About CityHush

The CityHush project will support city administrations with the development and implementation of noise action plans according to the directive EC 2002/49. Noise action plans made with existing technology suffer from major shortcomings: there is a poor correlation between hot spots and annoyance and complaints, most measures lead to increased emissions, and only indoor noise comfort is addressed.

In order to reduce noise in city environments, CityHush develops suitable problem identification and evaluation tools and designs noise reduction solutions for hot spots that show a high correlation with annoyance and complaints. The innovative solutions and tools under development are listed below.

Urban planning & noise score rating systems
- Q-zones;
- parks embedded in Q-Zones;
- improved indoor noise score rating models integrating low-frequency noise and the occurrence of high noise single events;
- noise score rating models for the outdoors.

Vehicles, tyres & road surfaces
- objective and psychoacoustic evaluation tool for low noise low emission vehicles;
- mathematical synthesis tool for noise from low noise low emission vehicles;
- general performance noise specifications for low noise low emission vehicles;
- novel concepts for low noise roads based upon dense elastic road surfaces;
- novel concepts for low noise roads based upon grinding of asphalt top layers;
- novel concepts for tyres for low noise vehicles, including heavy vehicles;
- criteria for use of low noise motorcycles;
- active and passive noise attenuation measures within the tyre hood.

Building design & noise barriers
- solutions for high low-frequency absorption at facades of buildings;
- solutions for high low-frequency isolation in the propagation path.

The CityHush project is co-funded by the European Commission under the 7th Framework Programme for RTD.

Duration: January 2010 - December 2012
Budget: appr. 5 m€
13 partners in 7 countries

www.cityhush.eu
Cost & Benefit Analysis (CBA) of Q-Zones

A particular focus within CityHush has been the implementation of Quiet Zones (Q-Zones) and the impacts on recreational parks embedded within the Q-Zone. A number of intervention strategies have been tested, e.g. electric vehicles, tolling etc., to obtain a reduction in noise levels within the park areas resulting in an improved acoustic environment, additional health benefits and a more useable and relaxing recreational space.

In order to understand the associated costs and benefits from a range of intervention measures where traffic could divert onto other parts of the local highway network, detailed traffic flow modelling was undertaken for a number of test sites, including Bratislava, Bristol, Essen, Stockholm & Gothenburg. Traffic data were collected from the various municipalities and transportation engineers to feed into a transportation model covering an area within the vicinity of the identified parks and potential Q-zone areas for the individual cities. A range of transportation scenarios were then run within the transportation model in order to identify the optimum size of the Q-zone, and also the way in which traffic diverts onto and from the local highway network.

The various intervention scenarios were modelled, using the noise prediction software CadnaA which can be easily adapted to provide a range of output data.

An extensive literature review of cost benefit analysis methods and noise (primarily, transportation noise) was also carried out in order to determine an appropriate methodology for identifying the costs and benefits related to specific intervention measures.

Ultimately, the HEATCO methodology (Developing Harmonised European Approaches for Transport Costing and Project Assessment, December 2006) was chosen as the preferred method for the cost benefit analysis of noise impacts. HEATCO was chosen because the methodology had proven to be appropriate for other European studies. Importantly, the methodology utilises different cost factors for the different countries across Europe, so it can be readily implemented within individual member countries in the future for actual assessments. Also, by choosing an agreed methodology which could be used in different countries, any monetary skew, which could otherwise occur between different member states can be avoided.

The methodology was initially piloted for the City of Bratislava, and this has proven its overall utility.

Additionally, the noise modelling has been used to identify the increase in the useable area of the park after the implementation of the various intervention scenarios. The decision to add a physical measurement to the monetarisation of the benefits of the proposals, which is largely related to health benefits, was taken because it provides a better understanding of the ‘useable area’

Bratislava test site
of an embedded park. This is important when examining a wide range of competing intervention strategies as it provides an indicator which administrators and planners may find easier to understand. Additionally, within the framework of the noise modelling software CadnaA, it was relatively easy to implement and demonstrate the versatility of the software for add-on tools and outcomes.

Importantly, the methodology used in this study can be presented with the costs of a variety of implementation measures, in order to fully understand both the actual costs and the often somewhat more intangible health costs related to noise. In this way the long-term costs of noise annoyance and health can be considered against the costs of implementation and the traffic related costs associated with diverted journeys.

Using the HEATCO methodology alongside the transportation costs has allowed for a detailed analysis of a range of intervention measures to be analysed. Multi-variant traffic noise modelling has proven that such analyses can be readily carried out in a cost-efficient manner (within the CadnaA noise modelling framework) in order to determine the most appropriate intervention strategy for an area.

Whilst the adopted methodology has been proven, it is however apparent that the anticipated noise gains identified at the early stages of the study cannot be realised. This is because during the daytime period, when parks are generally used, a large part of the noise environment is driven by more distant traffic sources. Even when local noisy traffic is removed in its entirety from the park area, the overall period noise levels (LAn) do not decrease significantly. It will still be the case, though, that some of the localised peak noise levels from traffic are reduced dramatically in close proximity to and within the park area, which may well result in beneficial results for health, which currently cannot be identified in the study.

The identified park area for the Bratislava test site straddles the Danube and is shown in the image on the left.

The noise cost outputs from the modelling for fifteen different intervention scenarios are shown in the table below.

The pilot study for Bratislava has proven the methodology adopted for a comparison of the CBAs associated with a range of implementation measures. In particular, it has demonstrated the relative ease by which implementation measures can be compared with each other and the optimum combinations of various intervention strategies such as electric cars, zone tolling, optimisation of the Q-zone boundaries and the optimum combinations of various intervention strategies such as electric cars, zone tolling, heavy vehicle bans etc.
Low-noise tyres for electric vehicles
At higher speeds above 50 km/h, electric cars are just as noisy as usual cars due to the fact that the overall noise is dominated by tyre and road noise. Within CityHush, a prototype tyre specifically addressing the issue of noise has been developed for compact electric vehicles.

One of the components of traffic noise is generated by the interaction between motor vehicle tyres and the road surface. The amplitude and frequency content of this noise is a function of many parameters, including the road surface texture, tyre dimensions, tyre materials, and construction and the tread pattern design.

In CityHush, engineers of the Goodyear Innovation Center Luxembourg developed a prototype tyre specifically aiming to fulfill the requirements of compact electric vehicles like Citroen C0, Peugeot iOn, Mitsubishi i-MiEV etc.

The design of the concept tyre is suited to complement the performance requirements of electric vehicles. Electric engines often provide a relatively high torque, even at very low speeds, which increases the acceleration performance of an electric vehicle in comparison to a vehicle with a similar internal combustion engine. This required the development of a modified tread design in combination with a new tread compound to ensure reduced noise generation, excellent grip on wet roads and low rolling resistance.

The prototype tyre has been tested in a semi-anechoic chamber on a smooth road replica. The noise reduction is around 4.5 dBA in comparison to a conventional treaded tire with similar dimensions. The prototype also will be evaluated on a low-noise road surface to establish the total noise reduction for the entire vehicle.

**Evaluation of the Effect of Restrictions on the Use of Studded Tyres in Quiet Zones**
Traffic noise reduction has two major benefits. First, citizens experiencing traffic noise as a disturbance and potential health risk will have a much quieter and healthier traffic environment. Secondly, areas which are currently not populated due to traffic noise pollution, may be reconsidered as residential areas, once traffic noise reduction has been achieved.

**Measurements**
Measurements have been performed on studded and non-studded tyres as well as on the reference tyre (normally used for CPX-measurements), using the single wheel trailer (see image below).

These measurements show that non-studded tyres emit up to 10 dB less noise at 30 km/h compared to studded tyres.

<table>
<thead>
<tr>
<th>Brand</th>
<th>Model</th>
<th>Dimensions</th>
<th>Type</th>
<th>Number in figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Michelin</td>
<td>ALPIN A4</td>
<td>225/60 R16 102V XL BSW</td>
<td>Non-studded</td>
<td>1</td>
</tr>
<tr>
<td>Vredestein</td>
<td>Wintrac Xtreme</td>
<td>225/60 R16 98H</td>
<td>Non-studded</td>
<td>2</td>
</tr>
<tr>
<td>Gislaved</td>
<td>Nordfrost 5</td>
<td>225/60 R16 102T XL</td>
<td>Studded</td>
<td>3</td>
</tr>
<tr>
<td>Continental</td>
<td>IceContact</td>
<td>225/60 R16 102T XL</td>
<td>Studded</td>
<td>4</td>
</tr>
<tr>
<td>Uniroyal</td>
<td>Tiger Paw AWP</td>
<td>225/60 R16 97S</td>
<td>Ref. tyre</td>
<td>5</td>
</tr>
</tbody>
</table>

In Europe, a number of countries allow the use of studded tyres on their roads: Belgium, Denmark, Estonia, Finland, France, Italy, Latvia, Lithuania, Luxembourg, Norway, Slovakia, Spain, Sweden, Switzerland, Great Britain, Czech Republic and Austria.

Studded tyres create increased noise emission (particularly at higher frequencies) due to stud impact and sliding. They also lead to excessive road wear, which forces road administrators to use rougher road surfaces with bigger max stone size. Moreover, studded tyres contribute to air pollution as they increase the number of PM10 particles that are produced by the friction between the studs and the pavement.

CityHush evaluated the effects of restrictions on the use of studded tyres in quiet zones with regard to noise pollution produced by road traffic.
Expected final results

A reduction of tyre/road noise by limiting the use of studded tyres in quiet zones can be expected during the winter season as measured with the CPX (Close Proximity) method. If the limitations are expanded to smoother road surfaces and to the exclusive use of hybrid electric vehicles, the total road/tyre noise reduction could be substantial.

However, currently the share of electric hybrid cars travelling the roads is only 1.3% of the total number of private cars (Stockholm City). Fitting all private cars with non-studded tyres without further measures implemented would result in a limited noise reduction for speeds around 30 km/h due to the driveline noise.

Development of a low noise road surface for inner city areas

It is important to reduce the tyre/road contribution to the overall sound power level generated by fully electric or hybrid vehicles. If this problem is not taken care of, the potential for noise reduction of such vehicles will not be fully exploited, since the sound generation at speeds already from as low as 40 km/h is totally dominated by tyre/road noise.

One way of reducing the tyre/road noise is to design the road surface properties in such a way that lower sound levels will be emitted from the tyre/road system. Normally the parameters of interest to alter are then:

- porosity or void content;
- surface roughness, (mainly controlled by the maximum stone size in the asphalt mix);
- elasticity or flexibility of the surface.

A problem with open-graded road surfaces is clogging and wear. Clogging is a severe problem particularly at lower vehicle speeds (typically below 35 km/h), which is representative for inner-city driving. This is because low vehicle speeds will obstruct the “self-cleaning” capacity of the surface that is normally obtained at higher speeds.

A quiet road surface that can preserve its low-noise characteristics even at lower speeds is thus needed. In the CityHush project, the “Smooth” dense road surface for inner-city applications has therefore been studied. By carefully selecting the size distribution of the stone ballast in the asphalt mix, it is expected that an smooth surface with a high wear rate can be achieved.

Earlier studies have revealed a poor correlation between measured MPD (Mean Profile Depth) and noise. Studies in CityHush showed potential for an improved correlation.

At the beginning of the project, a laser texture scanner (Figure 3) was developed by ACL. It was used to measure the road texture profile (Figure 1) and the road texture spectrum [which is a parameter that is based on wave-number (=1/wavelength)] for different road surfaces measured at the NCC Road Surface Laboratory in Sweden. On the basis of these measurements, some asphalt mix prescriptions were tested in field.
So far, the studies have revealed that it is possible to vary the road texture for a pavement by using the same maximum stone size. The studies also show that the produced NCC laboratory samples give a similar road texture profile/spectrum also when produced in field. The resulting noise emission is still not completely verified because the CPX-measurement needed to be performed prior to the start of winter. This meant that all pavements were only one week old when measurements were performed. All pavements were therefore soft, which resulted in a noise emission that was considerably lower compared to the more normal hardness of the road surface. The resulting noise emission is still not completely verified because the CPX-measurement needed to be performed prior to the start of winter. This meant that all pavements were only one week old when measurements were performed. All pavements were therefore soft, which resulted in a noise emission that was considerably lower compared to the more normal hardness of the road surface. The road surfaces will be tested again during the spring of 2012.

The measurements performed so far indicate that a road texture giving a high percentage of support for the tyre but also allowing for leakage effects between the stones, will result in a reduced tyre/road noise.

Figure 1: Concepts for evaluating road texture profiles. A road surface can be convex or concave. A concave type of road surface is a surface mainly consisting of a number of dips in the surface, while a convex one mainly has a number of protruding elements (stones). The supporting areas differ consistently between the two types of surface. The concave surface type would give rise to a convex support area curve and the convex surface type to a concave support area curve.

Figure 2: Measured road surface profile for three tested road surfaces in Gothenburg. The surface mainly has a concave behaviour of the surface profile which gives rise to a convex support area curve.

Figure 3: Automatic laser scanner developed for road texture measurements.
Low-frequency insulation of facades

Commonly used window types do not perform well when it comes to low-frequency sound insulation. Trucks and buses passing by at low speeds and at close proximity to building facades therefore generate noise inside the building with a predominant low-frequency content.

Trucks and buses are major contributors to traffic noise. At low speeds, the engine and exhaust typically produce low-frequency noise (LFN) with dominant frequencies between 31.5 Hz and 63 Hz.

In the CityHush project, a facade has been designed that has a high insulation value at low frequencies. It is a double facade consisting of an inner facade, an air gap, and an outer facade. As it is quite expensive to build a series of variations to determine the optimum configuration, it was decided to develop a prediction model based on the three chambers model (based on the acoustical superposition of the insulation between three chambers: interior-cavity-exterior). The model of course must be validated, and this can be done by means of laboratory tests on a limited number of configurations.

The following three set-ups were analysed in the laboratory. Figure 1 shows the configuration of set-up 3.

Due to the laboratory’s space limitations, the air gap between the two facades had to be limited to 305 mm.

Set-up 3 is identical to set-up 2, but non glass surfaces in the cavity between the inner and the outer glass facade are lined with mineral wool with a thickness of 50 mm.

The results of the measurements of the insulation values are given in figure 2. The results of the prediction method for these facades are also added in this figure.

From the validation of the predicted with the measured results, it can be concluded that the prediction method (based on the three chamber model) gives an accurate prediction of the insulation values of a double facade. Based on the model, the dimensions of the double facade that produces the best low-frequency isolation should be as follows:

- Inner facade: glass pane 6 mm – air gap 12 mm – glass pane 8 mm (6-12-8 mm);
- Cavity depth: 1300 mm; with the non-glass surfaces lined with mineral wool
- Outer facade: 12 mm.

Figure 3 shows the predicted insulation values of the designed double facade. As a comparison, the insulation values of a standard single facade (6-12-8) are also given.

By adding a second facade of 12 mm at a distance of 1300 mm, the insulation value at 31.5 Hz is increased with 12 dB and at 63 Hz with 15 dB.
CityHush at EURONOISE 2012
10-12 June 2012 in Prague, Czech Republic

At Euronoise 2012, a CityHush session “Acoustically Green Road Vehicles and City Areas” will be held. Topics of presentations include definitions and impacts of quiet facades and quiet urban areas, noise of electric and combustion-powered scooters, measuring and analysing road traffic noise, noise mapping on a large scale and embedded parks in quiet zones. The session targets urban transport noise experts from industry and research. For more information, visit www.cityhush.eu

Coordinator: Martin Höjer, Tyrens (Acoustic Control AB), Martin.Hojer@tyrens.se
If you wish to subscribe to this newsletter, please visit www.cityhush.eu/newsletter.html

www.cityhush.eu

CityHush is a three-year research project co-funded by the European Commission, under the 7th Framework Programme. The sole responsibility for the content of this publication lies with the authors. It does not necessarily reflect the opinion of the European Communities. The European Commission is not responsible for any use that may be made of the information contained therein.