INTEGRATION OF GIS DATA INTO CITY-WIDE NOISE MAPS

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1 INTRODUCTION

Noise mapping is a central part of the European Noise Policy. The target of these European approaches is to get reliable data about the noise pollution in the cities and to come to optimal harmonized strategies for the fight against this suffer. Many noise mapping projects that have been carried out in the meantime have shown, that such maps can be seen under different angles of view and that the mentioned target is only one among many others. If the data are acquired and combined to a digital model of the city, this model can be the basis of an extreme powerful noise information system used by the city administration and the public. Any question that arises about the noise load of a certain region can be answered immediately without spending further money for expensive expertises. If any commercial or industrial facility or even residential area is planned, a quick check about the change in noise levels produced by this is a task of some hours. We invented such systems in the environmental departments of cities and trained the members – mostly only one person - of the staff dealing with the noise problems. In these cases the noise map is printed out for a rough information of public, administration and politicians from time to time, but the main reason to update the digital model from year to year is to have reliable data for the own daily work.

This multiple use of the noise map or the digital model behind it is a fairly new approach because some years ago it was not possible to handle such a big amount of data by people who are not specialists in this field. But today the project file of a city like Munich, Vienna or Lisbon can nearly be handled like the document file of a word processing system, if certain requirements are fulfilled. The main part in this game plays the software used, because it is a tedious, time consuming and frustrating job to hold a noise map updated with a program that allows not to use all data sources available or that is not able to load and process the complete model in one run. We know of applications where the project was split into hundreds of separate files because the software used was only able to process small file sizes (and all below 100000 objects is small when dealing with noise maps for cities). This makes many steps necessary, that could be avoided if a well adapted software is used. On the long term such an approach is a road with a dead end and wastes a lot of time and money.

Another important point is that the software communicates with other applications. It is an enormous advantage, if it is possible to copy source data directly from an Excel Sheet into the Input Table of the mapping software, to cut and paste parts of a calculated noise map with some mouse clicks, to import the geographic data from a GIS like Arc Info or to link the noise levels calculated at building facades directly with a program to optimise the building by using the new EN 12354 approach. Unfortunately these features are not seen in the first stage of a noise mapping project, and so many unfortunate approaches to noise mapping of cities have been the consequence.

With this contribution we try to give some hints that such mistakes can be avoided.

2 MODELLING THE GROUND SURFACE WITH VARYING HEIGHT

The model of a city and for all other environments is produced by combining some objects that may depend in detail on the software used.

The topography with different ground heights is described by points and lines with defined absolute height. It is clearly advantageous to import these topographic objects from given databases or from GIS systems, because it is a tedious job to digitise them from a paper plan. It cannot be foreseen in the beginning of a project how many contour lines and points in the grid must be imported to the model, so it is of high priority to use a software that is able to load and process a huge amount of them. Two numbers are important to describe the quality of software in this respect

- the maximal number of contour lines in one file and
- the maximal number of points in each contour line.

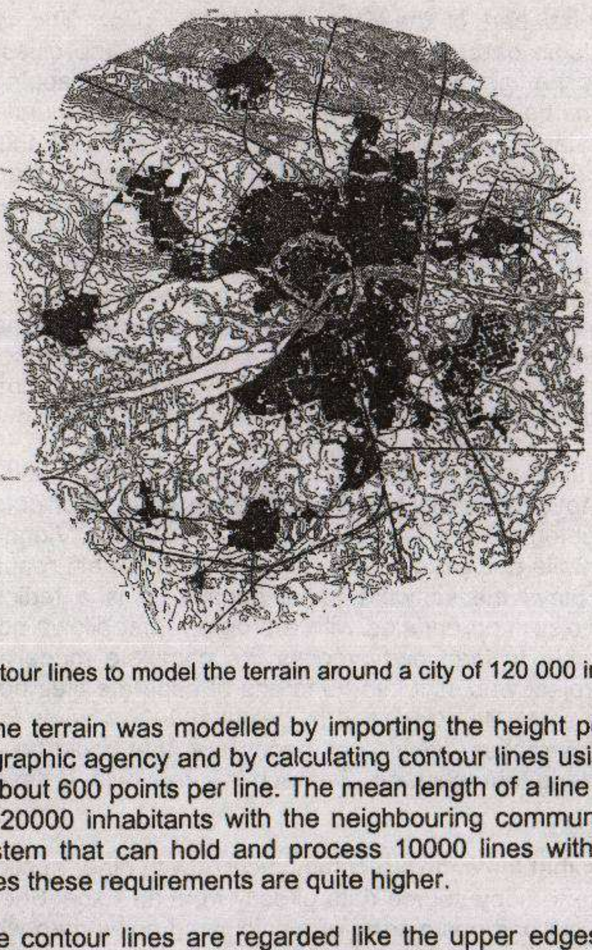

Fig.1 Contour lines to model the terrain around a city of 120 000 inhabitants

In the example shown the terrain was modelled by importing the height points from a GIS system used by the federal geographic agency and by calculating contour lines using this points. These are exactly 7768 lines with about 600 points per line. The mean length of a line is about 20 km. Even for this city of only about 120000 inhabitants with the neighbouring communities it is of tremendous advantage to use a system that can hold and process 10000 lines with 1000 points each as a minimum. For bigger cities these requirements are quite higher.

Fig. 2 shows, how these contour lines are regarded like the upper edges of vertical plates when screening is calculated. Unfortunately these contour lines are often too distant from another to give correct results when calculating noise propagation. The ray in Fig. 3 does not cross a contour line and therefore would not be screened, even if the ground between is elevated.

This is a problem in all cases, where the ground is modelled only by few contour lines, especially where these are produced by digitising from a bitmap or from a paper plan. Fig. 4 shows a hill modelled with only 2 contour lines – one as basis with 0 m and one to define the top with 30 m. It is clear that the ground between source and receiver is elevated and screening should be calculated. With the triangulation technique shown in Fig. 5 additional lines are generated and these are used like the original contour lines to calculate the barrier attenuation correctly.

It is clear that calculation time can be blown up enormously with such big projects if the software is not able to use intelligent techniques and reduces the number of calculations needed for each ray. The size of the model to be processed in one run is one thing, another one is the time needed. Such an evaluation of possible size and necessary time can be carried out if the same file is processed with different programs and the calculation time is measured. But this is only helpful if the conditions are exactly the same (calculation of reflections, projection method for extended sources, use of interpolation or not etc.).

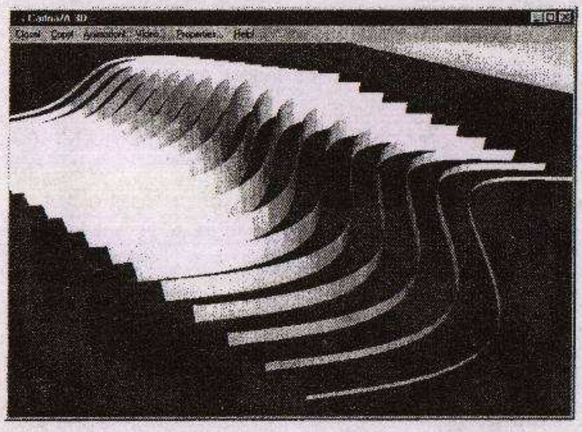

Fig.2 Contour lines as upper edge of vertical plates

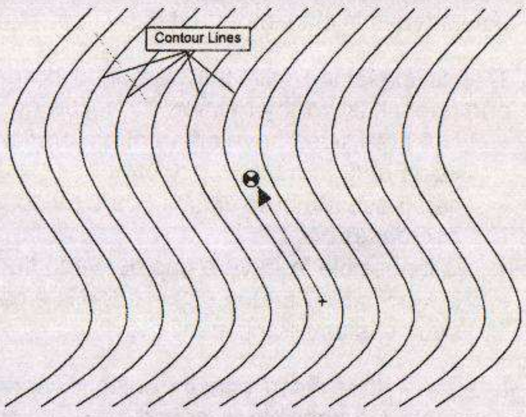

Fig. 3 Ray between contour lines

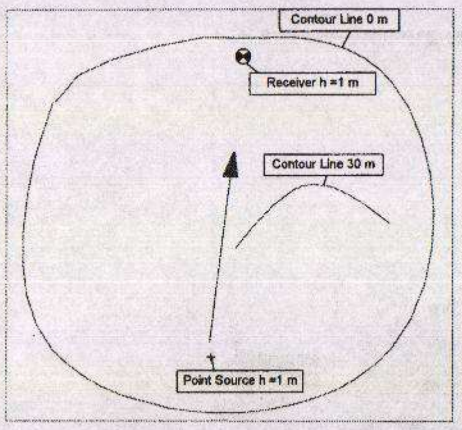

Fig.4 No Screening by the elevated ground

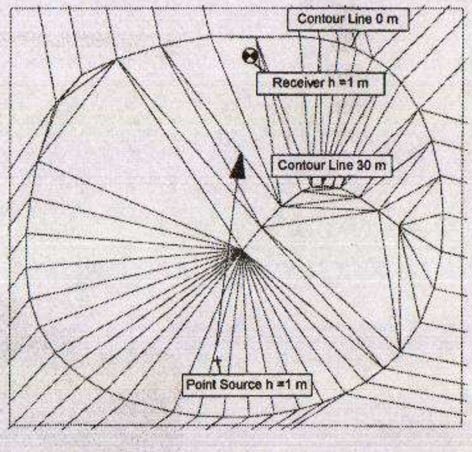

Fig.5 Screening by triangulation lines

3 MODELLING OF BUILDINGS AND OTHER OBJECTS

If the digital data of buildings, barriers, berms and other objects are imported from a GIS System, these can be 2 or 3-dimensional data. Again it is a fundamental necessity that the software used does not set limits to the number of objects and the number of points of an object. If this is the case, it is a tedious job to subdivide the total scenery into a patchwork of subfiles that are adapted to the limitations of the software tool used. Unfortunately the advertising material of some of these tools is extremely misleading. We found even examples where the producer of a program version "Standard" with a maximum of 200 screening objects declares, that this means that the program capabilities are nearly unlimited.

The model of Fig. 1 contains about 35000 buildings that must be loaded in one sweep. With the city of munich, where we imported the digital data directly from a 3-D digital model that was produced by Telecom to position the mobilephone antennas, about 150000 buildings are processed.

If software for city-wide noise mapping is evaluated, the following information is important:

- what objects can be used to model the built up environment (e.g. buildings, barriers, berms, cylinders etc.)
- how many objects of each type can be used
- how many points are possible for each object

It is clear that for professionals like consultants the possible description depth for each of these object types is also important.

This is explained with the barrier. If barriers should be used to protect living areas or for other purposes, it is worthy to know the following:

- can both sides have different absorption and can this absorption be defined as single number value and/or in frequency bands?
- can these attribute values (spectral absorption) be imported from spread sheet or from other databases?
- is it possible to have a gap between floor and lower edge (floating screen)?
- is it possible that the upper edge is a cantilever with correct calculation even when part of the source is under this cantilever?

It is clear that these special objects cannot be imported from GIS systems using only geometric data, but it is possible to define these properties as attributes. If this is done, the software program used should be able to interpret this attributes correctly and to produce the software specific structure for these elements.

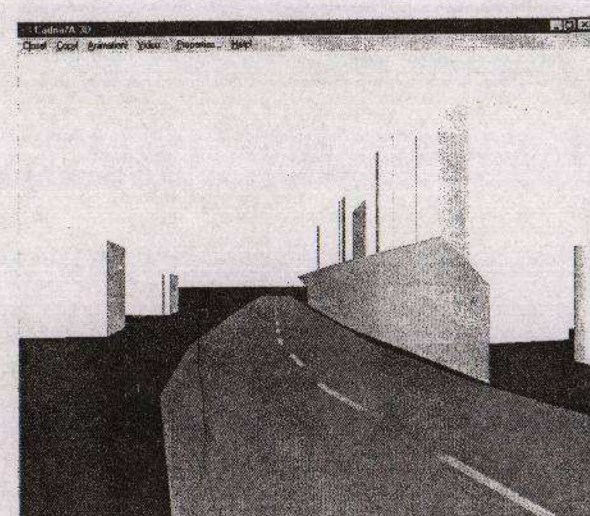

Fig.6 Barrier with cantilever imported from GIS and interpreted from attributes

Fig. 6 shows a barrier with cantilever, where the geometric data where imported from a GIS and its dimensions as attribute values from the GIS database. This enables the mapping program to interprete correctly the upper part of the barrier as contilever.

This more or less fotorealistic view shown with figure 6 is not only a nice presentation, but also very helpful to control the correctness of the model. Especially if data are produced or modified by the user of a mapping program, many mistakes can be avoided if the model is regarded with this 3D-view after a complicated object has been produced. To be used in this way as a tool to control the model during input it must be very easy and quick to switch to this presentation, otherwise it slows down the work and will not be used. If the program allows to move around in the model or to drive "virtually" along a road, this "controlling" can be done without any difficulty. This moving around in a model of the city with real time presentation needs extremely fast graphic processing and therefore such requirements should be taken into account when hardware is chosen.

4 PROCESSING AND DATA CONNECTION TO GIS SYSTEMS

All these data are combined to the project file of the city and processed. It proved to be very advantageous if more than one computer can share this job and if the software used organises this automatically. An example is the PCSP technique used with CadnaA (PCSP: Program Controlled Segmented Processing). To process with PCSP the complete file is loaded and seamless covered with rectangular frames like shown in Fig.7. This is done with the "Duplicate" command in seconds.

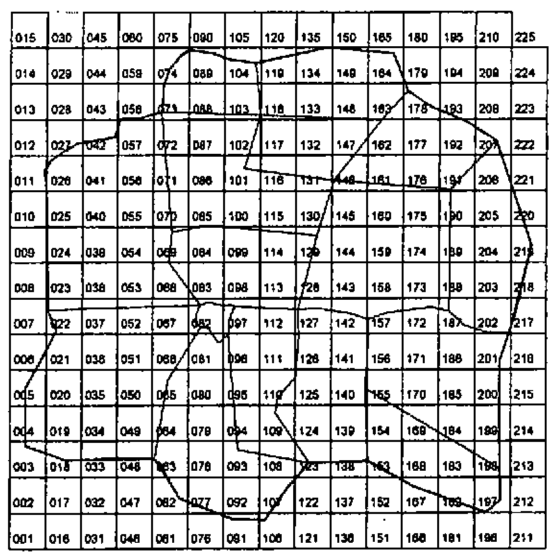

Fig. 7 Tiling of the whole area of a city with 16 districts

When this file is saved, the program produces automatically a second file necessary to administrate the rectangular areas. This makes it possible that more computers can share the calculation job automatically without any support by the user.

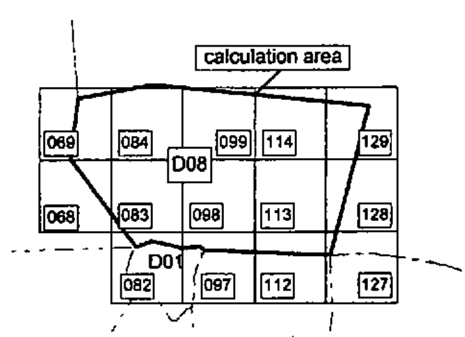

Fig. 8 Calculation of a noise map for district D08 with PCSP

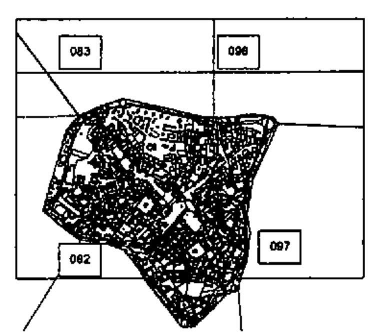

Fig. 9 Top View of district D01

Fig. 8 shows the tile structure of the neighboured districts D01 and D08, Fig. 9 is a top view to the build up structure of district D01.

Let's assume that two computers shall calculate a noise map for district D08. Then all tiles that have common areas with D08 are processed. Computer 1 loads all objects of tile 83 and of the surrounding tiles to a defined distance (about 2000 m) from the outer frame of tile 83 and calculates the map in this tile 83. At the same time computer 2 loads tile 84 and all the objects to the defined distance and calculates the map for this tile 84.

This automatic load balancing is highly effective, because the computers work independent and each can calculate, load and save at his highest possible speed.

When the program is linked to a GIS-System, it is possible to transfer all project data or only the calculated levels of the grid to this System. If the GIS System is only used to show the coloured noise map, it may be advantageous if the mapping software can export the coloured areas without any grid information. In this case the presentation cannot be changed (e.g. to smaller dB steps) by the users of the GIS System and there is no problem with confidentiality of result data.

5 NOISE MAPPING LINKED TO BUILDING ACOUSTICS

If the complete dataset describing a city in all aspects that influence the noise load at residential areas is available, many fascinating applications are open to be used if the software supports them. An example is the direct coupling of a noise mapping program with a program to calculate indoor from outdoor levels taking into account all acoustical parameters of walls, windows and even flanking transmissions.

Fig. 10 shows a typical scenario where road traffic noise is calculated at predefined immission points with the Mapping Program CadnaA and these calculated noise levels are directly coupled to the program BASTIAN for building acoustics applying the new European procedure of the European standard EN 12354.

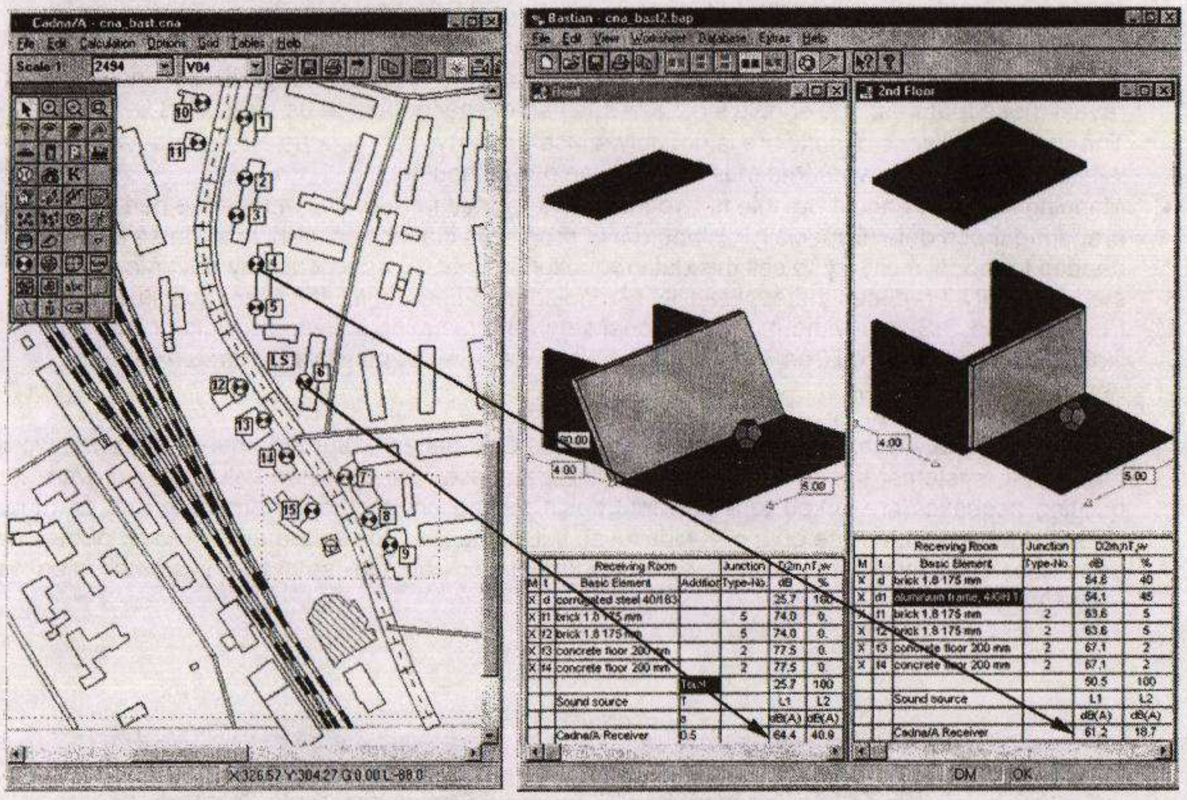

Fig. 10 Calculating noise levels with Mapping software and using these data parallel to calculate indoor levels and dimension the façade elements in software for building acoustics

In CadnaA the scenario with roads, buildings etc. is modelled and in front of the window positions where the levels inside shall be calculated immission points are defined.

With BASTIAN, that is open parallel with CadnaA, the mode where inside levels are calculated from outdoor levels is chosen. The immission points of the outdoor calculation in the open mapping program can directly be chosen in the window of BASTIAN where the noise source outside has to be defined. So each immission point in the mapping program is coupled with a calculation sheet in BASTIAN. If the transmission is defined using predefined or calculated elements like walls, windows etc. each change in these parameters like thickness of glass or density of the brick-material as well as traffic density at the road or height of a barrier can immediately be seen as an apparent change in indoor levels.

6 CONCLUSION

An inspection of advertising materials and publications about software for Noise Mapping reveals that in many cases the authors try to hide the shortcomings of their product under a cover of technical terms that are hardly understandable for the users in communities and city administrations.

From our point of view the following should be taken into account when noise mapping software is evaluated:

- Communication of the mapping software with widely used standard software and other applications like databases for emission values and programs for building acoustics is an enormous advantage. It is a great difference if such a communication is realized by reading and writing files or if the data can be exchanged directly without leaving the program. Especially with old fashioned programs it is tried to adapt them to some of this needs by implementing possibilities of file exchange, but the use is complicated and needs uncomparable more time than it is possible with direct data interchange. So the word "data exchange" is not enough to reveal these features, one should look how such an exchange has to be supported by the user.

- The user friendliness of software is not only a nice property, but reduces errors and helps that it is easier to distribute work that must be done on more shoulders.
- Mapping software should be able to use the data imported from a GIS without the need of preparing these data. Especially distributors of programs that are not able to address all objects needed to model a city try to sell this data reduction in the GIS as a generally advantageous step. In reality it reduces the applicability of a noise map apparently, if it is not possible to import from updated GIS-files without this additional step. The mapping software should not set any limit to the data imported from GIS, because otherwise it is not possible to formalize the updating of a noise map.

It is State of the Art that Noise Mapping software, GIS systems, spread sheet programs, word processing systems and other applications like databases for emission values or software for building acoustics are linked to a powerful basis for the environmental engineer and all other persons dealing with noise on a city-wide level. If it is intended to use the digital model of the city as noise information system, a careful examination of the software systems used is recommended.

Fig. 11 3-D-View of a city - screen presentation without the need of tiling the file.