



## The SONORUS project- Establishing a new approach to urban sound planning

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### Abstract

Environmental noise is today one of the biggest environmental, health and wellbeing problems within European cities and millions of people are suffering from the negative consequences of urban noise exposure. In order to respond to increasing urbanization, large-scale urban planning processes are developing faster. Unfortunately, the urban sound planning is often insufficiently involved resulting in unsatisfactory urban sonic environments which may even be a health risk for citizens.

It is widely accepted that the acoustic comfort within the cities should aim for more than just preventing and controlling excess noise exposure. It should instead support the wellbeing and health of residents. Frequently, two main obstacles prevent the attainment of such scenario: the first is that acoustical aspects are typically involved in an advanced planning or implementation stage only (too late), and the second is that, at this point, the acoustic interventions are limited to noise control only (too restricted). As a consequence, any approaches to plan and achieve healthy and supportive sound scenarios are restricted from the very beginning.

SONORUS – the urban sound planner project, a European Integrated Training Network (ITN), is trying to overcome this restriction by developing a new, holistic approach. The project's aim is based in improving three dimensions: Research, Application and Education. Nine European partners, coordinated by Chalmers University of Technology, are working together in this new approach and 14 young researchers are expected thus to lead the scope of Urban Sound Planning in practice and achieve better sonic environments in cities.

**Keywords:** Urban Sound Planning, soundscaping, noise control and design, noise prediction methods, holistic urban planning.

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## 1 Introduction

Noise is the second major environmental risk for European citizens [1]. Recent studies show that 125 million people are affected by high noise levels [1, 2] mainly in urban areas. Well known effects of noise exposure include sleep disturbance, cardiovascular diseases, annoyance and cognitive impairment, particularly on children [1].

Everywhere in the world cities are growing at a speed never seen before in the history. It is estimated that by 2050, around 75% of the world's population will live in cities [3]. Mega developments are already being planned in order to face this movement. The need to improve people's mobility within



the city will increase and will inevitably affect the urban infrastructure resulting in the expansion of the transportation networks. Consequently, negative impacts such as noise and air pollution are expected to rise. In order to overcome such a big challenge, the integration of urban and transport planning will be fundamental. In such a dynamic environment the urban sound planning has an opportunity to combine synergies with the other planning activities to achieve improved sonic urban environments, by aiming the avoidance of noise generation and defining strategies to value the characteristics of a good sonic environment.

Within the SONORUS project a holistic approach to urban sound planning has been developed and was included in all the three dimensions of the project: research, application and training. As a result, several tools that support and thus facilitate the integration of acoustic aspects into the general planning were developed and some are briefly described in section 4.

A new branch of urban planning is arising from this project, the urban sound planning. Early-stage researchers (ESRs) are being educated to become future urban sound planners. This new category of urban planning specialists, besides encompassing a broad acoustic knowledge, will also be proficient in the different features of urban sound planning. It is expected that they will be able to include the stakeholders' requirements and livability aspects into an overall sustainable urban plan that also comprises the acoustic demands.

In this paper we will present an overview of SONORUS project: the concept, the structure, some outcomes (tools and research) and a short summary of the practical application of the holistic concept to the test sites.

## **2 The SONORUS holistic approach to urban sound planning**

It is widely accepted that acoustic comfort within the cities should aim for more than just preventing and controlling excess noise exposure.

The conceptual intention of SONORUS is to improve urban sound planning by defining and introducing holistic approaches at the planning stage. This approach is seen to be crucial for an efficient and sustainable planning and design of acoustic environments. Nevertheless, this is only attainable if urban sound planners are involved earlier in the planning process.

Presently, the main objective of an acoustic intervention is defined in the regulations as a noise ceiling and usually considered after the urban plan project is already decided, limiting the opportunities of different approaches than the traditional engineering noise control. This approach is usually restricted in space (to the most exposed receivers) and in time (short-term perspective), missing the opportunity to contribute to improved environments.

SONORUS holistic approach to urban sound planning lies on prevent the occurrence of noise, by not limiting the interventions to the obvious noise engineering solutions but to include a combined approach that coordinates actions of different acoustic fields to provide an integrated solution.

The holistic approach to urban sound planning, within SONORUS project, therefore means that urban sound planners should be involved in the planning process from the beginning; the acoustic interventions should be extended from pure noise control to include sound quality and sound design; and that acoustic aspects altogether should be considered as one independent planning discipline [4].

The working concept for the application of the holistic approach involves: a strong interaction with all the stakeholders; the integration of social, economic, cultural, historical, and technical factors; the definition of acoustic objectives (comply with the legislation limits, but also identify and reinforce restorative sounds and/or participate in the protection of natural or historical sounds); the application of improved communication platforms by combining visualization and auralization tools; the use of state-of-the-art acoustic research, methods and tools; and also the ability to assess the sonic environment at different urban scales, from the small urban park to the large regional transport infrastructure.



### 3 SONORUS set up

The SONORUS project is an EU FP7 Marie Curie Initial Training Network (ITN). As an ITN the main purpose of SONORUS is to provide ESRs with tools to improve their research skills, whether by the integration in established research groups (Research), advanced education programs (Education) or by having the opportunity to apply the research at real test sites (Application). These three main themes will be further explained below. The combination of the outcomes from each theme, will hopefully result in an optimal solution to achieve a long term and overall improvement of the acoustic environment.

Fourteen ESRs have the opportunity to work within universities, research institutes and companies (SONORUS full-partners) to develop their projects:

- At the Division of Applied Acoustics, Chalmers University of technology (Gothenburg, Sweden) two ESRs are developing their research project:
  - Georgios Zachos: Development and implementation of auralization and visualisation of urban sound environments and traffic noise;
  - Laura Estévez Mauriz: Optimization of urban areas with respect to traffic noise and other environmental factors;
- At the Building Acoustics Chair, Eindhoven University of Technology (Eindhoven, Netherlands): also two ESRs with the following projects:
  - Fotis Georgious: Acoustic auralization modelling of inner city environments;
  - Raúl Pagán Muñoz: Numerical modelling for creating and preserving quietness near major roads in urban areas;
- At the Department of Architecture of the Second University of Naples (Naples, Italy): two ESRs with the following projects:
  - Virginia Puyana Romero:
  - Like Jiang: Development of new methodologies for the noise assessment of urban projects via multisensory approaches
- At the School of Architecture, University of Sheffield (Sheffield- United Kingdom): two ESRs with the following projects:
  - Francesco Aletta: Define an indicator (or a set indicators) for the description of soundscape perception
  - Stathis Margaritis: Assess the effects of vegetation in noise reduction in high-density urban areas
- At the Research Group Acoustics, Ghent University (Gent, Belgium): two ESRs with the following projects:
  - Gemma Echevarría: Improvement of urban sound environment at a low scale and reduction of citizen's annoyance through architectural design
  - Karlo Filipan: Auditory attention and soundscape
- At Müller, BBM, Road traffic noise group (Munich, Germany): one ESR is researching the following topic:
  - Sonia Alves: Development of and Holistic approach to urban sound planning
- At the Italian National Institute for Environmental Protection and Research (ISPRA) (Rome, Italy): one ESR is working in the following research topic:
  - Mercury Kountouras: Application of methodology based on soundscape study as integration of the national procedure for the environmental impact evaluation of large infrastructure.
- At the Swiss Federal Laboratories for Materials Science and Technology (EMPA), (Zurich, Switzerland): one ESR is working in the following research topic:



- Frederic Rietdijk: Develop a tool for simulating aircraft noise in an urban environment
- At the SP Technical Research Institute of Sweden, Section of Acoustics (Boras, Sweden): also one ESR is working under the scope of:
- Ignacio García Merino: The study of different measurement techniques and the auralisation of non-traffic sources that may affect such quiet areas, such as heat pumps, fans and others.

While the full partners are responsible for the realization of the project's work program in both, research and education, the associate partners are mainly involved in the third dimension of the project, the application. The associated partners provide test sites with very concrete challenges that should be worked by the ESRs to the application of the urban sound planning concept.

The associate partners include the city of:

- Antwerp (Belgium);
- Brighton (United Kingdom);
- Gothenburg (Sweden);
- Rome (Italy).

Another important role of the associate partners is to provide secondments places where ESRs can have the opportunity to learn the urban planning offices structure.

### 3.1 Research

The practical implementation of SONORUS holistic approach will require different tools, instruments and methods than the ones already available. So, in line with the basic concept of ITN's, the aim of the project research work within SONORUS is twofold:

- Technical substantiate the specific training of young researchers, by own research, thus assessing this training to be concluded on a state-of-the-art level;
- Complement the methodological toolbox of concepts, approaches and methods to provide a fully operational profile of urban sound planners in both, practicable methodology and applicable qualification.

The research package has three main topics: prediction methods and auralization, noise control and design and soundscaping. Each research topic and the main challenges will be described below.

#### 3.1.1 Prediction methods and Auralization

Urban sound planning requires accurate predictive methods for situations of sound propagation which cannot be obtained by conventional software tools for sound propagation. There are a considerable number of examples where the existing models are not accurate enough [5] and new tools are needed.

#### 3.1.2 Noise control and design

Within SONORUS existing models describing the effects of urban parameters on noise propagation were further developed to better evaluate and assess the application of novel noise control measures in specific urban areas. The work developed within this work-package include: implement and provide improved models for designing and assessing related noise control; overcome existing modelling limitations; find new design solutions to deal with urban noise; apply and test noise control measures and their design in selected application studies. Research resulting from this topic was already applied to the test sites and will be described later in section 4.

### 3.1.3 Soundscaping

The integration of soundscape approach in the overall urban planning was one of the key issues of SONORUS project: assess the way people perceive their environment and plan urban spaces where the soundscape is appropriate and reinforces the attractiveness of a public place. Different soundscape approaches were applied the test sites according exemplified in section 4.

### 3.2 Education

The SONORUS educational program included an extensive training program covering different educational needs to provide the young professionals with skills to implement this new concept in practice. The training program included: the integration in established research groups, the possibility to do research visits to other institutions (knowledge transference) and secondments (e.g. at the associate partners), attend four summer schools on technical topics organized by the network, participate in additional courses to develop complementary skills, participate in four city workshops and write conference and/or journal papers on the research outcomes along the project.

The technical summer schools' topics focused mainly in the SONORUS research topics, thus the topics of the courses included: Urban Sound Propagation (Ghent University), Urban Noise Control in Urban Areas (TUE), Computational Sound Analysis (Second University of Naples) and Auralization and Visualization as Communication Tools in the context of Acoustic Planning (Chalmers University). Adding to the technical courses provided by the network the basic training program also included a complementary course on Leadership and teambuilding.

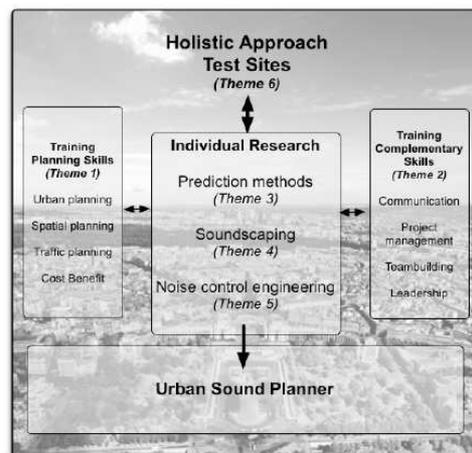


Figure 1- Elements of SONORUS

Each ESR was assigned an academic supervisor that together with the researcher designed and individual training and career development plan (TCDP). The TCDP requires that the ESR defines an adequate plan for the different levels training: research, educations and application. This document was updated regularly to assure a correct completion of the educational training required by SONORUS. The ESRs completing the educational program structure will qualify for a credit-based competence certificate as “Urban Sound Planners”.

### 3.3 Application

As mentioned before, the process of applying research and education to real test sites has a main role in the education of urban sound planners. The challenge of integrating a holistic approach was an additional challenge. Each associated partner provided one or more test site(s). Teams of 3 to 5 ESRs

worked together with the cities to find solutions from the perspective of an urban sound planner. As it was discussed in the [6] it is possible to extend the scope of acoustic intervention beyond the compliance of legislation and noise abatement measures. The results show that a holistic approach to urban sound planning can effectively contribute with innovative solutions and improve the overall quality of urban spaces. The results of the work on the test sites will be further explained in section 4.

## 4 Research outcomes for urban sound planning applied to the test sites

In this sense, SONORUS' city partners (Antwerp, Brighton & Hove, Gothenburg and Rome) are very important for the project's concept, as they provide test sites where the holistic concept is being implemented and the feasibility of this methodology was assessed with actual planning problems. A comprehensive analysis of the inclusion of a holistic urban sound planning into the general urban planning process and its practical implementation at the test sites is discussed in [reference to the group paper].

Antwerp: the area proposed by the city is generally affected by intense road traffic noise from different road infrastructures: two major highways and one local ring road. The high noise levels affect residential areas and one of the urban parks of the city. Each location demands a different approach: while the residential area requires noise engineering control measures to protect residents of the existing buildings, the planning of new residential buildings was discussed with the urban planning team and gave the opportunity to include an urban sound planning approach as the new buildings were studied in terms of spatial distribution (creation of closed or semi-closed courtyards; creation of quiet sides and the integration of green elements). The analysis of Rivierenhof Park included a dual approach: a perceptual analysis of the park users' and an analysis of the noise levels at the different areas of the park. Based on the results, a new distribution of activities was suggested for the park attending at the noise levels, topographical elements and existing infrastructures. Also, as the park is crossed by a two-lane road with intense traffic affecting the usability of the space as a restorative environment a comprehensive study including a FDTD (Finite-difference time-domain) analyses was conducted to find an optimized solution.

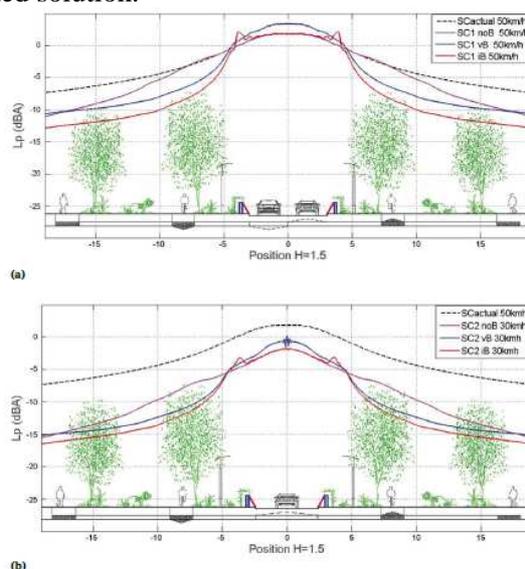


Figure 2- Noise exposure along the cross section at 1,5m height: scenario a) and scenario b) (extracted from [6])



It is concluded that a combination of noise abatement solutions (suppression of one lane and deviation of the traffic to neighbor roads, consideration of a low-noise road asphalt, include low noise vegetated barriers close to the road) can reduce the noise level up to 27 dB. Another specific problem that the SONORUS working group considered was the connection of the park with the city that at the moment is done exclusively using the bridge Turnhoutsebaan. Despite the spatial proximity, this bridge is exposed to very high noise levels, is visually unpleasant and unsafe. The approach of the group was to study solutions to restore the function of this bridge as a pleasant, safe connection to the park that would be an anticipation of the park's green area function or an extension of the experience at the park. Thus, at Ghent University a study of the multisensorial perception of the urban environment, using a 3D engine game and Oculus Rift DK2, was conducted. This experience allowed to have a virtual walk (visual and audio experience) along the existing bridge and to test different solutions [7].

Brighton: The Valley Gardens test site is a green area located in the city center that was affected by intense road traffic from several traffic lanes surrounding the area and had serious mobility barriers. Due to the many urban problems the site was far from achieving the potential as a meeting area both for residents and visitors and being a connection point for pedestrians. The ESRs group had a dual approach: an analysis of the existing road traffic noise levels and a characterization of the sound environment, using acoustic metrics but also perception maps. The data collected confirmed that the road traffic noise is the most dominant source and it is perceived as inappropriate to the Valley Gardens. Thus, several traffic scenarios studied together with the city were tested and an optimized solution was suggested. As a complete soundscape characterization of the area is available, this information might be integrated in other measures, namely, masking of road sound with gravel paths in certain locations, the location of sound barriers/embankments or other traffic calming measures. [6]

Gothenburg: Frihamnen is located in an inner harbor in front of the city center and was a former industrial area. This area is part of a long-term development that will be transformed into a dense mixed-use area and is intended to accommodate around 15.000 new residents and work places. The area is affected by intense road traffic but also a busy railway track. Additionally, the urban sound plan must consider the impact that the commutation movements to and from work and home will add in the future. Thus, at the department of Chalmers University, a dynamic traffic tool was developed to assess the impact of the transportation system and its effects on Frihamnen acoustic environment. This tool will be integrated with an auralization tool and will be available to evaluate the impact of different road networks, both from the perspective of an urban planning team and other stakeholders (as future residents). [6] [7]

Rome: The Roman Forum, Palatine and Coliseum area formed the SONORUS test site. The area, although being one of the major archeological sites in the world is inserted in the overall urban structure of present Rome city, therefore is affected by traffic road and of course by the intense human activities (the latest sound is part of the history of the site). One of the main objectives of the working group was to propose interventions that would improve the sonic environment in particular and at the same time enhance the experience of the visitors by improving the overall quality of the area. Two strategies were followed: acoustic measurement campaigns, traffic counts and field surveys (to evaluate people's perception) at eight designated points and soundwalks performed inside and outside of the area of the Roman Forum and Palatine. These two approaches promoted a participatory process with the different users of the area, inclusive tourists, to assure that the future proposed actions respect the heritage and promote cultural and economic development of the site. The analysis of users' soundscape perception in combination with sound pressure level measurements will permit, the evaluation of adequacy of sounds and sound sources at the site with users' expectations, facilitating the inclusion of sound planning within the overall planning process. [6] [7]



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## References

- [1] European Environment Agency (EEA), Noise in Europe 2014 (EAA Report No 10/2014), Publications Office of the EU, Luxembourg, 2014
- [2] WHO, Night Noise Guidelines for Europe, Copenhagen, Denmark, WHO, Regional Office for Europe, 2009.
- [3] Siemens. Como-Facts, Trends and Stories on Integrated Mobility. The future of getting around, issue 10, May 2013.
- [4] Alves, A.; Altreuther, B.; Scheuren, J. Holistic concept for urban sound planning applied to real sites. In Proc. *Forum Acusticum*, 7-12 September, Krakow, Poland, 2014, In CD-ROM.
- [5] Wei, W. et al. *An efficient model for background noise mapping*. In Proc. European Conference on Noise Control and Vibration Engineering, 17-19 September, Leuven, Belgium, 2012, In CD-ROM.
- [6] Alves, A.; Estévez-Mauriz, L; Aletta, F.; Echevarria-Sanchez, G.; Puyana Romero, V. Towards the integration of urban sound planning in urban development processes: the study of four test sites within SONORUS project, *Noise Mapping Journal*, V2 (1) 57-85, 2015.
- [7] SONORUS Students Blog, <https://sonorusfp7.wordpress.com/>, on-line 28/04/2016, 2016.