Acoustical considerations have to be an integral part of the design of a development, not added as an afterthought. The soundscape is a resource.

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Acoustic Design for Early Stage Urban Planning

Planning of urban outdoor space often involves a large number of stakeholders: local authorities, architects, developers, consultants, local inhabitants, and so forth. All may have different expectations, imposing (sometimes conflicting) constraints on the planning process. Current urban planning practice is mainly based on socio-economic concerns, aspects of visual aesthetics, safety and mobility. In order to cope with the long-term impact of large urban development projects on the wider community and the environment, most countries have established planning guidelines and regulations concerning environmental and sustainability issues. Aspects of noise are usually included in the environmental impact assessment of planning proposals, in the form of (legally binding) noise limits. However, at that stage soundscape considerations can no longer influence the overall plans; the focus is often only on minimising the adverse impact of high noise levels on future residents. The acoustic environment of the vast majority of public spaces (parks, squares, courtyards, etc.) is given little thought.

During recent years, there is a growing awareness that sound forms an integral part of the environment, and that it should be considered at the same level of importance as visual aesthetics in the urban planning process (Olafsen, 2009). For example, a good placement of buildings is much more efficient than remediating measures such as placing noise barriers or absorbing materials. Next to this, there is growing evidence that having a 'quiet side' at one's dwelling may reduce noise annoyance and health effects related to noise (Öhrström *et al*., 2006). Access to urban green areas with a fitting soundscape, within short range of one's dwelling, is also an important factor to consider in light of psychological restoration (Klaeboe, Engelien & Steinnes, 2006). Therefore it is clear that, to be most effective, acoustical considerations have to be an integral part of the design of a development, not added as an afterthought. Moreover, accounting for the sonic dimension at an early stage in the planning process makes it possible to consider sound as a resource, not just as a waste to be managed. Not all sounds are noise; some sounds do fit well in some environments, and we should strive to preserve or even accentuate these sounds, rather than to eliminate them. Acoustic design represents a more positive and holistic approach as compared to traditional noise control (both are complementary), aimed at designing entire environments that are pleasing to the ear.

Proposed Planning Methodology

We propose a two-stage methodology, which, if adhered to by planning authorities, should make it possible to account for aspects of acoustic design already in an early stage of the urban planning process. The two stages differ in their level of detail, and the type of advice that is expected from the acoustic consultant.

In the first stage, advice should be given on the placement of building blocks, roads, squares and/or parks. The main concern in this stage is to define a planning proposal that meets basic acoustic objectives. Balancing these with economical, aesthetic, safety and mobility objectives will require a good coordination with the architects and developers. Considering dwellings, basic acoustic objectives could be building guidelines or level-based noise regulations. Considering urban parks and squares, the basic objective should be to create potential for soundscape design. Of course, this does not mean that complete silence is the objective. Often only particular sounds should be avoided; other sounds may be tolerated or even wanted. Important aspects of this first stage are therefore to ac-

Figure 1. Aerial photograph of the case study area.

count for the vision of the local inhabitants, and to characterise the existing acoustic environment, in order to identify the most important sources of sound, both wanted and unwanted.

In the second stage, advice should be given on the detailed acoustic design of the public space and private gardens and balconies, which extends much beyond limiting the sound level. The general building and road layout is considered to be more or less fixed. The goal should be to shape the acoustic environment in line with the intended use of the space, integrating the sound from local activities. This implies creating zones with different acoustic environments, from lively to quiet, from natural to more urban, which will only be possible if the first-stage advice was followed.

Case Study Overview

We will illustrate the above approach using a particular urban development case study, putting emphasis on the methodology that was followed. In this project, the authors were involved as acoustic consultants to advise the local authorities in planning decisions.

The case study area is located in the south-eastern part of Antwerp and mainly consists of an abandoned gasworks site, a parking lot and a transformer station. The area is enclosed by an elevated railway to the north, a residential area to the south and a major road and freeway to the east (Figure 1). It is to be redeveloped into a residential area, with room for a coherent public green space. The main focus will be to attract new inhabitants, as well as to enhance the quality of life of the people already living in the neighbourhood. The architecture of the planned buildings has to blend with the surrounding art nouveau style. The use of high-rise buildings is therefore restricted to a minimum, posing a limit on the amount of space that can be reserved for the park, in order to keep the project economically feasible. Next to this, planning is guided by the presence of a number of old trees, which should ideally make part of the urban park, and the presence of a shed in the centre of the area, which could be remodelled into a multifunctional facility for the inhabitants, reminding of the history of the site.

Analysis of Existing Soundscape

The current acoustic environment was characterised using long-term and ambulant sound measurements, conducted at various locations in the area. Results of the former were used to validate noise maps (see below). It was found that the sound level centrally in the area drops below 55 dBA only during the night, so noise reducing measures will be necessary for (at least part of) the new dwellings. Together with the ambulant measurements, binaural recordings were made, which can be used in the second stage of the planning process for auralization purposes.

In-depth face-to-face interviews were performed with 15 people, carefully selected to have a good geographical spread around the case study area. Most participants were well informed about the redevelopment plans. The interview consisted of questions on the quality of their own living environment, and of open questions on the use of green space in their neighbourhood, on possible strengths and weaknesses of the redevelopment plans, on where they would personally like the park to be and how they would organise it, and on important noise sources that should not be overlooked in the soundscape study.

The surrounding area has a lively social atmosphere, and inhabitants expressed the need for

a place for everyday use within close range, in which they could relax. It was found that the noise from the railway is more or less tolerated; limiting the intruding noise from the freeway was found to be of greater importance. This led to the objective of keeping the daytime L_{Aeq} caused by the freeway below 60 dBA inside the planned park. A main concern mentioned by most inhabitants is that they would like the park to be contiguous with the existing residential areas. In order to process and visualise the results of the open questions, tag clouds were used. Figure 2 shows an example, based on the question on what they most like about their neighbourhood. The 'Dageraadplaats' is a square located nearby, which most people found to be well planned, and which could be used as an inspiration for soundscape design measures.

Figure 2. Tag cloud visualizing the main perceived assets of the neighborhood.

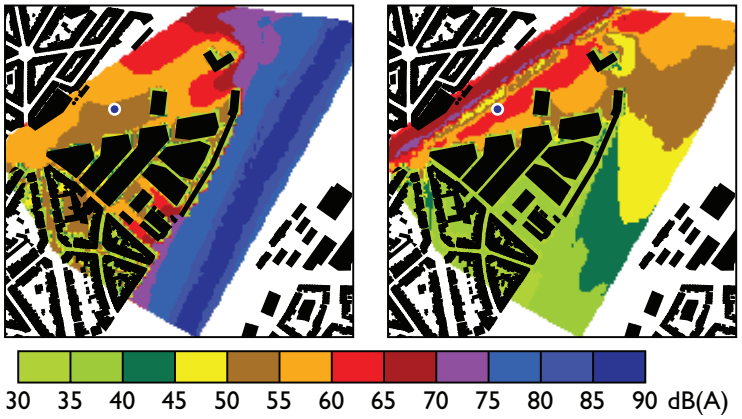

Figure 3. Noise maps ($L_{Aeq,day}$) for road (left) and railway traffic (right), for a particular building placement scenario. The blue dot represents a particular listener location.

Advice on Building Arrangement

Based on architectural, economical and mobility boundary conditions, and guided by the results of the survey, a set of building layouts were constructed in consultation with the architects and city planners. Figure 3 shows an example of a scenario, in which the park forms a peg from the western to the eastern edge, with a series of artificial mounds at the western edge. A line of buildings is used as a noise barrier. In case these are used as dwellings, it is essential that the most exposed façade is well insulated, and that the least exposed façade is sufficiently quiet, in order to secure a fair quality of life for the inhabitants. The interior design could be optimised also, for example, with the entrance along the 'quiet side' and noisier rooms such as the kitchen facing the freeway. In any case, a strict enforcement of acoustic specifications during construction would be required.

Noise maps for road and railway noise were calculated for the different scenarios, and validated using the sound measurement data. Figure 3 shows the L_{day} maps for the scenario considered in this paper. It can be seen that, for the park, noise from local road traffic does not form a major obstacle. Railway noise levels are acceptable inside the park, taking into account the fact that railway noise was found to be less annoying in the survey. The effect of the artificial mounds on freeway noise is little, but this is partly due to the receiver height of 4m (in accordance with European standards) which is not realistic for a park visitor.

Finally, advice on the selection of a planning scenario was formulated to the planning authority in the form of a SWOT analysis on the basis of noise and annoyance estimates, the potential for acoustic design of the urban park, the outcomes of the survey, and the fulfilment of various hard and soft design objectives. Strengths and weaknesses for each scenario were mainly based on acoustical information. Autonomous evolutions, such as traffic flow reductions, are examples of opportunities; the cost of remediating measures and associated necessary authority approvals are examples of threats.

Advice on Acoustic Design of Public Space

On the basis of the analysis in the first stage, black spots and areas of opportunity for soundscape design are identified and worked out in detail for one or a few building scenarios, in order to provide detailed advice on how to create a pleasing soundscape in the urban park. Design measures to be considered could be passive (e.g., introducing low-noise road surfaces, creating diffusive, irreg-

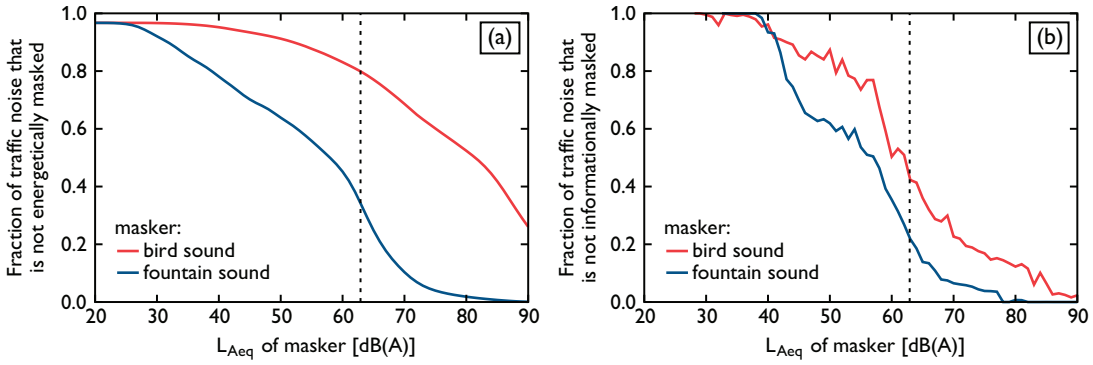

Figure 4. Simulated fraction of traffic noise that is not (a) energetically masked, and (b) informationally masked, as a function of the L_{Aeq} of the masker. The dashed line marks the L_{Aeq} of the traffic sound.

ular façades, or optimising roof shape, possibly using green roofs), or active, by accentuating existing sounds or even generating (or encouraging activities that generate) additional sounds. These sounds do not necessarily need to mask non-fitting sounds energetically; they could just distract attention from unwanted sound as much as possible. Popular examples of this approach are installing water features or adding greenery in well arranged spaces. The latter may enhance the sound level distribution, but may also attract songbirds. Another option is to install attractively and appropriately designed loudspeakers, or sound art installations, playing back fitting environmental sounds (e.g., Hellström *et al*., 2008; see also the next article in the present report, pp. 21–24), although further research is needed on issues of context and user choice.

Detailed propagation simulations, auralization listening tests or virtual listening tests using models for simulating soundscape perception are some of the tools that could be used at this stage (De Coensel *et al*., 2010a, 2010b). As an illustration, Figure 4 shows the potential of introducing the sound of a fountain or birds at a particular location inside the park in the considered case study scenario (See Figure 3 for the location), for masking the traffic noise. The applied model could be used to draw masking maps, delimiting the area for which design elements are effective in informational masking unwanted sound.

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