing for parallel processing.

- Cleaning false terrain data underneath bridges

A common problem results from fake terrain data where bridges are recognized as terrain in first place and in some cases even information on bridges will be missing. Refinement needs to erase and substitute terrain underneath bridge and recognize missing bridge information.
In the bottom left situation this is difficult as the road axis may still be reasonably well on flat terrain. Once the width of the road is regarded, analyse will show that the road is subject to abrupt changes in terrain gradient. Thus a bridge shall be placed.
Cleaning contour lines under a bridge is also a more complex action as you want to erase terrain along the undercrossing road, have a continuous change in gradient underneath the bridge and keep terrain situation next to support ends.

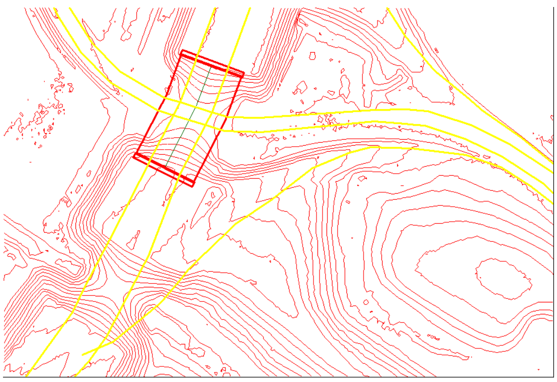

Figure 1: Invalid terrain near bridges

- Prolonging bridge axis

A systematic problem can be recognized with the length of bridges. Commonly the bridge axis is too short to match the terrain at a position where the terrain gradient is acceptable for roads. Thus the bridge need to be prolonged until terrain reaches an acceptable gradient.

- Shifting road axis to match terrain model

A new problem occurred when more accurate terrain data is used. When in the past terrain was given as 10 m grid and roads came in as 3-d axis, the near road terrain was reshaped with embankment constructions to set up a coherent model.

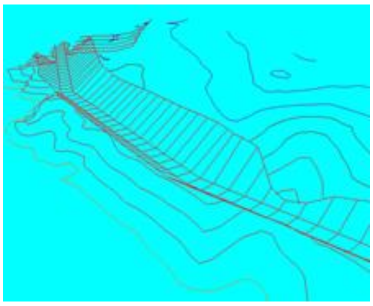

Figure 2: Embankment generated from 3-d road axis

Based on the 1 m terrain data we find two problems:

- In some case we could see that z-value collection for road axis had a systematic problem and z-values differed for the two sides of a highway on a slop which is not reflected by terrain data.
- In x,y position the road axis may not be in line with the terrain model. In Fig 2 the white dashed line is the original road axis, with two lanes on right and left. This axis is on edge of the inner contour line and beyond this position the emitting source line will be placed on a slope. Misleading barrier diffraction or false gradient correction for emission data is the consequence.
  To fix this the refinement macro checks the terrain gradient perpendicular to the road axis and will move the axis as shown with the yellow line in Figure 3.Figure **1**

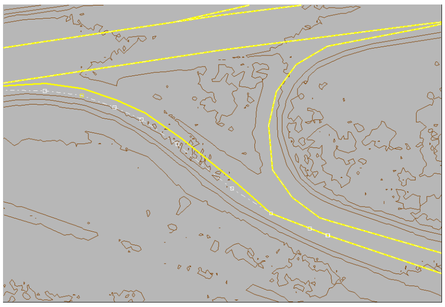

Figure 3: Replacing road vertexes in line with terrain

- Shifting Screens onto bridges

Information of width of road, width of bridges and position of screens are often not related. In some cases bridges need widening or screens need to be dragged onto a bridge.

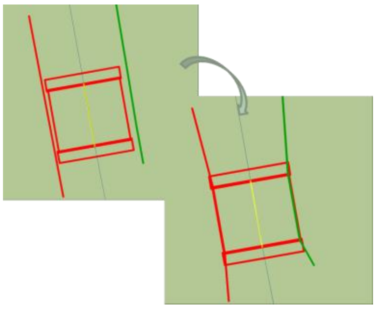

Figure 4: Shifting and distorting screen geometry

- Further examples will be demonstrated in the presentation

4. Multiple applications for model data

It seems to be logic to look for further applications of noise modelling data. The ODEN web interface will for instance allow a local community to select part of a state wide model and compare impact of different planning scenarios in acoustics, air pollution or solar radiation using central model data and calculation capacity without local installations or licences.

The central data base will increase in quality over the time as all participants may help to refine the data. Also the intensive refinement work as indicated in the chapter before will not have to be performed from scratch when starting a new round of mapping for instance.

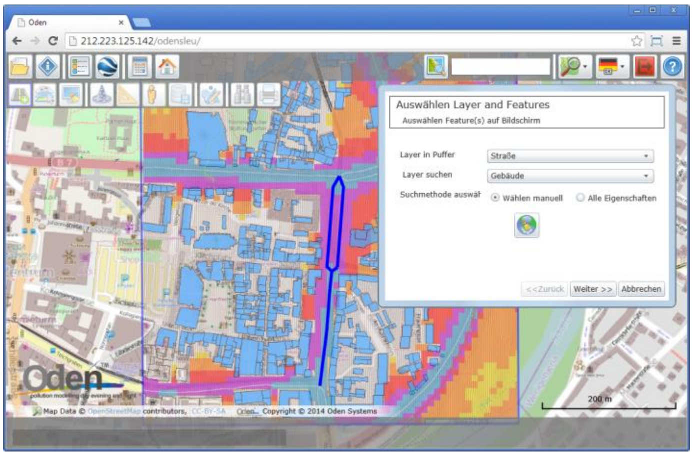

Figure 5: Selecting local region in ODEN GUI for detailed analysis

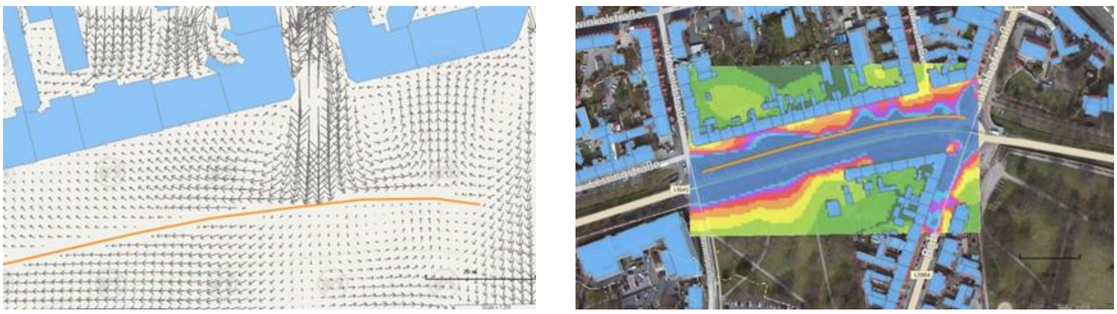

Figure 6: Air pollution analysis showing wind-field and NOX results

5. Use of model for nation-wide estimates in politics

Before we showed that noise mapping model data can be used for detailed analysis but it might as well be used for less detailed analysis for instance required on a nation-wide political level.

5.1 Estimating nation-wide infrastructural railway noise impact

The author was involved in a project initiated by the German “Bundesministerium für Verkehr und digitale Infrastruktur” (Department of transport) to support environmental analysis on the impact of railway infrastructural planning for 2030 with respect to air pollution and noise aspects. The led to the development of a “Settlement based Infrastructural Noise Assessment” (SINA) -
a fast responding prediction model for 2030 infrastructural planning of the German railway system taking account of railway network, potential traffic, buildings and inhabitants as well as road highways, i.e. all data in principle available from the mapping exercise.

Figure 7: German railway network

The total area was split in cells of 500 x 500 (m). About 500000 cells that include residential buildings and information on inhabitants which itself was taken from 100 x 100 (m) census data cells.

Different constellations of sources and settlement were pre-calculated to form the data base of impact values which were then combined with the emission situation of a planned scenario. The technique could produce results for stretches of e.g. 50-100 km of major and background tracks and ~80000 inhabitants within about 3 min, using LimA’s macro interpreter. By forging this concept into a hardcoded executable and shifting some of so far repetitive geometric analysis done by the macro interpreter into a pre-process, we expect to get this process done within second(s).

It could be shows that results were within a 3 db range apart from high level results. The system did anticipate that no residential buildings will be nearer to the track than a given minimum value, identified as being representative from German wide data analysis.

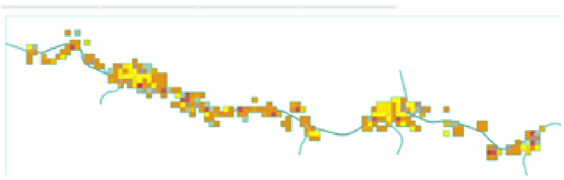

Figure 8: Example of reference test area showing total inhabitant noise exposure per cell

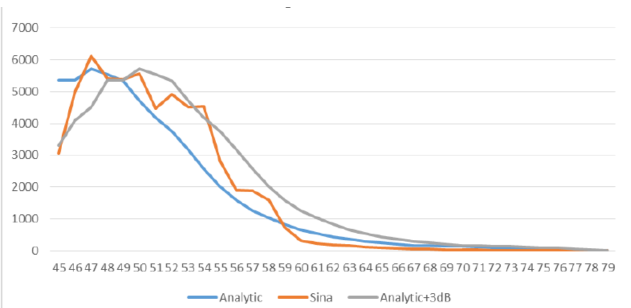

Figure 9: Comparing results of number of inhabitants per noise exposure level

for SINA method against exact calculation and + 3dB shifted exposure values

6. Conclusion

- Nation-wide data sets can be managed for noise mapping, abatement planning and also infrastructural analysis for political decision making.
- Data management issues have been solved so far. A key challenge is the initial data refinement for such large data sets.
- Higher quality and higher resolution data create conflicts with existing data that one would not aware of before and that will require extra refinements.
- Automated refinement of such data with help of e.g. LimA macros will keep costs down help to avoid errors in data handling.