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SONORUS Urban sound planning project and test sites: an example within the planning stage

Laura ESTÉVEZ-MAURIZ[1]; Sonia ALVES[2]; Jens FORSSÉN[1]; Wolfgang KROPP[1]; Joachim SCHEUREN[2]

[1] Division of Applied Acoustics. Department of Civil and Environmental Engineering. Chalmers University of Technology, Gothenburg, Sweden

[2] Müller BBM, GmbH, Planegg – Munich, Germany

ABSTRACT

SONORUS Urban sound planning project looks towards a proactive planning for improved sonic environments, coupled with the variables influencing the quality of life in cities. The project embraces a holistic urban planning approach, involving acoustics at the planning stage as another variable capable to enrich the built environment. To connect the research carried out with practical implementations, SONORUS incorporates four real case studies with different characteristics and a common demand on the improvement of the sound environment at different stages. This paper focuses mainly on Frihamnen test site (Gothenburg, Sweden), considered a strategic city project with the intention to transform the space into a dense mixed-use area. The paper goes through a general introduction framing the holistic approach in urban sound planning at four test sites. The discussion is centred in the research within Frihamnen and the workshop carried out with SONORUS members and city representatives, with the intention to analyse the acoustic situation and understand the impact of future developments on the sound environment. Finally, the work discusses about the consequences and possibilities that the holistic approach might have in urban sound planning and the entire urban planning process as a driving force to improve the liveability of spaces.

Keywords: Urban sound planning, road traffic noise, test sites
I-INCE Classification of Subjects Number(s): 52.3, 52.9, 76.1.1

1. INTRODUCTION

In general, new urban planning developments are extremely committed with the need of densification, speed, compactness (1,2) and additionally, with the notion of diversity, performance and resilience (3). Within this view, inadequate urban planning may lead to deteriorate the environmental quality and resilience capacity. For 75 % of Europeans living around cities that demand a high quality of live, environmental conditions have become one of the main keys to guarantee the liveability of spaces. Among these, the acoustic environment and noise exposure are generally neglected aspects in the urbanization process. The reasoning behind may attend to the difficulties to fulfil the guideline values and the limitations on available tools (4). Moreover, it can also result from the inability and lack of interest to integrate urban sound planning at the planning stage. This integration may bring opportunities to improve the entire built environment.

1.1 Urban sound planning

To integrate urban sound planning in this process, a holistic interpretation of it should be incorporated. We must extend the acoustic interventions to exploit all the potential benefits to obtain a good sound environment, even when noise has not raise as a matter of concern. Therefore, the use of available tools and the development of new ones will ensure a proactive urban sound planning approach.

[1] laura.estevez@chalmers.se

Although several research projects have been done in the field of urban sound planning (an overview can be found at 5), its integration throughout the urban planning development has not been extensively covered and exploited. In particular, the approaches are generally disregarding its connection to city authorities, which are involved in environmental and planning aspects. SONORUS project aimed to fulfil this gap investigating the potential the involvement of cities as partners may have, in this case Antwerp, Brighton & Hove, Gothenburg and Rome. Within these cities, four test sites are provided, were each of them has very different characteristics and demands. Furthermore, these test sites have been boosting the research done inside the SONORUS project, e.g. the development of tools that could help urban planners in the decision-making process.

1.2 Test sites

The main tasks among the four test sites are the revitalization, preservation and/or creation of a good acoustic environment. To cope with these demands, several methodologies and combinations of them were followed: soundscaping as the main theme used in Rome and Brighton & Hove test site, noise control and design in Antwerp and finally, noise prediction methods to control the acoustic environment in Gothenburg, being this last one the study case in the present paper. Further information about the test sites and the applied methodologies can be found at (5).

2. FRIHAMNEN AREA: URBAN SOUND PLANNING IN THE PLANNING STAGE

2.1 Why Frihamnen? Opportunities and challenges

Gothenburg city is located at the mouth of both sides of the river Göta. It is the second-largest city in Sweden with a population of about 550,000 inhabitants in the urban area.

Frihamnen (Free port) was built in the 1920s as an inner harbour located in front of the city centre. This area is loosing gradually its industry and hence, is being rediscover by citizens as an opportunity in many ways: public space, closeness to water and the city centre, etc. Meanwhile this place, with approximately the same size as the city centre (area: 1 km^2) is characterized by its emptiness, framing the singular structures that recall its harbour past. Here, “everything can happen”. This unique opportunity is presented in the way of a long-term project to be finished by 2040, transforming it into a dense-mixed area with around 15,000 people and the same number of working places.

The project is part of the Riverbank city vision (Älvstaden) (6). This vision seeks to integrate six urban developments at both sides of the river. The aim is to build a more *cohesive, inclusive, green and dynamic city*. In this regard, a series of workshops that establish a dialogue with citizens and experts have been promoted as the best way to ensure successful long-term projects. Due to its location, opportunities and extent, Frihamnen is probably the most important project in the Riverbank city vision.

Figure 1 – Gothenburg future Riverbank city vision and the Frihamnen project. Image adapted from: alvstaden.goteborg.se

Frihamnen is an opportunity to improve and to test new ideas in the urban planning process, making it attractive from the acoustic point of view. The entire plan is divided in stages. By 2021 the city is planning to have built 1,000 residences and the same number of workplaces, as well as a large area of the Jubilee Park. However, Frihamnen is a challenge from the environmental point of view, where rising water levels are seen as the priority. On the other hand, the list also contains current problems of contaminated soil and water, air and noise pollution coupled with the infrastructure problems.

2.2 Frihamnen in the urban sound planning project

Frihamnen SONORUS working group got the task to analyse the acoustic situation and understand the impact of future developments on the acoustic environment. Careful design within a holistic approach is the way out to a successful development. To reflect the problematic current transport noise situation (road, railway and tram), an accurate noise map was calculated through the software Soundplan (v 7.3). The whole area is submitted to day-evening-night equivalent level (L_{den}) above 65dB. This equivalent noise level is calculated according to the Environmental Noise Directive (7). In order to build, the Swedish legislation considers the $L_{AEq,24h}$ limit to be 55 dB. However, this limit level is neglected in the case the noise levels at the quiet side are below 55 dB, at least in half of the living rooms and bedrooms (8). The main noise source in Frihamnen area is the road traffic. Nevertheless, a high contribution is also coming from the trains traveling northwest-northeast from Frihamnen.

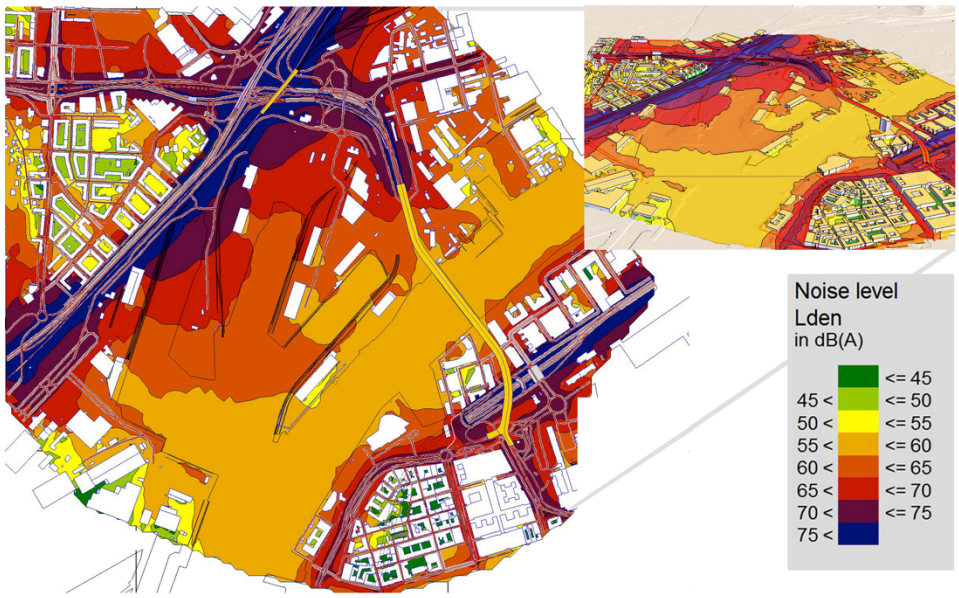

Figure 2 –Frihamnen area noise map (L_{den})

In this sense, the noise map is already raising concerns about the difficulties in the area for remedying future situations due to high noise exposure levels. If this fact is not addressed on the planning stage, it is very likely that the outcomes will force to patch both the urban design and dwellings, increasing not only the difficulty but the expenses and moreover, generating annoyance among citizens. Additionally, the area will be largely influence by the surrounding urban developments planned on both sides of the river in the Riverbank city vision (Älvstaden). These projects will affect the spatial, social and economical structures and the environment.

2.3 Added complexity: the stakeholders

Frihamnen project complexity increases even further due to the variety of stakeholders. To name a few, the company “Alvstranden Utveckling AB” and the council of Gothenburg with several offices involved as the traffic office (traffikkontoret), the planning office (stadbyggenskontoret), the environmental office (miljökontoret) and the real state office (fastighetkontoret). Aditionally, the

Swedish road and rail authority (trafikverket) is responsible for both the motorway and the train lines inside the city, as the ones located northern Frihamnen. This is driving the planning process to run in parallel, with one of them developed by the traffic office and subsequently by the planning office working group, and another one dependent on the national transportation authority, which affects the entire area, particularly its relationship with “Ramberg”, the park located northwest of Frihamnen.

3. SONORUS in Frihamnen

3.1 Test site work

The transport management and traffic design are decisive if one wants to start talking about qualities in the sound environment. The appropriateness of the sound environment to the desired plan activities and functions in the area is one of the main ideas to explore. Since the main source of noise, as well as the leading cause of annoyance and sleep disturbance related to quality of life and health is the road traffic noise (9), SONORUS find this as an opportunity to investigate the possibilities to improve the transport management and the traffic design. For this purpose the traffic scenario proposed by the city traffic office is used as a base model. This model has suffered modifications in the latest project reviews. As the transportation system has consequences in other urban systems through a cascade effect, the traffic situation will have a great influence on the quality of this area.

In general, noise mapping software work with static traffic, which may lead to underestimations (10,11). A dynamic assessment tool, representing the kinematics of the vehicle, is developed within the SONORUS project (12). The purpose is to study those plausible strategies that could improve the acoustic environment of the area. These strategies seek to address the appropriateness of the sound environment to the place (closeness to water, the location of residential areas, the influence of major infrastructures, etc.)

3.1.1 Frihamnen dynamic assessment tool: traffic strategies and noise emission

The dynamic assessment tool consists of a series of microscopic traffic simulations that allow the inclusion of vehicles kinematics, with a strong influence on the single-vehicle noise emission (10,11). The simulation gives as output single-vehicle data in terms of position, speed and acceleration. For the calculation of noise emission, a series of in-house Matlab scripts were developed implementing the CNOSSOS road emission model (13). The study focuses on the study of 9 traffic alternatives (Fig.3). Five of them are related to speed reductions or acceleration effects based on the first scenario, and the other four are attending to layout transformations.

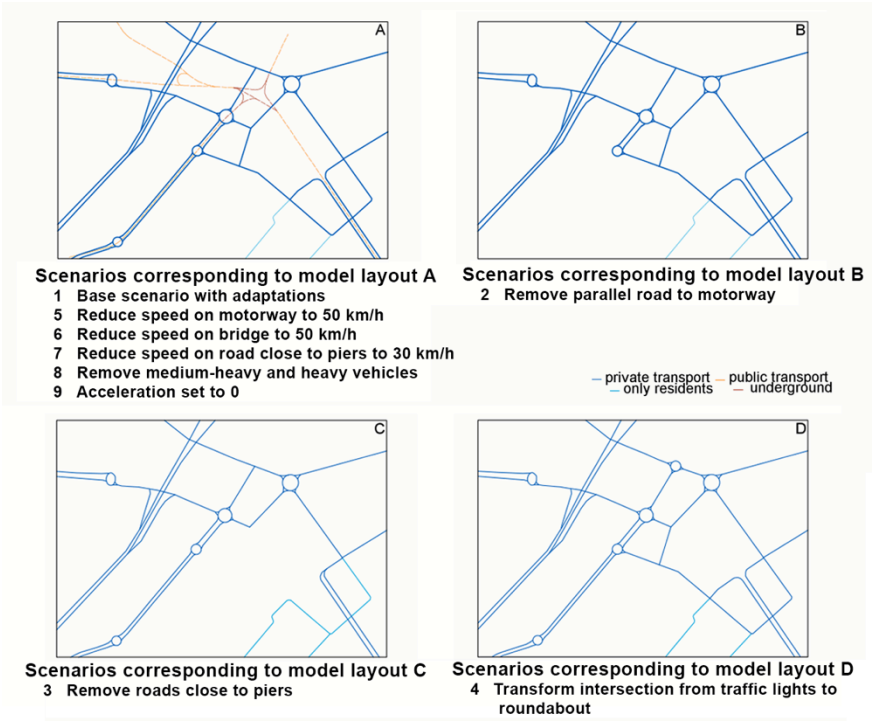

Figure 3 –Frihamnen studied scenarios

The sound power level for all individual vehicles in the peak hour is estimated for the 9 scenarios. To study the situations, 11 representative points were chosen (see Fig. 4, scenario 1). Noise maps for the second simulated quarter hour reflect the equivalent sound pressure levels differences among the scenarios. All of these have the same number of vehicles on the network.

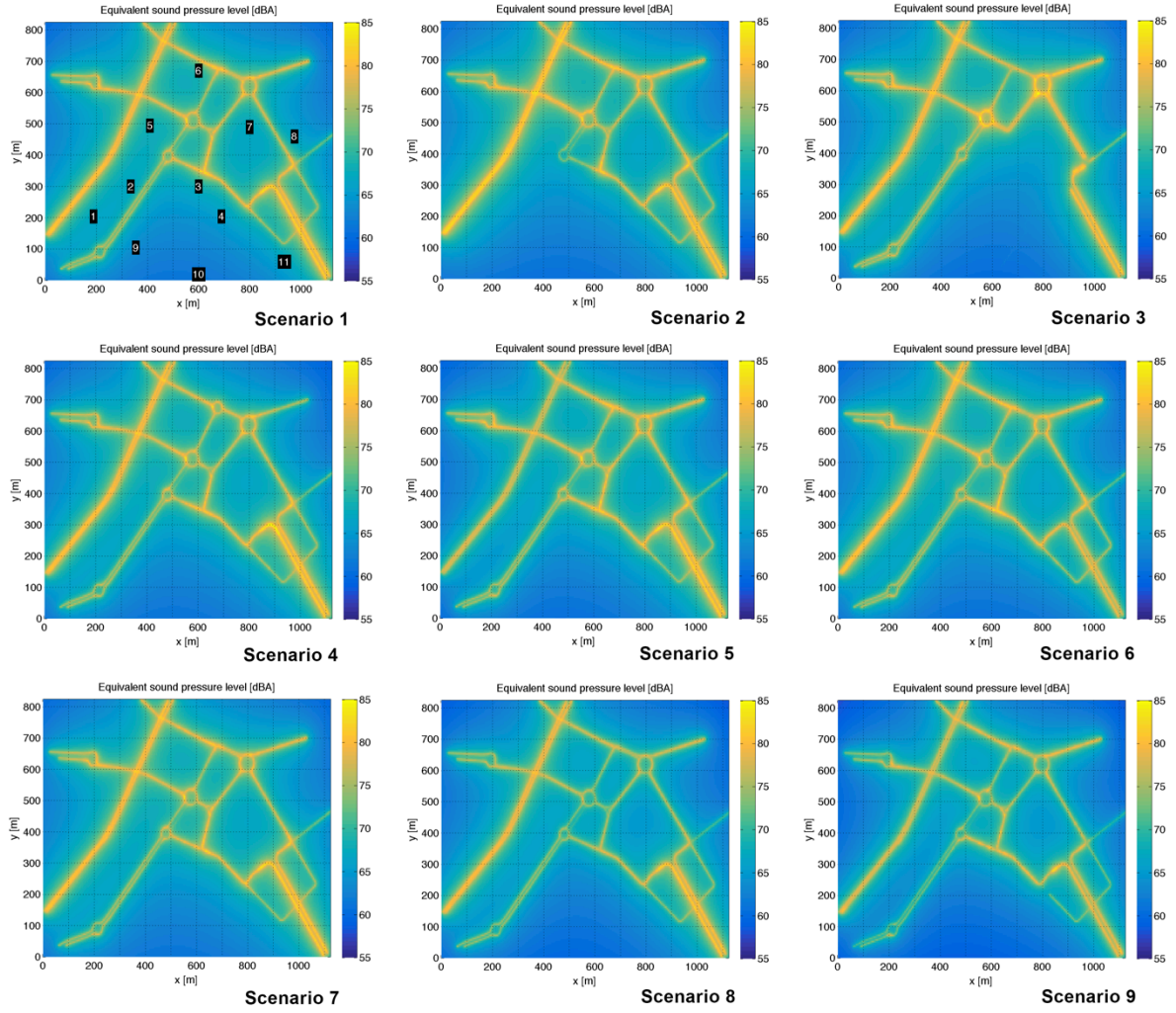

Figure 4 –$L_{Aeq,900s}$ of the nine scenarios

Apart from the noise maps, time patterns are also a useful output, making it possible to study e.g. the number of events above a certain level or the clustering of noisy periods. The time pattern of study point 4 (near the piers) and 7 (in the centre of the area) are presented (Fig. 5) for scenarios 2 (removing parallel road to motorway), 6 (reduce speed on the bridge to 50 km/h) and 8 (remove medium-heavy and heavy vehicles).

At point 4, higher fluctuations while similar sound pressure levels are present for the three scenarios. Removing heavier vehicles decreased slightly the equivalent sound pressure level (1 dBA). However, 85% of the time the levels are below 65 dBA, while only 41% in scenario 2. Due to its location, study point 7 has almost the same behaviour on scenario 2 and 6. Again, the elimination of medium-heavy and heavy vehicles (scenario 8) decreases noise levels in around 1.5 dBA. More interesting is that the time where noise levels are above 65 dBA is reduced from 97% to 75%. Here, the noise level and the number of noise events are related to annoyance at least as well as the energy-integrated noise measures or even better that this last ones (14).

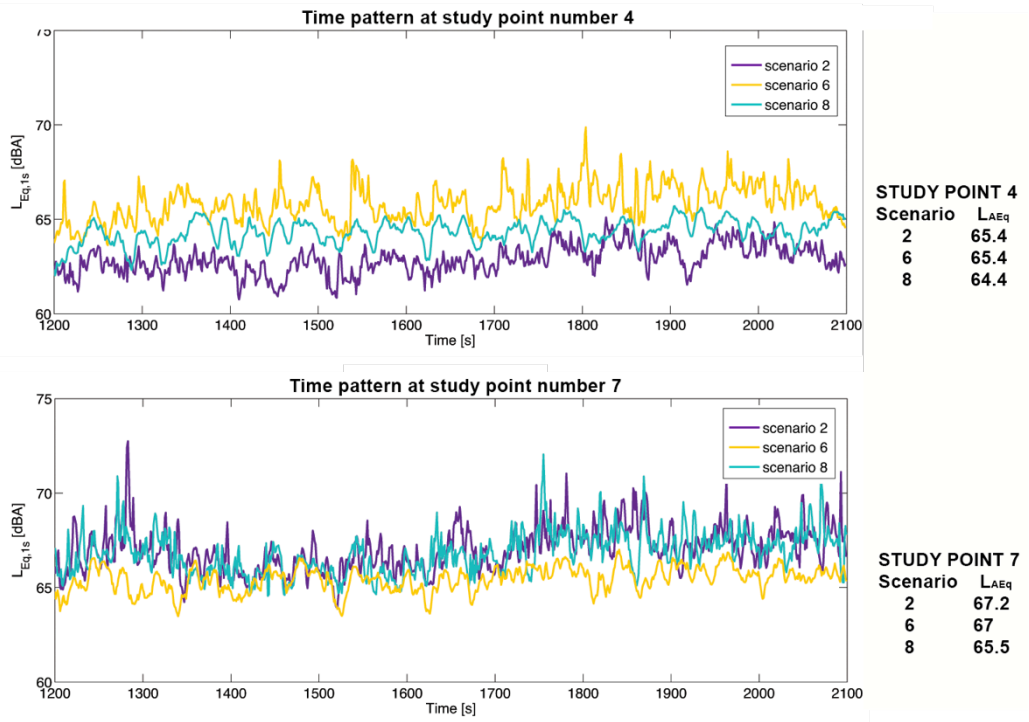

Figure 5 –Time pattern $L_{Aeq,1s}$ for study points 4 and 7 in scenarios 2, 6 and 8

4. SONORUS Urban sound planning workshop on Gothenburg test site

The research done in SONORUS was presented to the Frihamnen working group from the city planning office. As a continuation, the SONORUS team organized a workshop on Frihamnen test site. Test site workshops were also done in the other three test sites.

The aim is to embrace the integrated approach to urban sound planning. In practice, it is an opportunity to exchange opinions and ideas among those directly involved in the project (e.g. city planners, working groups, etc.) with SONORUS members from all Europe (supervisors, researchers and other city representatives). The intention is to acquire knowledge about the project as an attempt to provide solutions that may improve the urban sound environment within an integrated approach.

Figure 6 –SONORUS workshop on Frihamen test site

The workshop began with a series of presentations about the city and more specifically on the Frihamnen area and its past. Presentations moved forward to the future plans, the expectations, the possibilities and its boundary conditions e.g. limitations in construction due to closeness to the railway. Finally, the current acoustic environment and plausible future situations were presented.

Afterwards, participants formed five teams to work on the situation and the possible alternatives mainly through sketches and discussions, aided by maps and models.

4.1 Test site workshop outcomes: a summary

The outcomes of the workshop are condensed into 3 main topics: controlling the acoustic environment, the acoustic quality and the soundscape design, and finally, the economic aspects. These topics are concatenated and interpretations must be made with this integrative approach.

4.1.1 Controlling the acoustic environment

Time scale of the project: the construction period will last about 20-25 years. This will have a direct impact on residents and visitors in the surrounding areas, as well as the future ones. In this regard, different kinds of noise maps able to reflect the construction process and its acoustic impact are needed.

Introduction of noise reduction treatments: noise abatement in the propagation path through the implementation of greener solutions is highly recommended. Many of these treatments are shown as part of the HOSANNA project (15,16). In addition, ideas on innovative solutions can be taken from the four SONORUS test sites (5) and the research carried out in the project (for more information: sonorusfp7.wordpress.com).

Railway infrastructure: first, the proximity to the railway is already causing high noise levels and vibrations. To minimize this impact in the new urban development, avoiding reflections is the first purpose. This can be done through the construction of a sloped roof/building, which could also be designed as a pedestrian path. Presumably, this would facilitate the crossing to the other side of the motorway, in an attempt to erase the “urban scar” that this road is drawing in the northern part of Frihamnen. However, it is highly recommended to build some kind of acoustic screen during the 15-20 years of construction. Moreover, shifting building positions between the two rows of buildings next to the railroad could form a barrier to the Jubilee park, located in the northern pier.

Road traffic infrastructure and connectivity: strong recommendations are towards rethinking the idea of distributing traffic throughout the area. Such spread results in higher noise levels for a larger zone. Consequently, noise abatement measures in the entire area become difficult and expensive. Concentrating traffic and applying preventive solutions in surrounding limited areas will not only reduce the costs, but also attend also to the spatial configuration, bringing acoustic quality as a respond to the functions and uses (see 3.1.1). Additionally, the parallel road to the motorway located within Frihamnen area is having a major impact in terms of noise levels in the three piers. This road could allow only residents with electric vehicles and electric buses, reducing the noise levels. Thus, the area could become a street “scaled to people’s behaviour”. The introduction of an electric shuttle bus and the promotion of cycling and walking routes are important mobility decisions that will improve the sound quality of the entire area. This requires a careful study about the connectivity and accessibility, where e.g. distance to reach public transport is suggested to be less than 400 m. To avoid high noise levels at the south, the new bridge requires a careful design, incorporating a good shielding by the use of screens. Finally, the noise from the city centre should be considered in the analysis of the acoustic environment of the area.

Figure 7 –Working process and outcomes. Focus on controlling the acoustic environment

Buildings and sound absorbing solutions: the introduction of green and screening through the use of low acoustic barriers that could protect pedestrians and cyclists will greatly improve the acoustic conditions. This will keep an attractive design and avoid the feeling of insecurity. Incorporating vegetated roofs, especially in the lower buildings, as well as green or sound-absorbing façades will increase the acoustic quality throughout the area. Besides, there is a large number of sensitive areas as schools and hospitals, which in case of maintaining the current plan, may require special noise abatement treatments, including material aspects.

4.1.2 **Acoustic quality and soundscape design**

One of the main ideas emerging from the working groups is the promotion of the area among residents. It is very likely that it will be constrain by the high noise levels, especially during the construction period. Ideas on possible compensations to avoid these aspects are needed: attractive activities that make the best out of the acoustic quality.

Accessibility and sound attractiveness: access to both the city centre and the north area is important in order to achieve a cohesive city. The passage through the area should be attractive and accessible. For it, the city could use sound to connect the space as a kind of heritage, reflecting the possibilities to keep and recall its past as a former industrial area and harbour, building a landmark/soundmark throughout the piers. Taking advantage of the positive sounds that water features may bring to Frihamnen, we encourage the incorporation of the waterfront history (e.g. sounds of waves on resting boat hulls). Similar ideas can be developed as floating bridges and shipyard sculptures as a variation of the sound experience. Furthermore, exploring ground conditions and letting the citizens to walk in e.g. water of clay may bring different experiences to the citizens with the possibility to incorporate energetic and attention masking from road traffic noise.

Park area and piers: to cope with the uses and functions of this area as a park, special acoustic qualities are needed. The area will be submitted to high noise levels during the construction period, which will be around 20 years. During this period of time, park activities could be oriented according to the noise exposure of the area. Possible functions might be a recreational park with a large number of activities e.g. concerts, playground, sports, etc. Topography plays an important role in enhancing the sound quality of the park. In this sense, the construction of a railroad-oriented slope, incorporating the attractive idea to Gothenburg citizens to have a track loop to run in the park could block the noise from the northern infrastructures.

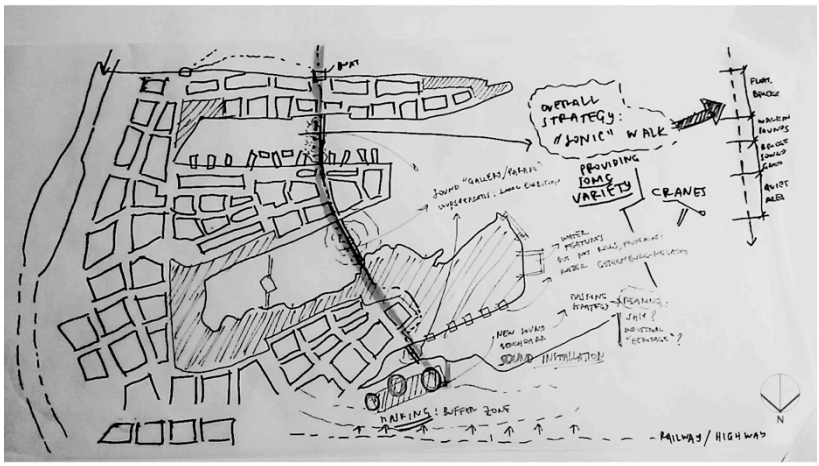

Figure 8 –Working process and outcomes. Focus on soundscape design

4.1.3 **Economic analysis**

The group encourages performing an extremely revealing investigation on the impact of the low attractiveness of the Frihamnen area due to its high levels of noise throughout the entire plan. In this sense, the traffic can be planned as a deterrent, i.e. providing a design difficult to drive through. However, this approach might drive the area and its surroundings to a higher noise exposure as a consequence of the spread of traffic and the increase in the distance travelled.

5. DISCUSSION

The present paper explores the application of an integrated urban sound planning process. A practical implementation of the holistic approach is shown through the Frihamnen test site. Gothenburg test site presents a complex scenario in which the urban planning process is constantly adapting to meet both the city and citizens requirements, while offering specific and plausible proposals. Research carried out in relation with Frihamnen SONORUS test site has been developed in parallel to the city project. In order to improve its sound quality, much remains to be done in the present test site. However, innovative solutions such as the ones presented through the conducted research, together with the very interesting proposals emerged from the workshop, open up enormous opportunities for the acoustic quality of the area. The aim is to show alternatives from a microscopic dynamic analysis to improve the acoustic environment without compromising the transport management, i.e. holding the same vehicle input and output at all alternatives. Thus, the project is narrowed down to the study of the desire acoustic properties in terms of the urban functions and activities.

Increasing awareness among citizens will create a greater demand of the environmental quality. This requires innovative solutions to cope with the agents and systems involved in urbanization processes. Although several innovative solutions to reduce the impact of noise have been looking through a retrofitting perspective (increase of sound insulation in buildings, noise barriers, etc.), the goal of the SONORUS project is to avoid such type of solutions. Our aim is to initiate the urban sound planning study and its practical implementation one step before when urban decisions are made. This will avoid expensive and complex solutions and overall, further physical modifications that could end in “patches”, transforming the planned vision of the area. To succeed in this holistic methodology, a comprehensive approach and a continuous dialog between the interested partners is needed.

The test site workshop on urban sound planning pointed at several challenges that the area is confronting with. This type of approach is proposed by SONORUS to incorporate urban sound planning in the planning agenda (17). Selected steps in this method incorporate the study of the site, understanding its scale and area of influence, the incorporation and comprehension of the several urban systems involved in city planning and the impact they might have in the sound environment. The study methodology needs to go a step further by the constant exchange of ideas with the differente actors involved in the project.

Through this type of workshops together with the tools developed in the project, we attempt to facilitate the process of understanding about the importance of incorporating acoustic quality aspects in the designing process, as a self-evident part of city planning.

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