Early Stage Sound Planning in Urban Re-Development: The Antwerp Case Study

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ABSTRACT

It has often been highlighted that sound planning should start at an early stage of development of an urban area. Nevertheless, no clear methodology has been outlined on how this should be realized in practice and what should be the role of an urban sound expert. We describe how urban sound experts played a role in early stage planning of the covering of the Antwerp ring road, a 10^9 Euro project, and deduct overall methodological guidelines. The involvement of urban sound experts has three main phases: (1) inform and educate; (2) co-create; (3) evaluate. During phase (1), scientific knowledge on urban soundscape design and sound propagation is translated to knowledge that applies to the local situation, a process involving simulation of prototype solutions. This knowledge can be used by the design teams in co-creation sessions, involving local citizens deriving views on the development of the area. In phase (2), urban sound experts become co-creators that, together with other members of the design team, modify and tweak solutions to meet the demands of citizens and vision of the planners. During the final phase, the urban sound experts evaluate the outcome of the design as part of a cost-benefit analysis.

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1 INTRODUCTION

The need for integrating noise mitigation in city planning has been identified ever since the growth of motorized surface traffic[1]. Early viewpoints advocated noise control through noise level guidelines in city planning, guidelines that need to be provided by noise experts. In this way, environmental noise is handled in an analogous way as air and water pollution, recognizing nevertheless its local scope. However, in contrast to these polluters, sound also has a function that is more closely related to architecture, landscape architecture, and scenery planning. It contributes to the identity of the city and the overall quality of life of citizens. Thus, urban sound planning should surpass the concept of A-weighted noise level as a dose[2].

In early planning stages, urban sound has often been forgotten[3]. Checking noise limits is still often seen as a necessary environmental impact assessment that can be evaluated after all planning is finished. At a detailed planning stage, a participatory urban soundscape planning process model[4] has been suggested. But for earlier planning stages, a clear methodology is lacking. In this manuscript, we plie for internalization of urban sound and soundscape planning in the overall planning process.

The re-development of the Antwerp ring road area that comes alongside the completion of the ring road in the North, is taken as an opportunity to implement and test internalization of urban sound planning in the overall planning process. The re-development aims at making the green area that surrounds the ring road and was part of the medieval city fortification, a public place suitable for a variety of functions: recreation, bio-diversity, sports infrastructure, mobility hubs, and commercial use. A total budget of over 10^9 euro is foreseen for this re-development. Fig. 1 shows the main roads including the ring road and the buildings colored according to exposure levels. The absence of buildings and dwellings in particular, close to the ring road illustrates the opportunities for creating new public open spaces. The final goal is to cover most of the ring road however, in a first phase, the available budget allows only partial covering that will nevertheless be flanked by other noise mitigation measures.

2 URBAN SOUND PLANNING IN THREE PHASES

2.1 Phase 1: inform and educate

Urban planning involves many stakeholders including the public at large or their representatives, planners, architects, mobility experts, sociologists, ecologists, and several layers of government. Traditionally, one often assumes that sound – treated as an environmental impact – can be considered at the evaluation phase after a co-creation phase. Yet this results in poor remediation of problems that could be avoided. If urban sound is to take its rightful place in the design phases, all stake-holders need to have a minimal knowledge of sound perception, noise sources, and noise mitigation. At this phase, the urban sound planner has the duty to translate general expert knowledge to information of relevance for the situation at hand and to formulate it in simple guidelines. In the Antwerp case study, noise mitigation measures in several cross sections of the ring road were simulated in detail (see Fig. 2 for an example). The information obtained from these simulations was translated to a set of rules of thumb and published in a booklet that could be used by the stakeholders in the design process (see Fig. 3 for an example).

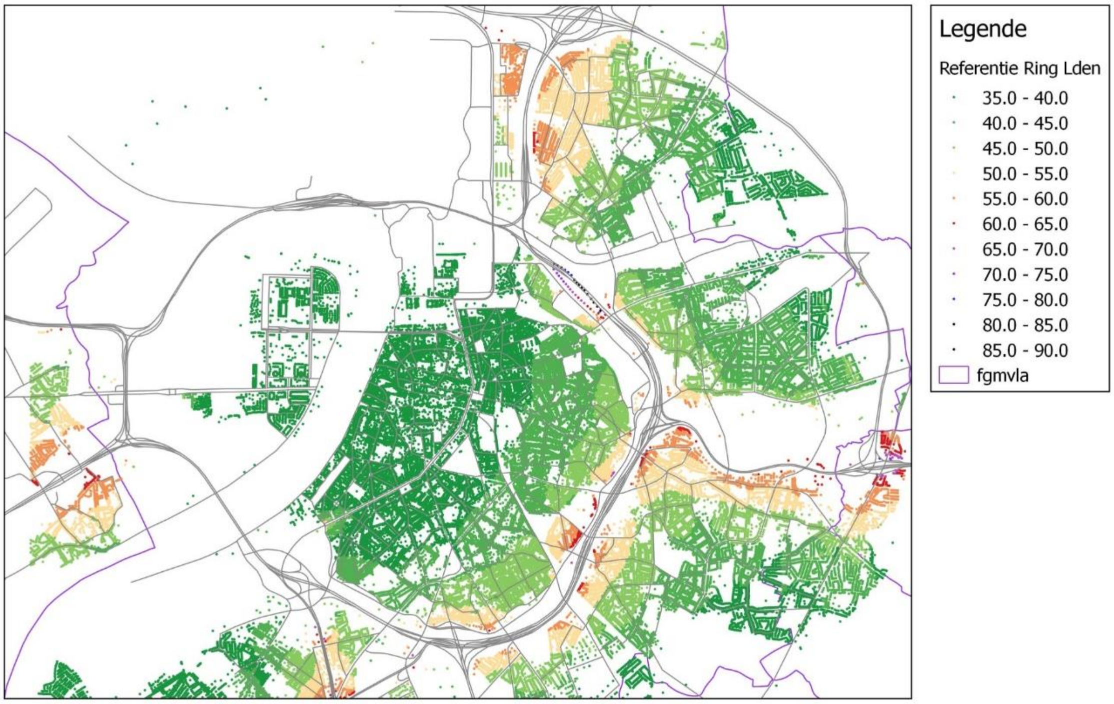

Fig. 1 – the case study area showing the main road infrastructure in Antwerp and the buildings colored according to noise exposure caused by traffic on the ring road.

During initiation sessions, stakeholders were instructed to consider sound planning in three domains:

- *Dwellings*: in the private dwelling, external noise must be limited so as not to draw attention during daily activities which also implies that low intensity local roads may have a reduced effect for the same L_{Aeq}; the importance of control of the indoor noise climate is highlighted; quiet side and window view are mentioned as possible mitigators.
- *Public space*: the soundscape of the public space should be carefully considered to match the envisaged use of this space and to reflect the identity of the neighborhood; acceptable background (L_{A50}) levels of background mechanical sound are derived from a prior study of existing city parks.
- *Agreeable soft connections*: to promote cycling and walking, paths should have an agreeable soundscape; the importance of structural and topographical details is highlighted.

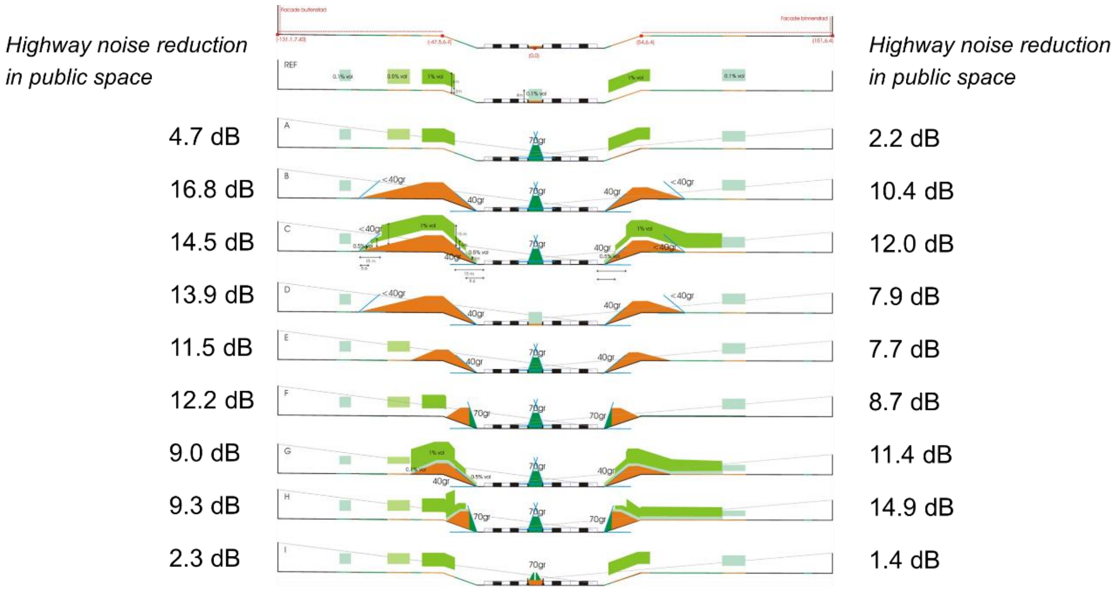

Fig. 2 – Reduction of road traffic noise (in dB(A)) by natural berms (at the road borders and at the central reservation) and vegetation (with a variety of vegetation densities) in the public space at the left and the right of the ring road (one cross section is given as an example). Sound propagation in a non-refracting atmosphere was assumed. A receiver height of 1.5 m was considered.

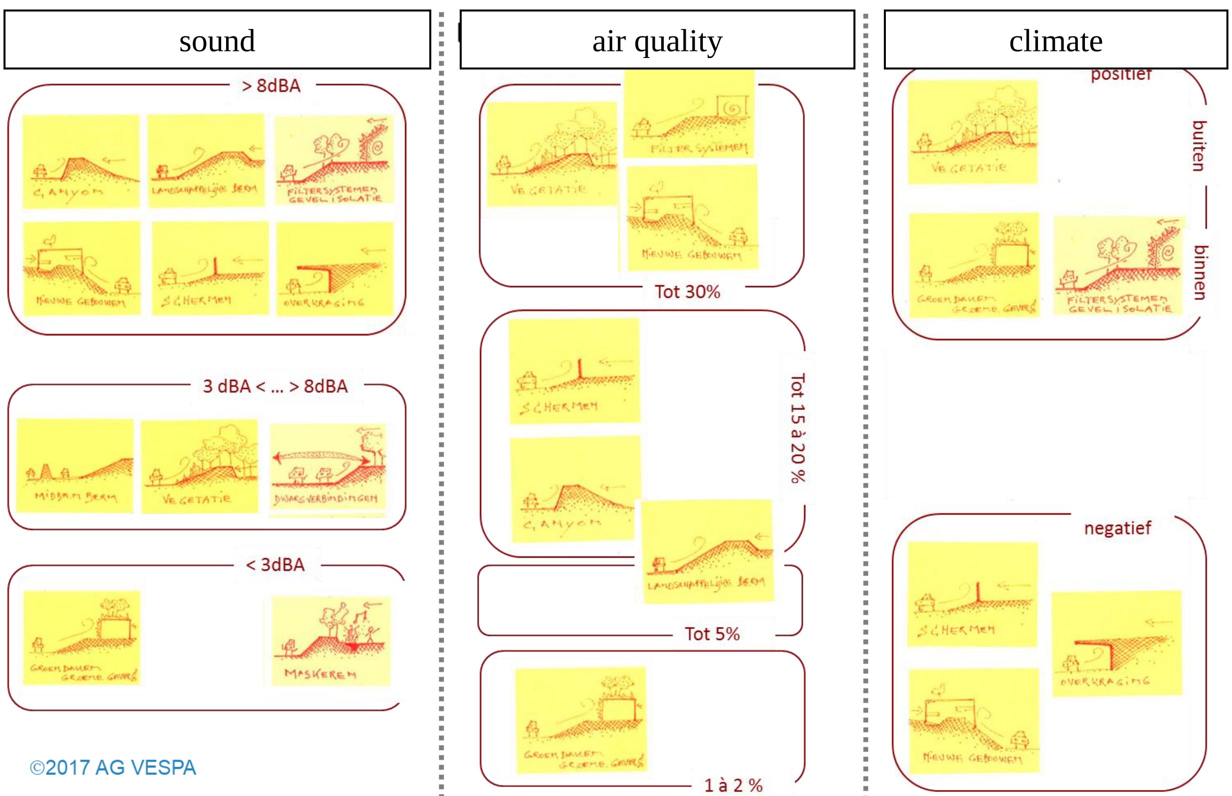

Fig. 3 – Rules of thumb for ring road impact mitigation; integrated with air quality and climate impacts (© AG Vespa).

2.2 Phase 2: co-create

Because of the size of the Antwerp project, six design teams were involved, each focusing on a sub-area of the ring road area. The co-creation process therefore has two levels of interaction: co-creation between the teams and field experts, including the urban sound experts, and co-creation between the teams and the local population (Fig. 4). The first wave of co-creation mainly transferred knowledge from the field experts and identified the main concerns of the local populations. Subsequent sessions in November, January, and February gave the field experts the opportunity to comment on and fine tune the designs proposed by the teams. The local population was continuously informed and consulted during evening sessions in all the neighborhoods.

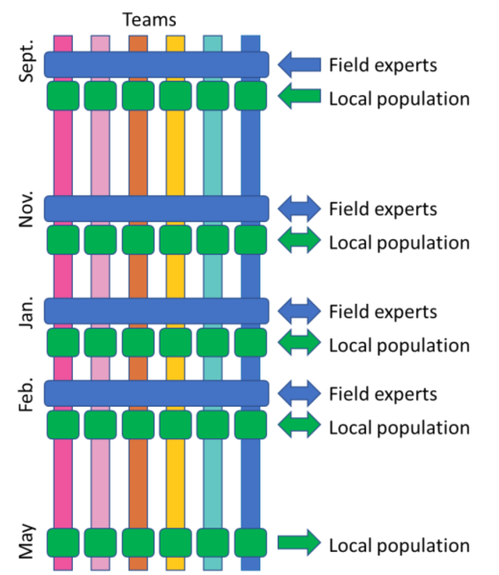

Fig. 4 – illustration of the multi-level co-creation process, colors indicating design teams

In between the co-creation sessions between the teams and the urban sound experts, SWOT (strength, weakness, opportunity, treat) analyses were performed and detailed numerical simulations were made. The latter focused on specific issues that arose during the discussion. A few examples: quantifying the effect of baffle-like partial coverage; illustrating the effect of rows of buildings as noise barriers; comparing terrain shaping to noise walls; illustrating the importance of ramps and access roads; quantifying road surface and vehicle speed impact.

The methodology used to involve citizens in their design process differed strongly between the team as did the way of summarizing and reporting information obtained. The flow of information between the population and the field experts suffered somewhat from this procedure.

2.3 Phase 3: evaluate

In a final phase, the urban sound planning is evaluated as an integral part of a broader impact assessment of the urban re-development. For this, a SWOT analysis is combined with quantitative evaluation of the scenarios. The SWOT analysis allows to highlight remaining weaknesses and risks that should be accounted for during the further planning stages leading to implementation. At this stage of the co-creation process, weaknesses should have been resolved and opportunities should have been further exploited. Risks are more difficult to completely resolve during the co-creation process because they originate in external factors.

For the quantitative assessment an indicator is chosen for each of the three domains:

- *Dwellings*: disability adjusted life years lost (DALY) are calculated for the current population and the expected population in new buildings; DALYs for annoyance, sleep disturbance, and ischemic heart disease are included with exposure effect relationships and severity weights taken from the WHO evaluation of burden of disease from environmental noise[8]. Façade exposure is used.
- *Public space*: the surface of public area (in ha) where a suitable soundscape could be created is evaluated; an L_{A50} traffic noise level above 50 dBA is assumed to prevent

creating a restorative space, a level of 55 dBA to prevent a suitable soundscape for play and game, and a level above 60 dBA to prevent a suitable soundscape for commercial and lively recreational functions (e.g. pubs, restaurants, and terraces). Estimated noise levels at 1.5m height during the day are used in this evaluation.
- *Agreeable soft connections*: the length in km of designated cycling and walking paths where the soundscape could become agreeable is assessed; L_{Aeq} due to traffic above 65 dBA is assumed inacceptable.

Using these indicators, several combinations of designs for the re-development of the Antwerp ring road area could be quantitatively compared. Due to the sensitive nature of these numbers, they are not included in this manuscript. Concerning the evaluation process itself, a few observations can be made. DALYs put the effects of re-development in a broader perspective, but this indicator also is less sensitive to changes and thus less convincing for the public at large. For example, the ring road accounts for less than half of the burden of disease by traffic sound in the Antwerp agglomeration. Therefore, even a 10^9 euro project does not alter this total amount considerably. On itself, each DALY counts but it may be hard to convince the population and government based on a relative reduction of health impact that is only a few percent.

The second indicator, surface of public space where a suitable soundscape could be created, is more sensitive and highlights the largest benefits in the case study considered here. Its calculation required a significant amount of expert judgement and could not simply rely on calculated noise maps and this for several reasons: noise calculation models (CNOSSOS was used in this case) are not accurate enough to account for the effect of terrain variations and green that are key design elements in the public space[5]; designs are not detailed enough and imprecise (e.g., shape and position of noise barriers; the proximity and influence of other noise sources cannot be duly accounted for, etc.).

3 PLANNING STAGES: THE NEED FOR DIGITAL TWINS

Large scale projects like the covering of the Antwerp ring road involve different iterations. At each iteration, goals and plans are refined. Urban sound planning must cope with this iterative process. In the case study – which is a global first planning stage – , the strategy was adopted to assure at each planning stage to create maximal opportunities for the next urban sound planning stages or at least not to jeopardize such opportunities. For the three domains this implies (numbered by planning stage):

- *Dwellings*
    1. Create opportunities to develop new living areas without the need for internal noise mitigation such as building as noise barrier and greening.
    2. Assure that individual dwellings can be constructed without the need for high performance acoustic facade insulation.
- *Public space*
    1. Prevent noise disturbance from traffic, industrial, and mechanical sounds that would jeopardize creating a soundscape that matches the envisaged function of the area (restorative, play and game, commercial and lively recreational).
    2. Foresee land use and topography that avoids soundscape conflicts within the public space.
    3. Finetune the soundscape by bringing in matching and interesting sound accents.
- *Agreeable soft connections*
    1. Avoid joint routes for soft and motorized mobility.

2. Shield from high unwanted exposure at critical places such as crossings.
3. Design soundscape elements that evoke the mental image of the destination of the path where possible.

Multi-stage and iterative urban sound design currently suffers from an important lack of data-uniformization in the entire process of urban planning and design. Working with 6 teams of urban planners and designers in the Antwerp project revealed that there is a lack of common protocols to exchange data and information between experts and that any de-facto standards are oriented towards visual functions. Traffic information is not systematically connected to actual road locations; buildings are not identified as objects with their own characteristics; height information and topography are only available in cross sections; etc. This implies that at every iteration a significant effort needs to be spent in data transformation and re-interpretation of written and visual material.

Imprecise information transfer between field experts may also lead to imprecise conclusions in cost-benefit analysis. Sound is particularly sensitive to slight changes in geometry and material choice, for example in bridge design, tunnel linings, berm shape, or planting. Assumptions made by the urban sound planner may be omitted in a final implementation phase or may be omitted in the cost-estimate.

In building industry, building information models (BIM)[6] have been introduced for data centralization and uniformization. Inspired by NASA, mechanical engineering has introduced the digital twin concept[7] to master the complexity of systems from the design to the operational phase. Urban sound planning could strongly benefit from being internalized in a data driven urban planning and design framework like BIM or digital twinning. Such systems have the advantage that they could include audiovisual material and time sensitive information that is paramount in introducing urban sound planning.

4 CONCLUSIONS

Internalization of urban sound in an early re-development planning process, although often advocated, is not straight forward in practice. Based on our experience with the Antwerp ring road project, the following guidelines can be formulated:

1. Including an initial phase in the process where stakeholders are *informed and educated* about the latest state of the art in urban sound planning seems extremely useful.
2. Considering the *dwelling and the public space* – and soft connections in some cases – as different domains is advantageous because of the completely different approaches that are needed in design and assessment.
3. In large multi-stage development, each planning stage should be assessed and optimized such as to allow maximal freedom in the next stages and to avoid jeopardizing *opportunities* to create agreeable living environments at that stage.

One of the main flaws in current practice in urban planning and design: data integrity and aggregation, also reflects on urban sound planning. The lack of aggregated data is much more problematic for a multidisciplinary activity like urban sound planning. In an initial phase of a project, the ideas that are generated are vague and imprecise and not always consistent with technical or legal boundary conditions. The lack of integration of for example mobility systems and their use, or even simply the lack of 3-dimensional information, makes the job of the urban sound planner difficult. The lack of standardization and uniformization of data transfer protocols leads to imprecision and misinterpretation, and above all causes an exponential growth in manual labor in an iterative design process. This calls for new methodologies that could even include recorded sound which could be inspired by BIM or digital twin concepts used in other disciplines.

5 ACKNOWLEDGEMENTS

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