Noise prediction method uncertainties

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Summary

If one is talking about “uncertainty” in context of strategic noise mapping acc. to Directive 2002/49/EC, one generally is talking about noise prediction software caused uncertainties. Our noise mapping experience gained in the passed 20 years says that noise prediction uncertainties have at least four important aspects:

- 1st aspect: Source data
- 2nd aspect: Human mistakes
- 3rd aspect: Calculation
- 4th aspect: Result interpretation

1st aspect: Source data

The noise level calculations according to Directive 2002/49/EC (Environmental Noise Directive, in brief: END) require a lot of different input data sets. But. not all data is available and shows the necessary accuracy.

Availability

- Source data for noise predictions is often obtained from different sources and therefore has different levels of detail and accuracy.
- In many cases the geometry data do not have all necessary attributes (e.g. building height) assigned.
- Some attributes (like traffic volumes or percentages of heavy goods vehicles) have to be mean values, in some cases of time periods of up to 10 years. These values are often deduced from values concerning only short periods of time.
  For example traffic volumes, counted on two different time periods of half an hour each, may be used to estimate the mean traffic volume of the last 10 years of a road. If there is a traffic jam on a road nearby in one of this time periods the counted traffic may be atypically and the estimates mean traffic volume may deviate to some hundred percent.
- Some attributes change during the course of the day. Often only average values without differentiation for day, evening and night are available.
- In quite some cases necessary data may be missing at all (e.g. percentages of heavy goods vehicles or types of road surface).

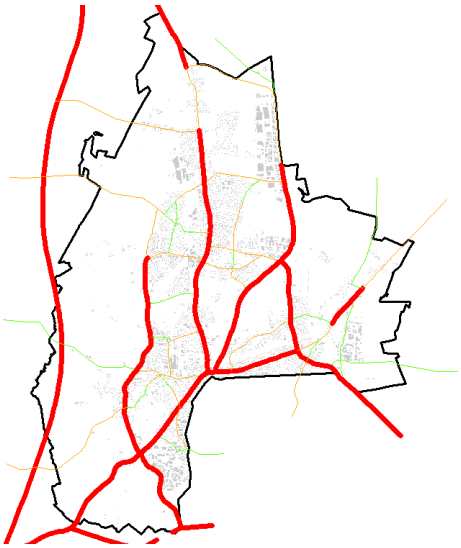
Accuracy

- Data sets very often have different levels of detail (e.g. buildings with/without jutties or with/without information concerning the shapes of roofs).
- Very accurate geometrical data in most cases lead to highly increased calculation times and have to be simplified. For these simplifications often different methods (leading to different accuracies as well as differing results) are used.
- Data sets may have different (or no) geo-referencing (e.g. different data sets do not match geometrically).

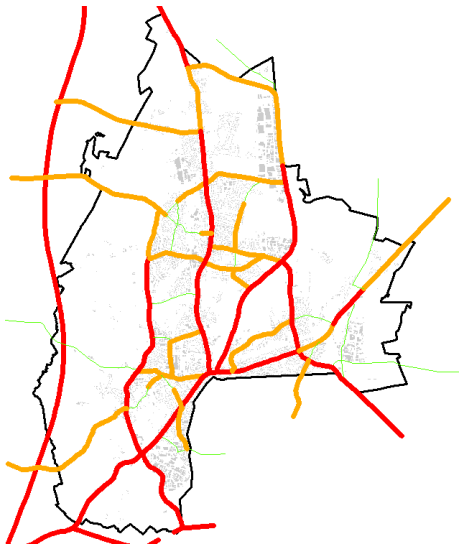
- Attributes are not always correct (e.g. wrong building heights).
- Attributes are often missed for parts of noise mapping data sets (e.g. no population values for certain buildings).
- Attributes of data sets have different levels of accuracy (e.g. integer vs. float).
- In most cases there is no detailed information (or no information at all) available about the accuracy of data sets. Meta data may not be available at all.
- In some cases the meaning of certain attributes are not explained. This can lead to misunderstandings (e.g. mix-up of relative and absolute heights).
- Missing data may have to be guessed or roughly estimated or experience based default values have to be used.

Noise sources taken into account

Noise mapping results depend also strongly on the noise sources (e.g. the density of the road network shown in pictures 1 and 2) taken into account:

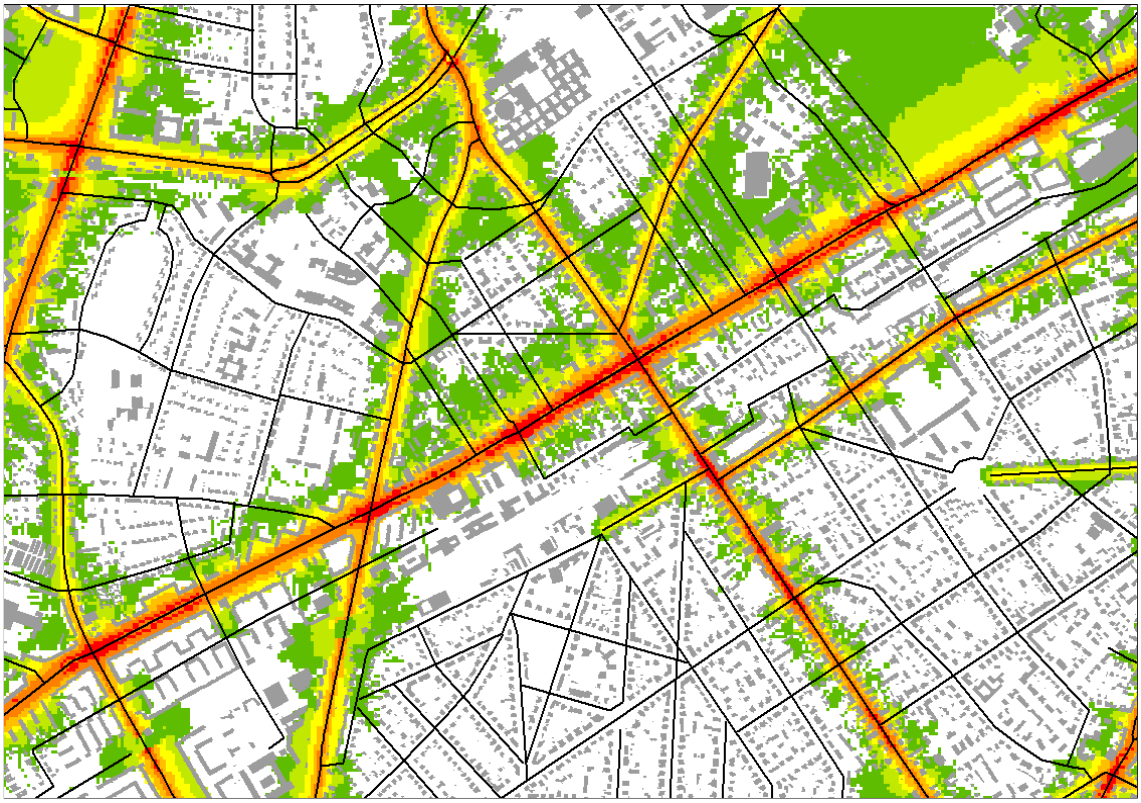


Picture 1: Roads > 16,000 vehicles/day

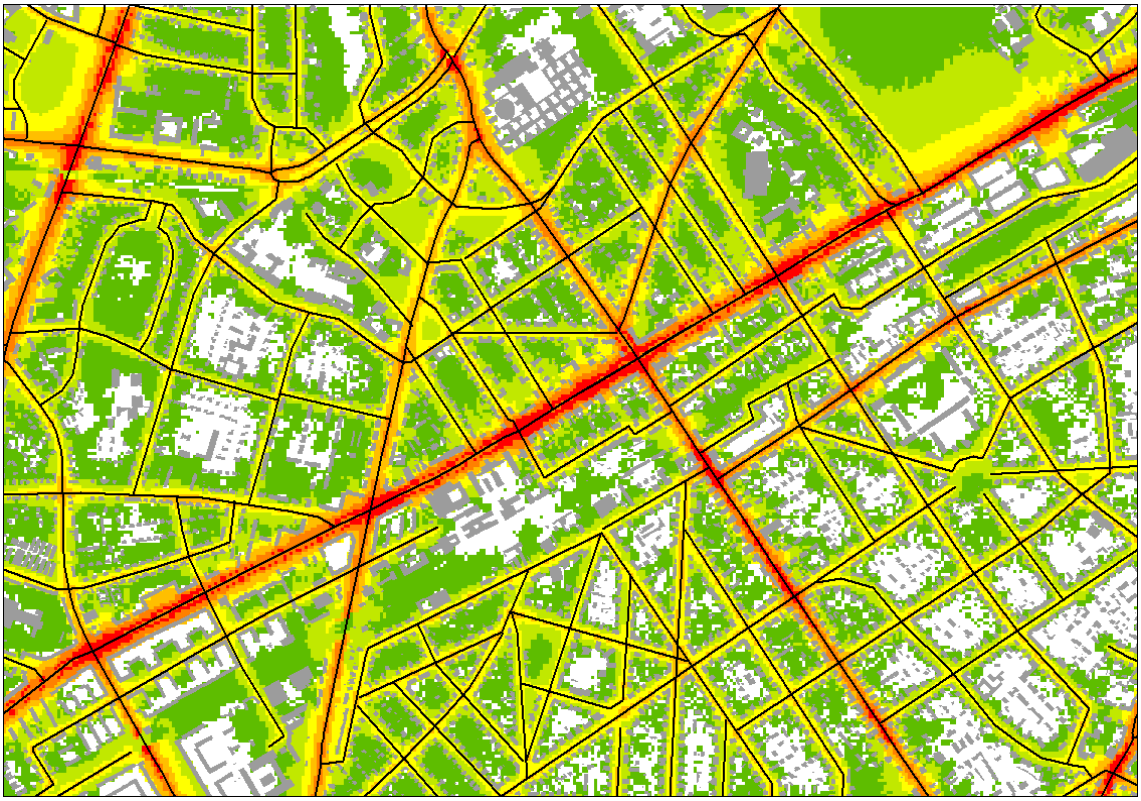


Picture 2: Roads > 8,000 vehicles/day

Respective noise maps are shown in the pictures 3 and 4 for another area:



Picture 3: Noise map showing noise levels of roads > 16,000 vehicles/day



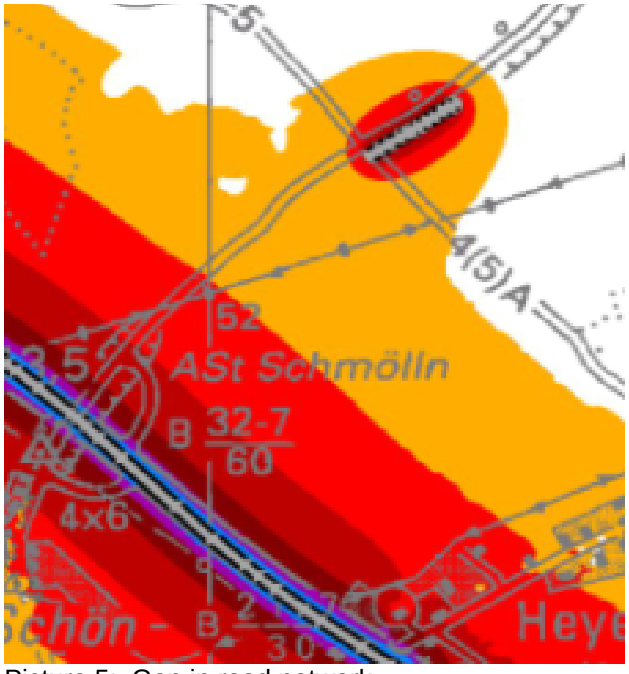
Picture 4: Noise map showing noise levels of roads > 5,000 vehicles/day

2nd aspect:
Human mistakes

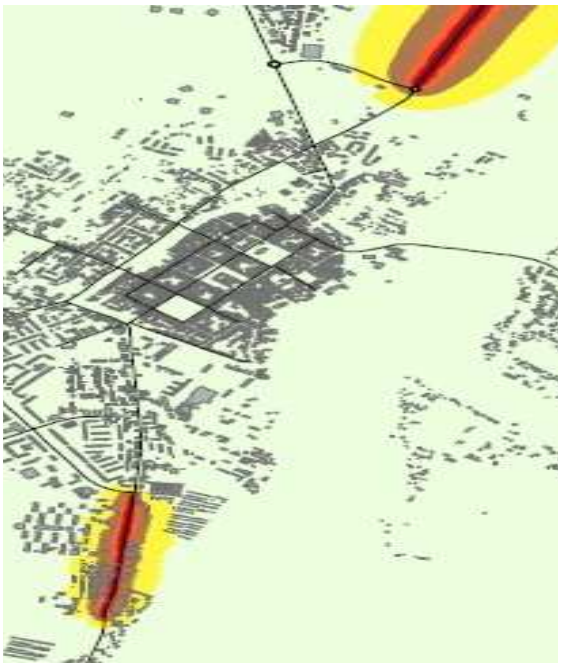
Data selection

- Persons, that aren't familiar with the area under investigation, often build the calculation models. Therefore they don't know which sources and obstacles are relevant. This leads to models with more objects then necessary, which are more complex to check.

- If data is selected by attribute there may appear data gaps as shown in pictures 5 and 6:



Picture 5: Gap in road network


Picture 6: Gap in railway network

Data processing

- Human mistakes can change or misinterpret data while processed:

  - Geo referencing is a very complex matter. For this reason different source files already may have errors in the geo referencing. Also the correct geo referencing is not known in some cases.

  - Field values may not be of the same type for whole data sets (e.g. 1% of the data has a notice character like "*", which does not convert to a number correctly).

  - Data corruption or data changes may occur without notice.

  - Data conversion may lead to unexpected data changes.

Data check

- For large data files there can't be made complete checks. Part of the data may be checked via graphical display and check of highest / lowest value.

- Data checks require knowledge of the area, but shouldn't be made from the person, who prepared the data. There isn't always someone available for this.

3rd aspect:
Calculation of noise levels

Method

- All calculation methods include simplifications. In most cases the effects of these simplifications aren't known (or there are no descriptions of effects available). Even most of the simplifications itself are unknown.

- Many computation methods still in use have been designed for carrying out calculations without computers.

    - Most of them do round (or round up) "intermediate data" and results (sometimes not even delivering a clear definition of "intermediate data").

    - Also they implicate simplifications like not calculating reflections of obstacles some hundred meters away, but they don't specify them. Software is able to take "all" reflections into account, even from buildings some kilometres away, but the calculation time will be enormous, but the results will increase (not necessarily significant).

    - Most calculation methods are not valid (or are very inaccurate) under certain conditions. The French method for road traffic as an example is only valid up to 800 meter from source (strictly meaning no point can be calculated, that is further away to any source, so the area has to be quite small).

    - Also no propagation above water (in certain calculation methods) is valid. Therefore no lakes, rivers or creeks are allowed in the area under investigation.

    - Some calculation methods assume moderately adverse wind velocities and directions (downwind). Others need real wind situations, which are in most cases not available, at least not for the actual spot. In case of huge calculation areas they may differ inside the area, which is not taken into account by the calculation models.

    - Most calculation methods are designed to calculate noise level values rather too high then too low.

Software and computation errors

- Software may ignore the rule to round (or round up) "intermediate data", because for a computer this is time consuming (rather then time saving) and prevents some code optimisations.

- It has been proven, that software of some complexity can't be free of errors. Therefore errors in the calculation routines of Software may lead to certain variances in the calculation results.

- Different interpretations of the calculation method do lead to differences in the implementation and therefore the results.

- Software errors can lead to completely wrong noise values (may be recognised), slightly different values (only in special cases recognisable) or wrong values in special cases (e.g. under bend noise walls).

4th aspect:
Result interpretation

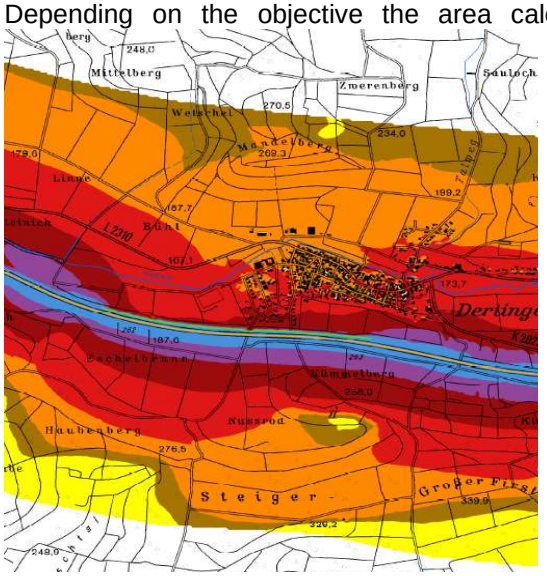
- Calculation of noise levels does always have a defined purpose. Every result has to be interpreted according to this purpose. Otherwise some parameter may not be realised (e.g. unexpected calculation height of 20m instead of 4m above ground).

- Incorrect results are (independent from the reason) in most cases hard to identify.

- Results from different sources are often not easy to compare, because even colors defined by standards are quite different if they are printed on paper or shown on the computer screen:

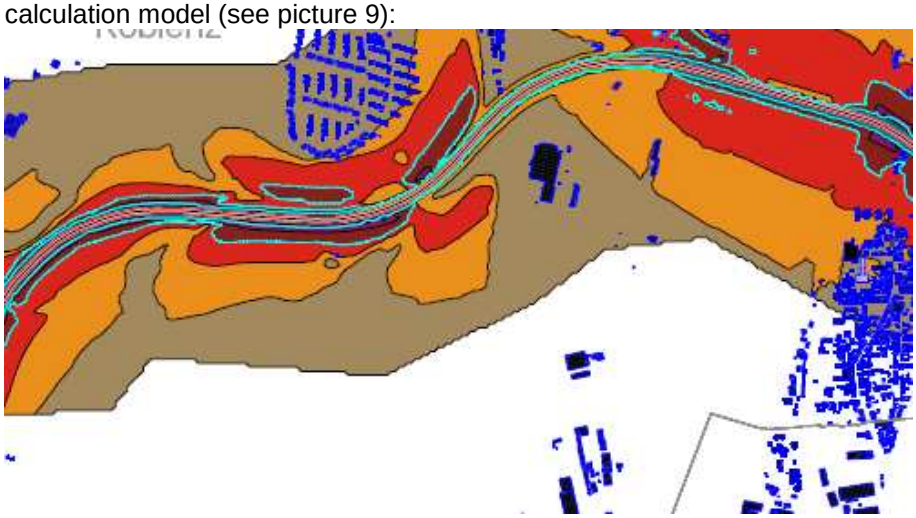
Picture 7: Noise levels >70 dB(A) acc. to German DIN 18005 Part 2 printed from different printers

- Depending on the objective the area calculated may have been too small (see picture 8).



Picture 8: Noise map with too small calculation area

- Results may be displayed in combination with data, that was not relevant for or not part of the calculation model (see picture 9):



Picture 9: Noise map with detailed elements not relevant for the noise level calculations

Conclusions

Noise prediction method uncertainties can influence the noise mapping results and the acceptance of noise mapping results significantly. But, the noise prediction method is only one aspect under several.

Of much more importance are aspects like input data availability or qualification of the personel carrying out the noise mapping work.