inter.noise
HAMBURG 2016

Road Noise Auralisation for Planning New Roads

Per FINNE[1]; Jakob FRYD[2]

[1] DELTA Acoustics, Denmark

[2] Danish Road Administration, Denmark

ABSTRACT

This paper introduces a method to create auralisations involving road noise. The method has evolved over some years now and is based on binaural recordings of real vehicle recordings. The overall purpose is to make exact and reliable sound presentations for people living next to planned, expanded or remodelled motorways. Among others, The Danish Road Administration has experienced that explaining future noise with graphs, noise maps and words leaves a large group of the population frustrated – Simply because they have no prerequisites to understand these terms. Even in cases where noise is reduced, this is not really trusted by some neighbours.

We believe that auralisations based on accurate terrain modelling and pass-by sound recordings of real vehicles are the feasible way to involve more people in the debate of future road projects. It certainly can give most of the population a sense of the noise induced annoyance, they are facing. Thus, auralisations are an important and a supportive tool to add to ordinary noise maps etc.

Additionally, auralisations have shown very powerful in explaining general acoustic terms and sound propagation e.g. the influence of wind direction and speed, the effect of noise reducing surfaces, and noise barriers.

Keywords: Road Traffic Noise, Highway projects, Auralisation, Sound propagation. I-INCE Classification of Subjects Number(s): 52.3, 68.4, 24

1. INTRODUCTION

Auralisations take a greater role in decision making and explaining acoustic phenomena. It is possible to explain acoustic behaviour and to communicate much more details in acoustics using sound examples and auralisations. Additionally, auralisations can under specific circumstances be made with accurate noise levels in the playback system in order to precisely model the future soundscape.

Normally, noise propagation and noise exposure is communicated by means of noise maps of L_{den}, L_{Night} and other technical indicators. It has gradually become more difficult to explain these terms for neighbours and laymen in general. Furthermore, corrections to these parameters are made for special noise appearance and behaviour like evening and night corrections, and in some cases impulse and pure tone corrections which make the official indicators impossible to compare with actual noise measurements. This, combined with a general increased focus on noise annoyance, makes it difficult to communicate noise behaviour from new noise sources like roads etc.

Auralisations make it possible to support the official noise maps and enumerations of the number of people exposed to noise. Somehow, this is analogue to visualization at least when it comes to the process of presenting new projects for the public in the Environmental Impact Assessment process (EIA). Who will possibly present a new road, bridge or railway line without using a proper visualization of the project for the public?

[1] pfi@delta.dk
[2] jaf@vd.dk

2. COMMUNICATING NOISE WHEN PLANNING NEW ROADS

When planning a new road project – or similar – the noise consequences generally are presented on noise maps with noise levels stated as numbers called equivalent levels. While these noise maps may be based on very precise calculations and may be entirely correct, numbers presented as equivalent levels are difficult to understand for laymen. When carrying out public hearings on projects which have significant noise consequences, it is important that citizens and decision makers understand the impact of a new project.

Auralisations make it possible to actually hear, how the new road – or any new outdoor noise source – will sound in different situations and soundscapes. First of all people living next to a new motorway would want to know, how it will sound in their own backyard or on the garden terrace. Very often people also have a special interest in knowing, how it will sound in a downwind or an upwind situation – phenomena which are not covered by ordinary noise maps. The Danish Road Administration – being the authority of planning and maintaining major roads in Denmark – has an obligation and an interest in obtaining and explaining the adequate consequences of new roads as good as possible for the public and especially for the future neighbours. This goes for the future noise exposure and – not to forget – the possibilities and consequences of noise reduction measures. This is done in order to give the most realistic and adequate picture of the future situation. In this, The Danish Road Administration intends to use auralisations in addition to mandatory noise maps and enumerations of noise exposed dwellings and people.

3. RECORDING METHOD

The method used for auralisation is based on recordings of single vehicles passing by. Each vehicle is recorded by using binaural recordings with HATS (Head and Torso Simulator), figure 1. Due to the following manipulations of the recordings, practically no background noise or irrelevant noise should be recorded during pass-by, a fact that gives very strong restrictions on the sound quality of the recordings. All useful pass-by recordings were typically taken late evenings and nights due to the difficulties in finding places with no significant background noise. Singing birds, vehicles on distant roads or agricultural machinery can be significant damaging for this type of recordings.

Figure 1 – Recording vehicle passing by using HATS

Recordings were also made with practically no or very low downwind speed, so the following corrections were as little as possible. The pass-by recordings typically lasted 30-60 seconds, corresponding to 750-1500 metres distance at 90 km/h. Thus the recordings are useful for auralisation of single vehicles as well as for mixed traffic due to a specific traffic flow of a certain road.

Recordings were made on straight, flat roads at approximately constant speed with no or very little terrain variation. Recordings were made close to the road – typically 30 metres from the roadside (nearest lane) – figure 2. The road surface was a reference surface according to the Danish noise prediction method Nord2000 (SMA 11 or Ab8t), thus giving the opportunity to create auralisation of different types of surfaces – once you have correction values for the different surfaces in use.

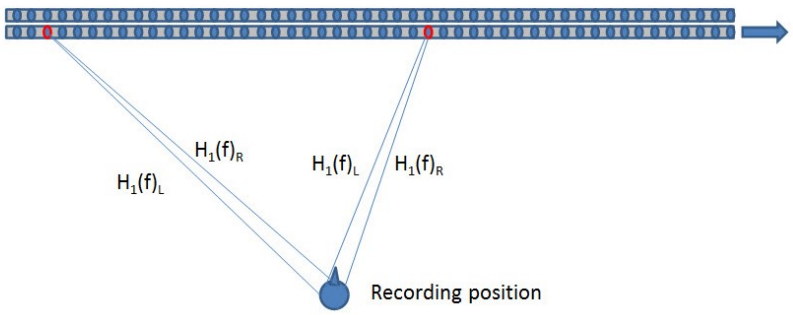

Figure 2 – Recording configuration

Transfer functions for the left and right ear for two out of a large number of point sources representing the road line. Each lane is considered individually.

4. AURALISATION METHOD

The method used for auralisation is straightforward and based on corrections to the individual pass-by recordings using precise calculations of sound propagation from the recording situations as well as the point of auralisation. In order to modify the time signal each correction value refers to approximately a 10 metres segment of the road. The length of segmentation is not mandatory, but should be considered in relation to the auralisation situation i.e. positioning of noise barriers, terrain variations etc. But the segmentation has also a significant influence on the perception and the quality of the auralisation sound file.

The process of auralisation is illustrated in figure 3.

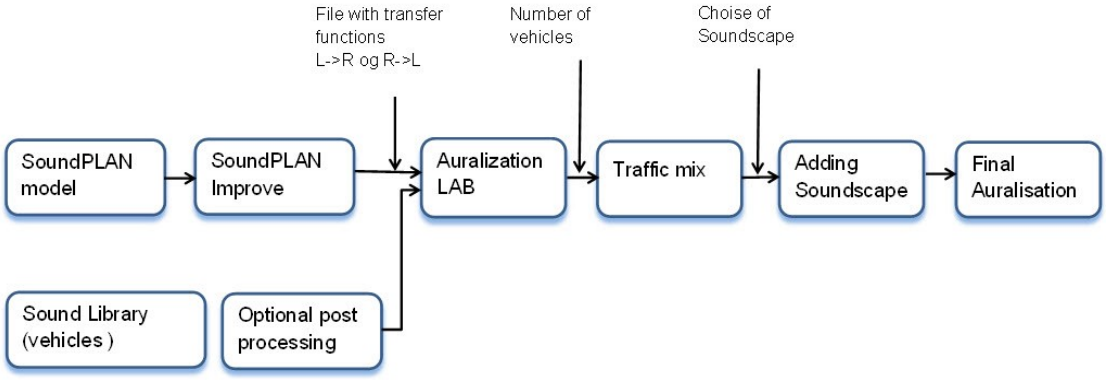

Figure 3 – The overall auralisation process

Often, noise maps and other noise predictions have been made prior to auralisations giving the opportunity to benefit from existing 3D-noise models. In Denmark, SoundPLAN is the de facto standard prediction program due to the implementation of Nord2000. In figure 3, other programs covering Nord2000 could be used as well.

SoundPLAN improve is a special program able to extract transfer functions from the SoundPLAN databases.

The library consists of a large number of vehicle pass-by sound files e.g. light vehicle or heavy vehicles at 80 km/h. The post processing is used to correct for different surface properties e.g. noise reducing asphalt or surface.

Each vehicle pass-by is modified using the relevant time-slice transfer functions calculated using

Nord2000 as indicated in figure 2. Please note that the point of auralisation normally corresponds to a complete different geographical and topographical situation compared to the recording site. Changes in sound propagation are dealt with using the calculated transfer functions from the recording site $H_1(f)$ and the point of auralisation $H_2(f)$, figure 2 and 4.

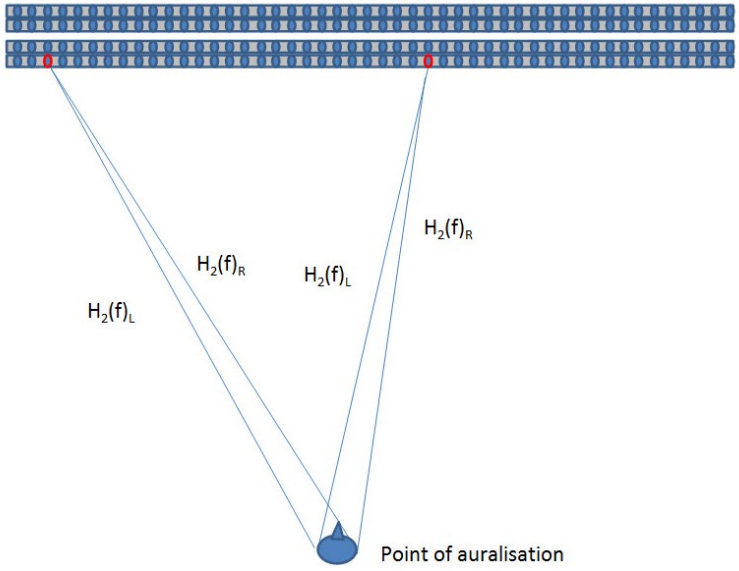

Figure 4 – Auralisation configuration

Transfer functions for the left and right ear for two of the point sources each representing a segment of the road line. Each lane is considered individually.

The Auralization LAB module (figure 3) creates the modified sound file corresponding to the auralisation position. When all vehicle pass-by calculations are made, they are mixed into one sound file with the specific requirements of speed, traffic intensity and so on.

At last, the soundscape is added. This is normally a binaural recording of background noise having specified characteristics like “Afternoon, in open land“, “Birds singing in open land“ etc. The soundscape is of great importance and gives the listener an important feeling of context, while listening to the auralisation.

5. AURALISATION PLAYBACK

Due to the binaural recordings and processing the playback obviously should be on headphones of a good quality. Playback using PA-systems for public addressing in meeting halls and so on is also possible with few corrections to the sound files. For communication purpose the important question is whether playback can be intended for web downloads, where you have no control of the playback system including the calibration level. By introducing the web presentation we have incorporated a simple method which gives the listener the opportunity to make an approximate calibration by using a speech signal adjusted to “the sound of a person speaking at normal speech level at 1 metre distance“ which is approximately 60 dB. So, the listener should first play this speech sound file and correct the playback volume according to this.

6. EXPERIENCE

So far, the method of auralisation has been used in connection with public hearings held according to an EIA process (1,2). This project was to build a four lane motorway to replace a two lane highway between two major cities in the western part of Denmark. Auralisations were presented at public meetings during the EIA process (figure 5). Here, the public could test the auralisations using the available calibrated headphones. The auralisations were incorporated in a non-stop movie playing auralisation of:

- Noise reduction (noise from a motorway reduced respectively 3 dB, 6 dB and 10 dB)
- Noise 100 metres from a two lane highway at 90 km/h
- Noise 100 metres from a four lane motorway at 110 km/h
- Noise 100 metres behind a noise barrier (four metres high)
- Noise 100 metres from a motorway with noise reducing surface

All the above auralisations refer to a rush hour situation with neutral wind and propagation over flat ground.

Figure 5 – Auralisations presented during a public meeting (EIA process)

The Danish Road Administration has noticed, there is a great public interest in the auralisations and it is believed to be a standard part of presenting future road projects when noise is expected to be an important issue.

It is important to match the expectations for the future noise, including the limited possibilities to reduce noise. Often citizens and decision-makers have too high expectations for noise-reducing measures such as noise barriers or noise-reducing asphalt. The experience is that people often get disappointed to hear the effect of a noise barrier or noise-reducing asphalt. On the other hand, citizens are pleased to be presented with auralisations, even if the message can be discouraging. They feel better informed about the consequences, and they have thus better opportunities to participate in a public debate about the project.

7. WEB AURALISATIONS

Auralisations can be informative when explaining noise propagation and behaviour. In order to explain some of the important parameters a website was built with a number of educational and practical auralisations.

The web site uses a special web application (SenseLabOnline) made for download and playback of sound files, listening tests etc.

The web site has a procedure for calibrating the playback system in order to have useful and realistic noise levels in the playback system as described in chapter 5.

The web presentation is changing frequently as new auralisations are made. At present, you can find auralisations covering noise from a motorway:

- With noise reduction of 3 dB, 6 dB and 10 dB
- The influence of noise barriers and noise reducing surface
- The downwind and upwind influence (± 3m/s and 5m/s)
- The influence of hard and soft ground at distances up to 400 metres

Basically, all presentations are made using neutral wind and propagation over soft ground unless otherwise noted.

The web presentation can be found using this link: Road Noise Auralisations.

8. CONCLUSIONS

Based on the experience so far we believe auralisations based on accurate terrain modelling and pass-by sound recordings of real vehicles are a proper way to improve the information flow involved in public hearings. In the debate of future road projects it gives most of the population a sense of the noise induced annoyance, they are facing.

Auralisation is an important tool to complement noise maps, etc. in order to improve communication with the public about noise in general and about noise consequences of a specific project.

The method presented is still based on much manual work, and at this point it is expensive in use, but a number of improvements have been identified in order to make it more smooth and cost effective.

Also improvements on the technical development are needed. This could possibly be synthesis of vehicle pass-by, a combined program for calculating Nord2000 sound propagation and modifying the sound files (Auralization LAB, figure 2) as well as a smooth program to mix sound files.

REFERENCES

1. Finne P, Fryd J. Hvordan kommer den nye vej til at lyde? (in Danish) Proc Aalborg University Trafikdage 2014; 25-26August 2014; Aalborg, Denmark 2014.
2. Finne P, Fryd J. Hør den nye vej før den er bygget (in Danish). Trafik & Veje, 2015 JUNI/JULI pp. 44-46.