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URBIS: AN INSTRUMENT FOR LOCAL ENVIRONMENTAL SURVEYS

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1. INTRODUCTION

The proposed European Directive [1] on environmental noise concerns noise from road, rail and air traffic and from industry. It focuses on the impact of such noise on individuals, complementing existing EU legislation which sets standards for noise emissions from specific sources. Implementation of the Directive would require the following points that are supported by the UK Department of Environment, Food, and Rural Affairs (from: Briefing Note on the Environment Council's Common Position from the UK Department of Environment, Transport and the Regions by Joseph, Earle, and Dalgleish, 2001):

1. the determination of exposure to environmental noise, through noise mapping, by methods of assessment common to the Member States;
2. provision of information on environmental noise and its effects to the public;
3. adoption of local action plans, based upon noise mapping results, with a view to preventing and reducing environmental noise where necessary and particularly where exposure is great;
4. preservation by the Member States of environmental noise quality where it is good;
5. collection of data by the Commission to inform future Community policy.

The Directive will require mapping and action planning for all the major environmental noise sources. The mapping methods required by the Directive are best suited to addressing problems in a strategic way but they are not necessarily suitable for assessing localised problems.

TNO has developed a GIS based instrument, Urbis, which can assist municipalities in fulfilling their future obligations. Existing information on the current (and future) situation can be used as input. The noise propagation model in Urbis is designed for the purpose of noise mapping in large urban areas. Possible future specifications concerning the method of mapping can be easily implemented in Urbis due to the modular structure of the system.

2. THE INSTRUMENT URBIS

Urbis is a GIS based system for environmental surveys in municipalities. Noise, air pollution, odour and safety hazards as well as annoyance and health effects can be assessed with a high level of detail. This results in detailed maps and indicators of the environmental quality and effects. Wherever possible, the surveys are based on available data. Existing data on traffic, inhabitants, emissions etc. are processed. By using existing data, the effort it takes to produce noise and noise effect maps is limited [2].

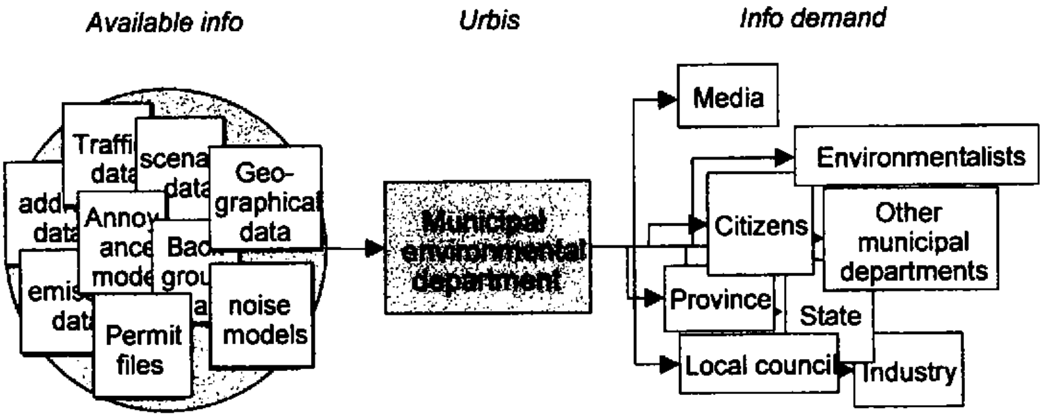

Fig. 1 Urbis attunes the information offer to the information demand.

The steps in the Urbis data processing procedure correspond with the steps in the cause-effect chain shown in figure 2. Information on various activities is input for Urbis. For road traffic for example, data on traffic intensity, speed, and road surface height and type are input for the system. With emission models Urbis calculates emissions from these activity data. For some sources, noise emission data are in some cases directly available (e.g. industry) and then need not be calculated in Urbis). Data on ground surface type and building heights and configurations are used in addition to emissions to calculate the noise immission levels. For some sources, the noise immission is available directly (e.g. noise contours for air traffic). Exposures of dwellings and inhabitants are estimated on the basis of the noise immission maps.

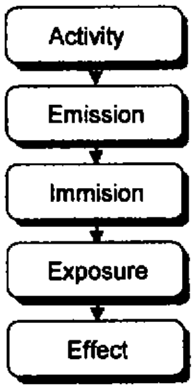

Fig. 2 Cause-effect chain

The annoyance level depends on the noise exposure and, in addition, also on the source type (aircraft, road traffic, railway, industry). Therefore noise loads from different source are first translated into the equal-annoying noise levels of road traffic before combining them into a single measure of the overall noise load. On the basis of this cumulated noise load, the total expected percentage of highly annoyed persons can be determined, using the dose-response relation for road traffic [3][4].

The results from the surveys with Urbis are detailed maps for noise and indicators on noise and noise effects for each part of the municipality (or district). These indicators can be e.g. percentage surface exceeding a noise limit, expected percentage highly annoyed or percentage inhabitants with a certain noise load during nighttime. These indicators can be determined for each source type separately and for the cumulated noise load. Because the surveys in Urbis are produced on the basis of models instead of measurements, future scenarios can also be explored. Effects of expected developments in, e.g. road traffic intensities, emissions of vehicles and air traffic noise can be mapped. Also, the effects of policy decisions on road traffic flows, spatial planning, etc. can be assessed. The difference in noise levels between scenarios and the present situation are mapped.

Figures 3 to 5 show noise levels from different source types. Figure 6 shows the cumulated noise level. Figures 7 and 8 show examples of indicators that are calculated with Urbis [5].

2.1 The noise model in Urbis

There are several standard methods for the calculation of noise propagation. For example in the Netherlands there are two statutory calculation methods for road traffic noise: SRM1 and SRM2. These noise models were developed for noise control and regulation purposes. In some cases, the simple method SRM1 can be used, but in many cases the complicated SRM2 is obligatory. The CRTN model is used in the UK for the calculation of road traffic noise.

The use of the standard calculation methods was not a good option for noise mapping on the scale of cities or municipalities. With SRM1, only noise levels at the side of a building facing the road can be calculated, because object shielding is not accounted for in this model. On the other hand, SRM2 is a complex calculation method. Noise propagation is calculated for 8 separate frequency bands, and has no limit to the number of reflections that can be included in the calculation. An important reason why SRM2 is less suitable for noise mapping lies in this complexity. The calculation time required for producing a noise map becomes very long if no concessions are being made on the level of detail of the input data or the spatial resolution of the result.

For the development of Urbis, a noise model was needed which can calculate noise levels in a large area with many buildings within a limited calculation time. A noise propagation model [6] was developed which uses a standard spectrum per source. For each combination of a receptor point and a noise emission point, it searches for the most important object with the largest effect on the sound transmission and calculates the shielding caused by that object in a deterministic way. The influence of the rest of the buildings on the path from the emission point to the receptor point is taken into account in a statistical way based on the sizes and orientations of the buildings. In addition, the most important reflections are taken into account (opposite objects and first order reflections in silent streets).

Fig 3: noise load due to road traffic

Fig 4: noise load due to rail traffic

Fig 5: noise load due to industry

Fig 6: cumulated noise load

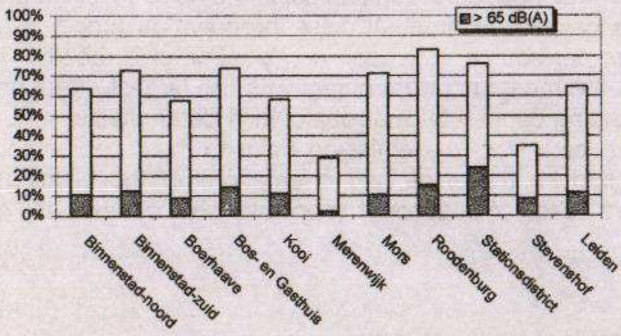

Fig 7: Percentage surface with noise load due to road traffic > 50 dB(A) in different districts and the whole city of Leiden

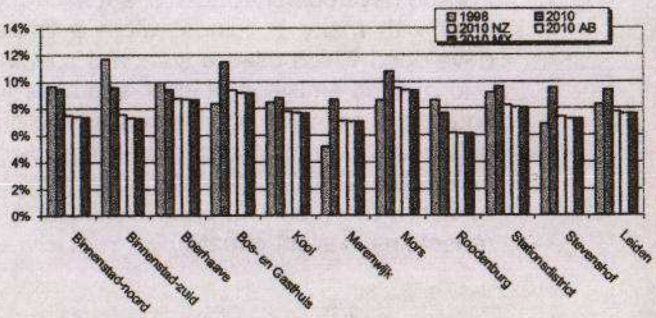

Fig 8: Expected percentage highly annoyed due to the cumulated noise load in different scenarios in different districts and the whole city of Leiden

Because the calculation time with the noise model in Urbis is relatively short, a high density of receptors can be used. The spatial resolution of the noise map is optimised for urban areas. A hexagonal grid of receptor points is used with a maximum distance of 25 meters. Where gradients in the noise level are expected to be high, the density of receptors is higher so that the spatial resolution is increased up to 5 meter. On buildings facing the noise source, dedicated receptors are placed automatically on the façade with 5 m intervals. In this way, the noise exposure (and noise effects) are directly based on calculations without interpolations, which are difficult in urban areas.

The level of detail and accuracy of the input data that is used for the calculation of noise maps is generally the limiting factor for the accuracy of the result. The use of a more detailed noise model, like SRM2, for the calculation of noise maps would therefore of little use.

3. APPLICATION OF URBIS IN LOCAL NOISE POLICY

Developments in many counties and the EU directive on noise force municipalities to extend their role with respect to environmental noise.
In the United Kingdom, the "Rural White Paper" was published in November 2000 [7]. This paper sets out the Government's policies for rural England and states that the national noise strategy will include mapping the main sources and areas of noise. There are many options for the organisation of, and responsibility for the production of noise maps. However, it is likely that local authorities will have an important role in this [8].

An effective noise policy with ambitious but feasible goals can be introduced by implementing a policy cycle (Fig 9) in which formulation, implementation and evaluation of the noise policy is alternated [9].

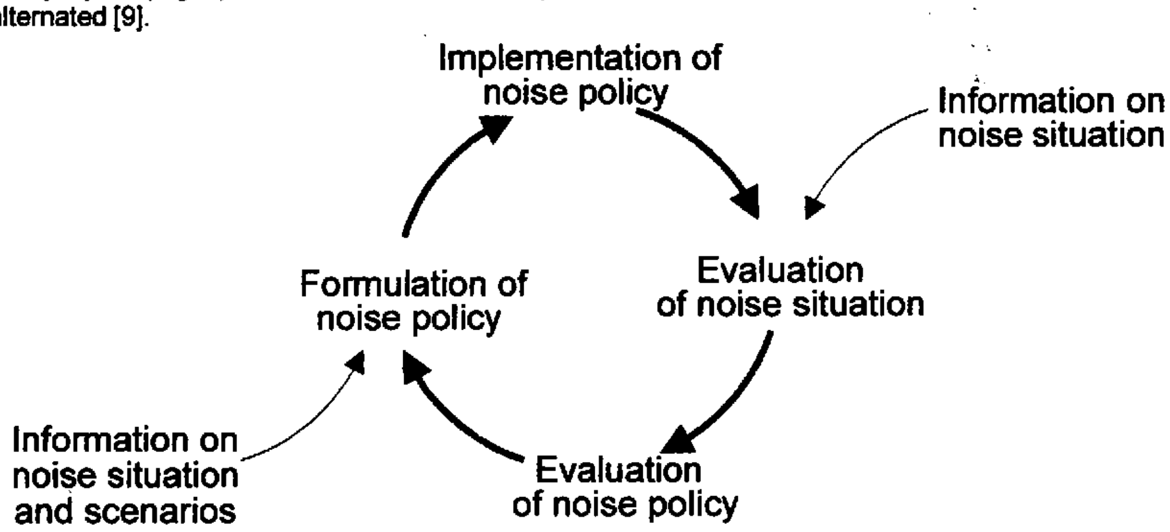

Fig. 9: Municipal policy cycle on noise and information input

In this policy cycle, the formulation of noise policy or noise action plans is preceded by an assessment of the current noise situation and the noise situations according to possible future scenarios. For the formulation of the local noise policy, it is useful to know what the relative contributions of different sources are to the total noise load and noise annoyance. The possibilities for the local government to reduce the noise load where this is dominated by for instance noise from motorways or air traffic are limited.

For other sources, such as local roads or industry, the municipality may be able to reduce the contribution to the noise load.
It is important to know what the noise load from different sources will be in the future. Therefore the autonomous scenario must be explored, in which the growth of (auto) mobility is taken into account as well as national noise reduction measures, developments in air traffic movements and other developments beyond the power and responsibility of the municipal government. Besides this autonomous variant, it is also important to assess the effect of measures to reduce the noise and noise annoyance (e.g. changes of traffic flows, noise screens, other road surface). In this way, a (cost) effective noise policy can be formulated. On the basis of this information, ambitious but realistic goals can be formulated in terms of indicators of noise and noise effects. These goals can differ for districts in the municipality on the basis of their function and the feasibility of the noise reduction of the goals.
After the execution of the formulated actions, the noise situation is assessed and evaluated (see figure 9).
Input for the evaluation will be information on the noise situation after the implementation of the policy. This way an assessment is made of whether or not the goals in the noise policy were reached. The noise and noise annoyance situation after the implementation can be compared with the situation before the implementation or with a simulation of the current situation without the measures (but with autonomous developments). This way the effectiveness of the measures is examined.

On the basis of the evaluation of the noise situation, the noise policy can be evaluated. Was the noise policy effective? Were the goals set in the original plan reached? Were the measures as (cost) effective as predicted? Did external factors make that the goals could not be reached? Were the goals realistic in the first place?
The outcome this evaluation, together with the assessment of new scenarios forms the basis for the formulation of a new noise policy or noise action plan and a new round of, say, four years, is entered.

Some care has to be taken with the use of targets: there is the risk that the policy field is oversimplified, attention could be given to measurable issues only and the political accountability is increased. Nevertheless, the use of targets in a policy cycle has benefits as stated above. It provides insight into goals to be reached through an action plan, it guides the allocation of recourses, and it supplies concrete milestones for evaluation and adjustments.

4. CONSIDERATIONS REGARDING NOISE MAPPING

There are several important factors determining the success and effectiveness of noise mapping: accuracy and spatial resolution cost efficiency and the embedding of the use of noise maps in the organisation. It is advisable to take these points in consideration when setting up a noise mapping project.

The accuracy of the noise map has to be sufficient for the formulation of noise policy. The results of the calculations have to be comparable to other noise calculations. The input data are often the limiting factor for the accuracy of the noise maps. Especially data on road traffic volumes are often not very accurate. Because these form the basis of the noise calculations, it is important to put a great deal of the effort into obtaining accurate and consistent traffic data.

The spatial resolution of the noise maps has to be sufficient for the calculation of noise exposure of dwellings and noise effects. If the spatial resolution of the noise maps is too low, say 100 meter, the noise levels at the intermediate points are determined by interpolation. Especially in urban areas, where there are many shielding objects, this will lead to large inaccuracy in the predicted exposure and effects.

Cost and time efficiency is an important factor of a noise mapping project. Therefore it is important that the effort that is necessary for the creating of a noise map is limited. It takes effort to collect the input data and to make it suitable for the calculation software. By implementing the noise mapping software on a GIS that is able to convert data from many different formats, the effort for the preparation of the noise map can be reduced and data from different information source holders can be used.

In practice, the collection of the necessary input data is the most time consuming step for the production of the first noise map. In addition the calculation time is important. The noise mapping software will be used for the assessment of scenarios. These scenarios often consist of small changes in input data (a new type of road surface for example). Long calculation times will make the assessment of more scenarios time consuming and not very practical. Planners and decision makers will not accept long response times to relatively small questions.

Maybe the most important factor for the success of noise mapping is the embedding of the use of the noise maps in the organisation. When the current noise situation is kept up to date and questions in the form of scenarios can be answered quickly with limited effort, the noise map will be used in planning and decision making. The storage and exchange of necessary input information is to be tuned to the making of noise maps (e.g. traffic and geographical data is to be kept up to date and consistent). Also the use of the noise map has to be integrated in processes related to noise, traffic and planning. For the creation and analysis of noise maps it is necessary that people become aware of the possibilities of the noise maps and integrate that in their practice.

5. CONCLUSION

Developments in many counties and the EU directive on noise force the municipalities to extend their role with respect to environmental noise. In many cases they used to play a reactive role, by responding to complaints and requests but their role will become more pro-active (formulate their own noise policy, anticipate on future developments and information requests). Noise maps can play an important role in this development. They provide the information that is needed for the fulfilment of this extended role.

By the implementation of a policy cycle in which information on the current noise situation and in possible future scenarios alternates with the formulation of targets and the implementation of measures, the municipal noise policy can become more (cost) effective. By the integration of noise aspects in an early stage of planning for the development of new, or renovation of existing areas, the noise environment can be improved. By communicating with the (future) inhabitants on the future noise situation, support for the plans can be increased.

Urbis is a GIS based system for environmental surveys in municipalities. Noise, air pollution, odour and safety hazards as well as annoyance and health effects can be assessed with a high level of detail. The noise propagation model and its implementation in Urbis are designed for the purpose of noise mapping in large urban areas. This way, optimal accuracy is reached with limited calculation times. Wherever possible, the surveys are based on available data. Therefore, the effort it takes to produce noise and noise effect maps is limited.

There are several points that have to be considered when starting a noise mapping project: accuracy and spatial resolution; cost efficiency and the embedding of the use of noise maps in the organisation. It is advisable to take these points in consideration when setting up a noise mapping project.

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