



## Urban Tranquility – Towards immersive representation of noise and well-being in urban environments

Poul Henning KIRKEGAARD<sup>1</sup>; Arnthrudur GISLADOTTIR<sup>2</sup>;

<sup>1,2</sup> Department of Engineering, Aarhus University, Denmark

### ABSTRACT

In the coming years, Aarhus University will participate in the Urban Tranquility project, the aim of which is to develop an index for holistic acoustic quality. The project will be the first step on the way towards a paradigm shift in the construction industry, based on more in-depth knowledge of the impact of the design of buildings, town squares, planting and infrastructure on the sound environment. The present paper is addressing issues regarding immersive representation of noise and well-being in urban environments as an integral part of design of sound environments.

Keywords: Urbane Noise, Representation of Noise, Social Costs of Noise  
I-INCE Classification of Subjects Number(s): 52.1,52.9, 67.4

### 1. INTRODUCTION

Due to the urbanization there is a clear need for densification of cities and efficient land use. Densification of urban cities implies higher levels of noise which places new demands on buildings and urban planning so that quiet environments can be created. Environmental noise pollution relates to noise caused by road, rail and airport traffic, industry, construction, as well as some other outdoor activities. Due to high levels of noise, it is difficult today to build dwellings in many key places in the cities that fulfil noise levels and regulations. Large areas of land adjacent to roads and railways, currently buffer zones can be occupied in the future implying that noise requirements and acceptance among tenants must be treated, even during the construction phase. To solve these issues, close cooperation between governments, contractors, developers, managers, universities and institutes is required. Through the research project Urban Tranquillity managed by Lund University, such a cooperation is established. The project will develop new methods, processes and products to create future silent cities. The aim is that through applied research and innovation-oriented activities find methods and strategies for designing silent environments in a dense city with buildings that harmonize with traffic and infrastructure for sustainable urban development. A good sound environment promotes well-being and health. It has been documented that exposure to residential road traffic noise is associated with a higher risk of diabetes (1).

The Urban Tranquillity project is linked to applied research and innovation related to housing, the built environment and infrastructure development. The focus will be on methods for designing housing and other buildings through densification and on methods for predicting and evaluating the impact on the living environment of noise, vibration and local wind conditions in a dense city. The present paper is addressing issues regarding immersive representation of noise and well-being in urban environments as an integral part of design of sound environments. The structure of this paper is as follows: Section 2 introduces issues regarding noise and human wellbeing in urbane environments. Section 3 is dedicated to ideas for research tasks in the Urban Tranquillity project for communication of noise results using visualization, virtual reality and augmented reality for the design of urbane environments. Finally, in Section 4 conclusions are presented.

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<sup>1</sup> [phk@eng.au.dk](mailto:phk@eng.au.dk)

<sup>2</sup> [arnthrudur.gisladdottir@post.au.dk](mailto:arnthrudur.gisladdottir@post.au.dk)

## 2. NOISE POLLUTION AND WELL-BEING IN URBAN ENVIRONMENTS

Noise affects people and has a greater impact than previously thought. The acoustic environment in which we live is possibly much more important than previously thought. In recent years, researchers have documented significant correlations between noise, mortality and lifestyle diseases (1). Players in the construction industry are aware of reducing noise levels when they build new urban environments or improve the existing ones, but they are fumbling towards a good solution.

Recently the European Environment Agency (EEA) made a comprehensive assessment of the European environment's state, trends and prospects, in a global context. The synthesis report informs future European environmental policy in general and its implementation between 2015 and 2020 in particular. It includes a reflection on the European environment in a global context, as well as chapters summarising the state of, trends in, and prospects for the environment in Europe. The report has one chapter outlining how human health and well-being are intimately linked to the state of the environment. Good quality natural environments can provide multiple benefits to physical, mental and social well-being. However, environmental degradation — such as that caused by air and water pollution, noise, radiation, chemicals or biological agents — can have negative effects on health. The following section quotes parts from the report (2) addressing that exposure to noise is a major health concern in urban areas

Noise pollution has long been recognised as a quality of life and well-being issue, but is increasingly being recognised as a public health issue. Road traffic is the greatest contributor to noise exposure in Europe. While its potential to contribute to harmful impacts is clear, tackling noise pollution is challenging, as it is a direct consequence of society's demand and need for mobility and productivity.

The Environmental Noise Directive requires EU Member States to undertake noise mapping (producing results in terms of common indicators) and to prepare action plans based on the noise maps. These action plans also aim to protect urban quiet areas against an increase in noise.

In 2011, at least 125 million people were estimated as being exposed to high levels of road traffic noise above the  $L_{den}$  noise indicator of 55 dB. In addition, many people were also exposed to rail, aircraft, and industrial noise, particularly in towns and cities, see figure 1. The average exposure to noise (i.e.  $L_{den}$  above 55 dB and  $L_{night}$  above 50 dB) in selected urban agglomerations remained broadly constant between 2006 and 2011 according to comparable data reported by countries for these two years.

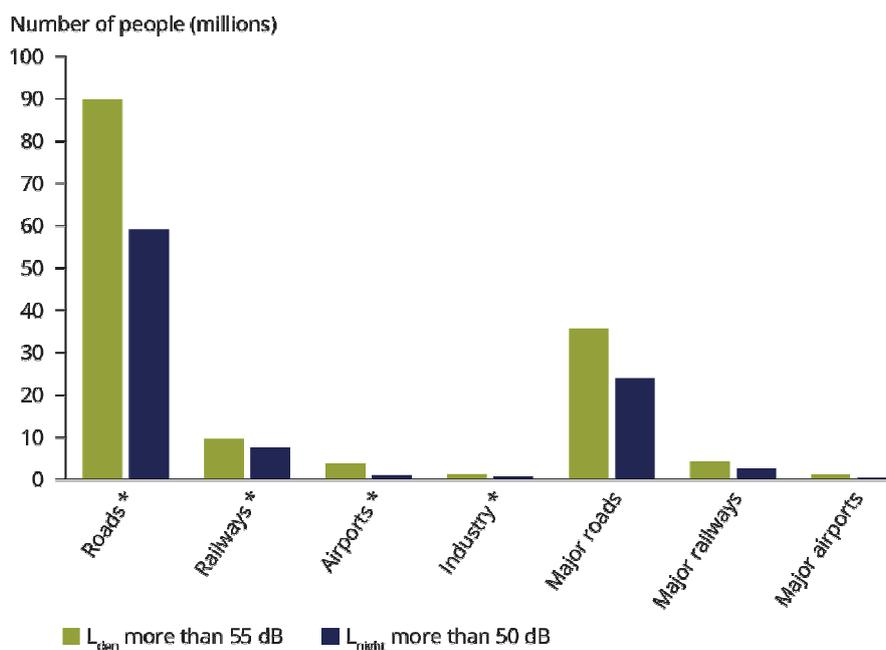


Figure 1 - Exposure to environmental noise in Europe within(\*) and outside urban agglomerations in 2011

Environmental noise is not only a source of annoyance; it has been linked with increased risk of cardiovascular diseases, including heart attack and stroke. The European Environmental Burden of Disease for noise is estimated as being at least 1 million life years lost per year, based upon earlier noise exposure data for 2006 and for road traffic alone. Most recently, exposure to environmental noise has been estimated to contribute around 10 000 cases of premature deaths due to coronary heart disease and stroke each year, with almost 90% of the noise-related health impacts being associated with road traffic noise. However, these numbers are likely to be largely underestimated, as many countries do not report complete data sets, an issue that prevents robust trend and exposure analysis.

Reduction of exposure to noise is an important public health measure that must be addressed by both European and local measures. Examples of local measures include installation of road or rail noise barriers, where appropriate, or managing flight movements around airport locations. However, the most effective actions are those that reduce noise at source, for example by decreasing noise emissions of individual vehicles by introducing quieter tyres.

Green areas can also assist in reducing urban noise levels. There are opportunities to rethink urban design, architecture and transport in order to improve the management of urban noise. A recently issued guide on good practice in quiet areas is designed to support cities and countries in their efforts. Opportunities to improve public awareness and citizen engagement would also benefit from being further strengthened.

There is also emerging evidence that environmental noise may interact with air pollution, leading to greater impacts on human health. This illustrates the value of considering integrated mitigation approaches that address common sources of both air pollution and noise, such as road transport.

Further efforts to significantly decrease noise pollution in Europe by 2020 will require an updated noise policy aligned with the latest scientific knowledge, as well as improvements in city design and measures to reduce noise at source.

### **3. IMMERSIVE REPRESENTATION OF NOISE**

One of the tasks in The Urban Tranquillity project is the development of a method for immersive representation of noise and well-being in urban environments. Researchers will carry out a number of experiments and build a model that can predict the behaviour and influence of sound regarding a number of different health and well-being parameters. This means in practice that they will be able to assess the acoustic quality of a building or urban renewal project as early as the design stage. This will make it possible to optimise the acoustic quality of a design project while it's still on the drawing board. The design of the facades might need to be changed, the windows might need an extra layer of insulation, or perhaps there are absorbent surfaces in the urban space, noise barriers, road paving or other things entirely that provide the best effect. There are opportunities to rethink urban design, architecture and transport in order to improve the management of urban noise. Green areas can also assist in reducing urban noise levels which was mentioned in the EEA report (2).

Recently use of Virtual Reality environments has been proposed for an immersive representation of computer-generated acoustic scenes. Integrating acoustic simulation, visualization, and auralization into the design process aims at interactive design and immediate exploration of virtual models (3,4,5)

In (6) the combination of virtual reality technology and audio rendering techniques is used for a new approach for environmental noise assessment that can help to investigate in advance the potential negative effects of noise associated with a specific project and that in turn can help designers to make educated decisions, see figure 3. The audio-visual impact of a new motorway project on people has been assessed by means of immersive virtual reality technology. In particular, participants were exposed to 3D reconstructions of an actual landscape without the projected motorway (ante operam condition), and of the same landscape with the projected motorway (post operam condition). Furthermore, individuals' reactions to noise were assessed by means of objective cognitive measures (short term verbal memory and executive functions) and subjective evaluations (noise and visual annoyance). Overall, the results showed that the introduction of a projected motorway in the environment can have immediate detrimental effects of people's well-being depending on the distance from the noise source. In particular, noise due to the new infrastructure seems to exert a negative influence on short term verbal memory and to increase both visual and noise annoyance (6).

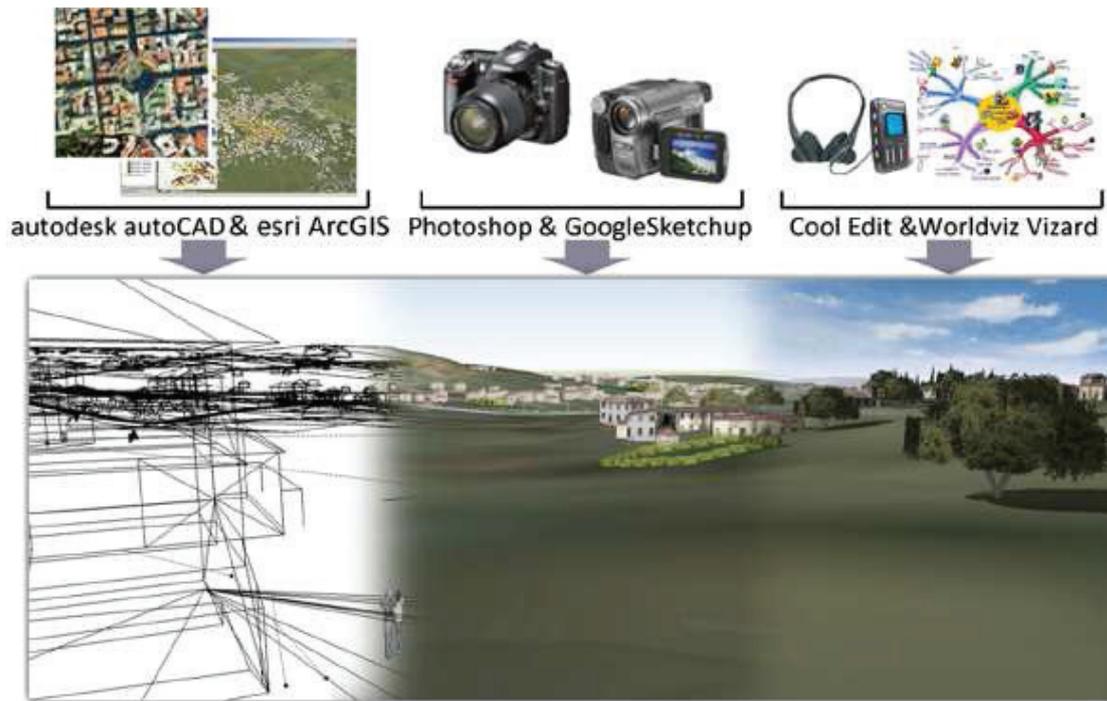


Figure 2 - The figure shows the tools, software and materials used for visual stimuli construction. The basic 3D model of the area was created by means of Google SketchUp 3D modeling software (bottom-left of the figure) by using GIS data and satellite images of the area (top-left of the figure). Afterwards, video and photo data acquired in the actual rural area (top-center of the figure) were matched to the basic 3D model (bottom-center of the figure) and other dynamic (cars, animals, people, etc.) and static elements (plants, sky, shadows, etc.) were added to make the virtual environment as realistic as possible (top- and bottom-right of the figure).

The Urban Tranquillity project will follow some of the findings in the project (3-6) and develop a VR based method for immersive representation of noise and well-being in urban environments.

#### 4. CONCLUSIONS

The present paper has introduced one of the tasks one the research project - Urban Tranquillity. The project will be the first step on the way towards a paradigm shift in the construction industry, based on more in-depth knowledge of the impact of the design of buildings, town squares, planting and infrastructure on the sound environment. The tasks presented in the present paper is addressing issues regarding immersive representation of noise and well-being in urban environments as an integral part of design of sound environments. Today the visualization of noise levels (in dB as an example) does not represent the actual effect of noise in urban environments. There is no connection between the noise level shown and the perception of it. In order to gain a better understanding of how noise in dense areas affects the well-being of people representation of noise needs to include how it is it is perceived. By linking engineering results, acoustic parameters, and the perception of sound better and design solutions can be achieved.

#### ACKNOWLEDGEMENTS

The authors would like to show their gratitude to the European Union for financial support via the Interreg V project “Urban Tranquillity”.

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