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INTEGRATION OF AREA NOISE CONTROL PROGRAMMES INTO A CITYWIDE NOISE CONTROL STRATEGY

W. Probst DataKustik GmbH and ACCON GmbH, Munich, Germany
B. Huber DataKustik GmbH, Munich, Germany

1. INTRODUCTION

Noise Mapping has become an important tool for the development of noise abatement programmes. Many projects of this type have been started in the last few years, and with the exploding power of normal computers available for everybody and the high technical standard of the software for noise prediction it has become possible to develop noise abatement strategies based on the source data even for the largest cities.
In very big cities it is often the case that the local districts are responsible for all decisions about noise abatement measures, while the central city administration has to deal with all strategies influencing more of these districts or even the whole city. With this contribution some of the consequences of such a sharing of responsibility for data acquisition, for the development of a computer model of the city and for the organization of an effective noise abatement strategy are discussed. It is also shown what functionalities of the software are helpful or may even be necessary to avoid the noise map and the strategies against noise from being patchwork in nature where each part is constructed independently from the other, rather than a clear and strategically organized job linking all sources, regions and actions that influence the noise in a regarded area.

2. NOISE AND NOISE SOURCES IN A CITY

The main and dominant noise sources in cities are car traffic, railways, airports with the flight tracks over suburban and city regions, industrial and commercial activities and sporting and leisure facilities.
From our own experience and from all studies that have been made it is clear that transportation noise is absolutely dominant and that industry and sport or leisure facilities play a much less important role. To rank the traffic sources we can ask what is the sound power level normalized to 1s that is produced by the system if one person is moved a distance of 100m. This sound power level is about 107 dB(A) for the train, 110 dB(A) for the car and 130 dB(A) for an airplane.
Much more important is the question, how people suffer under the noise produced by these sources. Fig. 1 shows a ranking that is the result of a study organized by the German federal agency for the environment. From this it is clearly seen what we all know – road traffic noise is the most important reason for noise complaints in cities, followed by aircraft and railway noise. This was also the result of all our noise mapping projects that were combined with presentations to the public – most of the people in cities complain about traffic noise.

This has severe consequences on the effort we should spend for data acquisition in mapping projects. Time and money needed to measure all the emissions that are necessary to produce a computer model of a factory or a sporting facility are in most cases in bad balance to the importance of this source type. So in noise mapping projects for cities it is usually a good compromise to model industrial areas with area sources and to detail this step by step if for other reasons such an evaluation of more precise data is necessary.

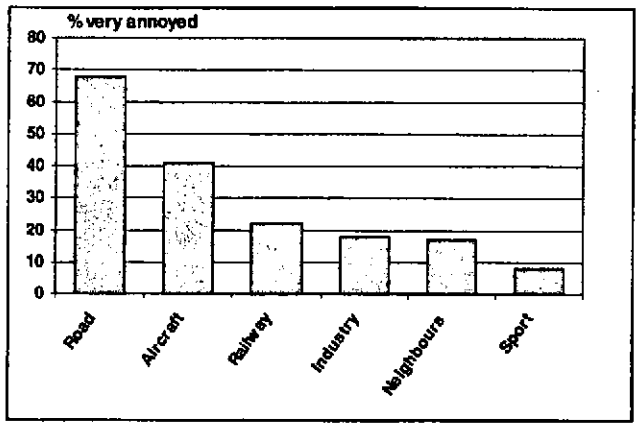

Fig. 1 Percentage of people annoyed by noise from different sources (Federal environmental agency)

3. TYPE OF MEASURES, ACCURACY OF DATA AND ORGANIZATIONAL ASPECTS

The main target of noise mapping projects regarded from the publics view is to get a better chance for a life with reduced noise levels (even if this means in reality often a hope that the noise doesn't increase with the same degree as it would without such efforts). Therefore we should look to the consequences of such a noise map with respect to the priority of measures before we decide about the necessary accuracy of the data that are used to model the city. It makes no sense if a lot of money is spent to measure the height of buildings with accuracies in cm when the calculation algorithm for noise levels in screened areas assumes a maximal attenuation by diffraction of 25 dB, because this is reached for nearly all rays that are screened by buildings of typical height. It is also stated from experience that the set of successful noise abatement measures is not very sensitive to the accuracy of input data, as far as traffic noise is concerned. We know that some consultants go into great detail in very restricted areas, when it would be much more advantageous with respect to noise reduction to concentrate on the data that is available and to do this work in a larger frame.

This is particularly the case if a noise mapping project and a successful noise abatement strategy is planned for a big city, which consists of more subunits like the districts shown in figure 2.

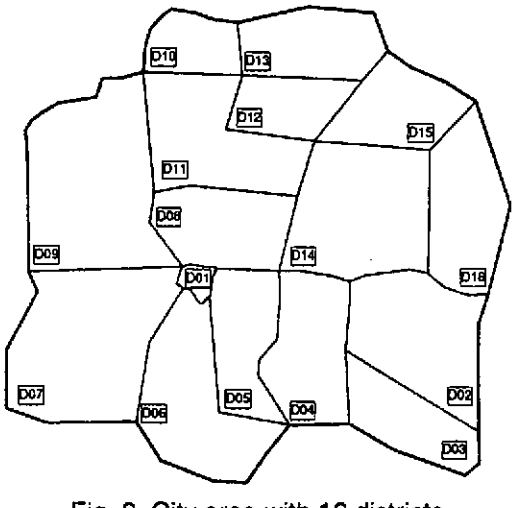

Fig. 2 City area with 16 districts

In such a case we have to distinguish measures that have to be organized by the local administration of a district and those that must be organized on a larger scale.
The first type are "local measures" like changing the surface of a road (low noise surface), locally restricted changes in the traffic flow, installing a new point to point bus connection or a new barrier.
The second type are measures that touch more of these districts or even the whole city. Typical examples are changes in the whole concept of traffic flow and distribution or the improvement of public transport systems. If we want to organize a mapping project in our model city of figure 2 with about 16 local district authorities (LA) and with a central authority (CA), then we have to take into account these organizational aspects additionally to the technical necessities.

4. LOCAL AND CENTRAL DATA ACQUISITION

If the noise map for such a district is calculated, then the model with all sources must be available for a greater area. Fig. 3 shows as an example the data acquisition area that is chosen if a noise map for the district D8 with an area of 31 km² shall be calculated. All the buildings, roads and other sources and objects must be taken into account in this calculation process on an area of 90 km², if we assume that all sources in a distance of less than 2000 m around each calculation point shall be regarded.

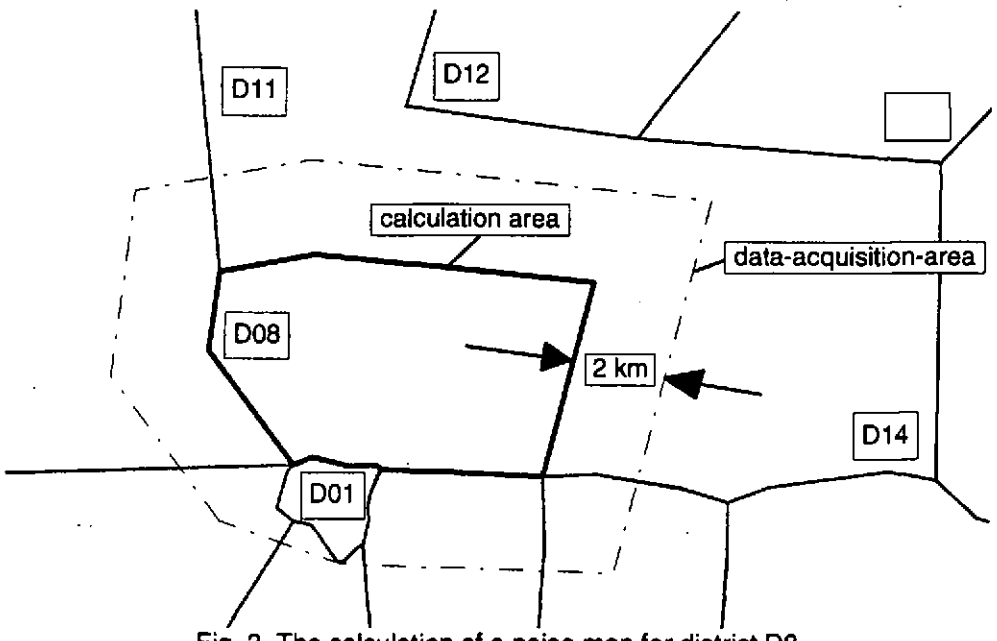

Fig. 3 The calculation of a noise map for district D8

In special cases with sources of high sound emission, e.g. a motorway with many heavy trucks and much traffic, even a greater distance may be necessary. So it is clear, that it is not advisable for each district to run their own mapping project without any coordination between neighbouring districts.

If the noise level at a receiver point in a district N produced by a source, e.g. a road, is calculated, there is no problem if the acoustically dominating part of the road is completely in the same district and if the LA is responsible for this road. In this case data acquisition, calculation and development of a noise abatement strategy can be handled locally.

But it may be that the acoustically dominating part of the road is in the same district, but source and/or target of the car flow and therefore the reason for most of the traffic is in other districts. In

this case data acquisition and calculation can be handled locally, but a cooperation is necessary if an effective noise abatement strategy shall be derived.

In some cases the source that produces noise inside a district is located completely outside this area. Examples are the passing motorway or an airport in a relevant distance. If aircraft noise influences the noise situation in a district and the noise map shall be calculated and handled locally, there are only two optimal solutions:

1) The LA is supplied with the complete model of the airport (or the motorway) with all flight tracks and aircraft movements and uses this aircraft model like all the other parts of neighbouring districts that influence the immission in his own calculation.
2) The noise map for the area of the regarded district for aircraft noise is calculated by the airport or by the district where it is located and this data is combined with the noise map produced by the district.

To organize noise by the local authorities can be summarized as follows:

Advantages:
- Data acquisition is clearly easier, as far as the data of sources and objects inside the district are concerned.
- The decisions are nearer to the source and the target of all these efforts, this shortens time and saves money
- The results and consequences are better accepted if the public is involved, and this information can better be presented and discussed by the LA.
- The most important point is that the acceptance by the local politicians is much better if the strategy is based on research organized locally.

Disadvantages:
- Data formats and the whole procedure may lead to incompatible models and results.
- All discussed aspects about data from neighbouring districts are difficult to handle, because no district can run this project without using information from the other districts.

Organizing a mapping project by the central authority can be summarized:

Advantages:
- Not everybody has to be convinced that a city-wide project is required.
- Sources, measures and strategies are not restricted to boundaries, so the development of integrated concepts for the whole city are far easier to be tackle.
- Data processing may be cheaper, because hardware and software is installed at one location
- There is no problem concerning the compatibility of input data, used software and calculated noise maps.

Disadvantages:
- Decisions are too far from the people who are involved in the consequences.
- Acceptance by the LA may be small.
- Data acquisition is much more difficult, because there may be poor support by the LA

By summarizing it can be concluded, that
- Data acquisition is preferably done by the districts
- This has the prerequisite that the structure of these data and the formats must be harmonized, so that all the data from the districts are sampled in the same databases
- This affords that decisions about the depth of investigation and the whole strategy must be fixed in advance (details about data coding and formats in the next chapter)
- Calculations can be made locally or by the CA, but the results must be available on the district level. How this is organized, depends on the type of data handling by the LA. If they use e.g. a

GIS system like ArcView or ArcInfo, then it is possible to return only the coloured areas that present the areas of equal noise level to this GIS-System. But if they want to use the project data for further investigations or as a noise information system for all their planning tasks, they should use the same system to be completely compatible with the CA.

From all this we can conclude the following.

A unique procedure of sharing responsibility between CA and LA or between districts and authorities, institutes or consulting groups who do the work is advantageous, but not necessary. If some districts want to run their own system and use it in the sense described and others want to delegate all these actions to the CA or another organisation, it should not be seen as a problem that threatens the success of the project.

But it is clear that some principles are compulsory in this framework.

- In the planning stage the data-set to describe each source type (e.g. roads), a somewhat unique accuracy-level of all data of one type, a unique format for these data (this means the definition of the database) and clear arrangements how to handle objects that are crossed by a separation line between areas where different parties are responsible for data acquisition must be defined.
- Independent if one, more or even all districts do their own calculation and are responsible for a part of the project administration: The agencies doing the calculation must have access to all the data that may influence the result in their calculation area. To formalize this process it is advantageous to define a free flow of certified data in this network and a clear defined duty for all subsystems to feed their certified data in the defined area into the common database.
- If a district uses the system as a planning tool, then the necessary changes in parameter values are done in a local copy of the database.
- The software used should be able to handle the data of the whole city in a unique manner. From this some requirements, discussed in the next section, can be derived.
- The development and assessment of noise abatement measures must take into account that only some of these measures can be organized locally, many and normally the most important ones influence more than one district. Therefore the experts who are responsible for the long term solutions should use the results of the whole city and not work in the frame of one district.

5. SOFTWARE-STRATEGIES TO SUPPORT POWERFUL NOISE STRATEGIES

From the technical point of view an enormous amount of time and money can be wasted if old fashioned software is used. Some of these aspects that proved to be important are described.

Import and Export of Data
It is clear that it is a waste of time and money if data that is available cannot be used or if this use is very circumstantial. This means that the mapping software should be able to import all geometric and attribute data. It is necessary to be very critical in this respect, because the word "Bitmap-interface" does not define if it is possible to load and adjust many bitmap-files in one project, to rotate and calibrate them to get a background screen presentation usable even for the presentation of big areas. Automatic calibration should be possible if the bitmap is georeferenced.
It should be possible to import the data from GIS-systems like Arc-Info, Arc-View, Atlas-Gis or Map-Info in one run without using the additional step of DXF export and import. Extremely important is a very comfortable way to transform data in this import process so that different coordinate systems of the imported data are not a problem.
A powerful interface to databases is a must, because this is the way as discussed above to use the data of a common database.

PCSP – Program Controlled Segmented Processing
PCSP is an extremely powerful technique if noise maps of big cities have to be calculated and handled. Calculations for Munich, Basel and Vienna have shown, that this is nearly a requirement for all future cases.

Figure 4 shows how the whole project file is segmented automatically into definable tiles if PCSP-method is used. The whole city with all buildings, sources and other objects are in one data file that is loaded (even if the districts are handled in different files, these are loaded together to accelerate this procedure). Then the rectangular tile 001 is defined and duplicated 15 times in horizontal and vertical direction (with the example shown the side length of the tiles is 2 km). When this file is written back to the hard disk, an additional file for the internal organisation of the PCSP-procedure is created automatically.

This file can be processed by one or more computers operating in parallel. Each of the computers started loads all the objects of a file enclosed in one tile and additionally in a region with a defined distance to the tiles border – e.g. 2 km. When the map (e.g. as 10m grid) for this tile is completely calculated, the levels are written to the disk. Then the next tile with the defined neighbouring regions is loaded and processed in the same way. At the end the grids of the tiles are loaded together to a map of the whole city.

This tiling is done automatically. The size of a tile can be chosen so that even a computer with relatively small RAM can process the whole city step by step. If more computers are started in the PCSP-mode, the load balancing between them is also organized by the software automatically.

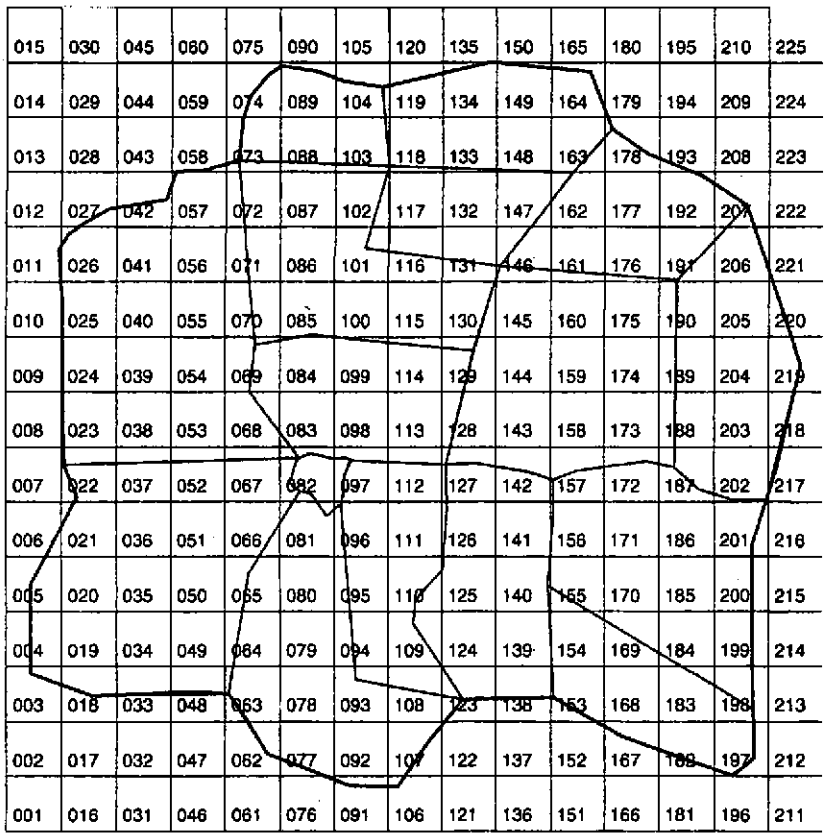

Fig. 4 Tiling of the whole area of the city

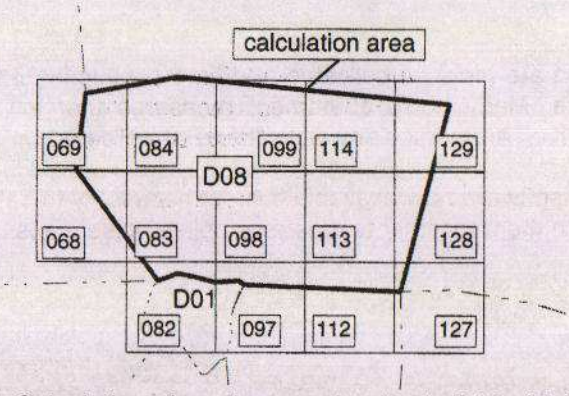

Fig. 5 Calculation of a noise map for district D08 with PCSP

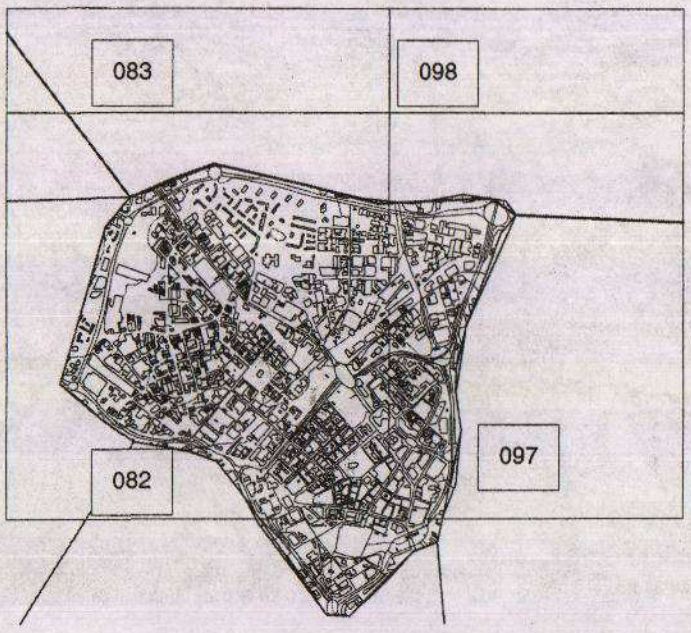

Fig. 6 Top View of district D01 (see fig. 4 and 5)

Let's assume that two computers shall calculate a noise map for district D08. Then all tiles that have common areas with D08 (see fig. 5) are processed. Computer 1 loads all objects of tile 83 and of the surrounding tiles to the defined distance (about 2000 m) from the 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.

Size of files that can be processed

It is very important for noise mapping of cities that software and hardware can handle big files, so that the whole city or parts as large as possible can be processed together. Even if it is possible to do the calculation with PCSP, it saves a lot of time if the tiles are not too small. The evaluation of a map, the assessment of the number of people exposed to given noise levels and other evaluations

are not comparable and are more complicated and time consuming if they have to be undertaken with numerous patches. Many noise abatement measures that influence more districts like a change in traffic distribution are particularly difficult and complicated with small files.

With the hardware and software now available it is not necessary to calculate and print many small noise maps and to paste them together to create complete noise maps of cities.

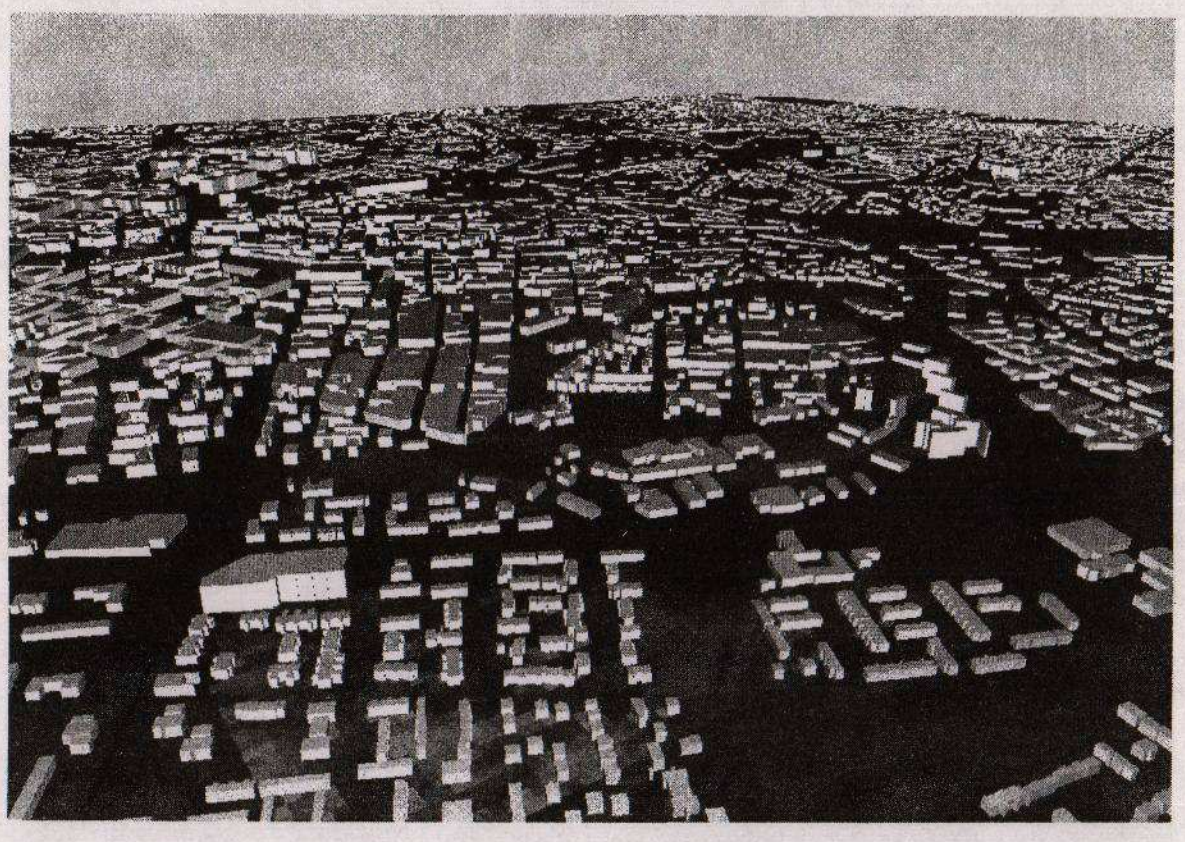

Fig. 7 3-D-View of a city - screen presentation with software CadnaA (DataKustik GmbH, Munich)