Issue 3 - March 2012

CityHush

CityHush – Accoustically Green Road Vehicles and City Areas

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

Editorial

We are happy to present this third issue of the CityHush newsletter. Throughout 2012 this year, two seminars and two trainings will be held to give you more detailed insights into the CityHush research results. Specifically for local authorities, two training workshops will be organised to learn about concepts to reduce traffic noise in cities as developed in CityHush. These concepts include quiet zones, noise absorbing facades, low noise road surfaces and others.

The CityHush dissemination seminar series starts in June: at Euronoise 2012, 10-12 June in Prague, 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.

Go to **www.cityhush.eu** and register to our mailing list to our mailing list to be informed!

We wish you a pleasant read and look forward to seeing you at any of our seminars!

In this issue...

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.

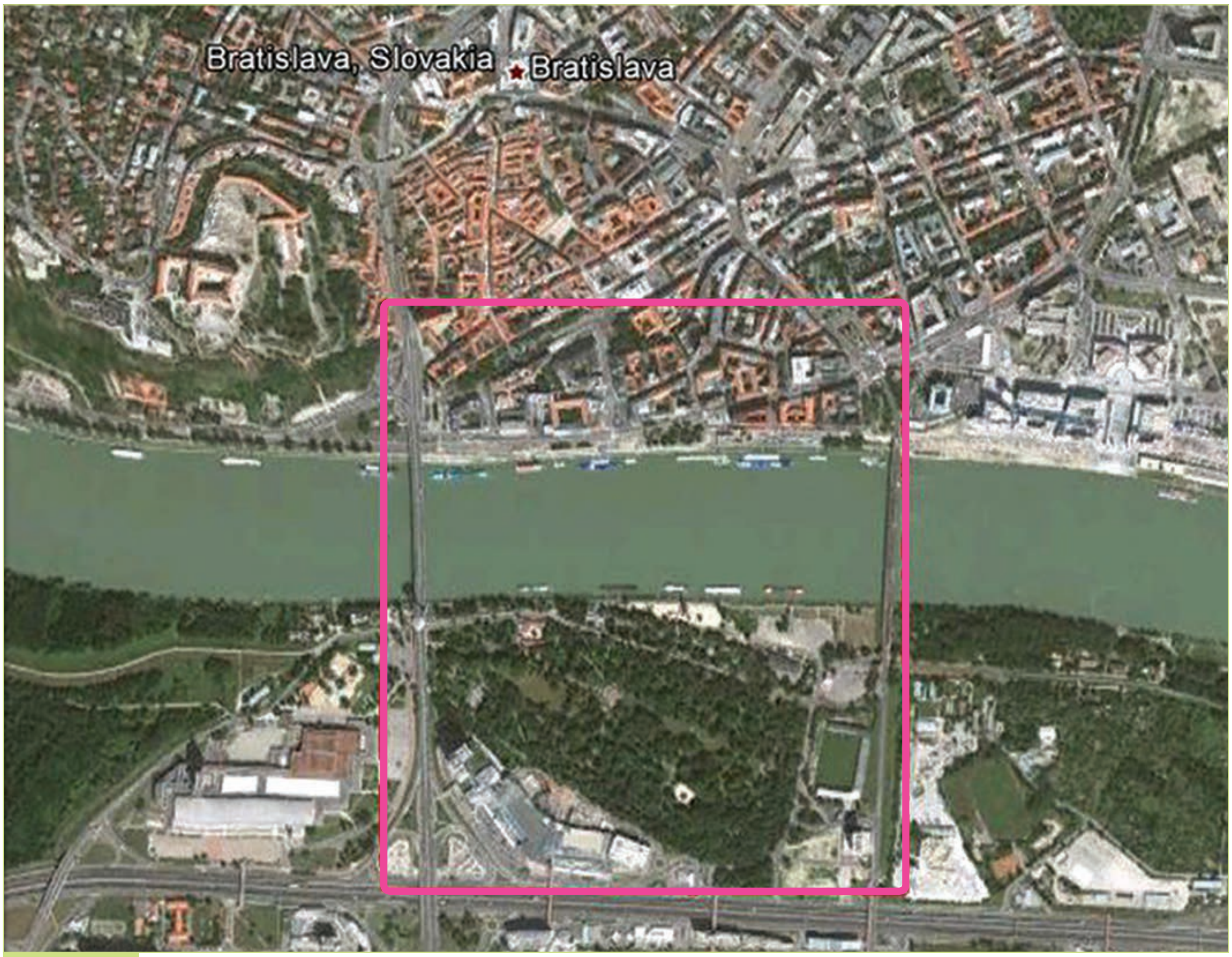
The various intervention scenarios were modelled, using the noise prediction software CadnaA which can be easily adapted to provide a range of output data.

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 (LAeq) 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 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 specific tools developed within the framework of the CadnaA noise software format. As this work is expanded to the other test sites, it will be possible to identify the parameters for the optimisation of the Q-zone boundaries and the optimum combinations of various intervention strategies such as electric cars, zone tolling, heavy vehicle bans etc.

$L_{denn'}$	Cost factors	Noise Costs - Costs per Year														
dB(A)	€	S16	S17	S18	S19	S20	S21	S22	S23	S24	S25	S26	S27	S28	S29	S30
≥ 44																
≥ 45																
≥ 46																
≥ 47																
≥ 48																
≥ 49																
≥ 50																
≥ 51	14	1924	2642	3129	3265	2669	3129	2330	2628	3373	4186	4186	2845	10336	5026	5392
≥ 52	26	6457	8714	17244	7428	6719	17192	18740	7585	20000	17871	17871	8189	8976	5879	5879
≥ 53	40	11819	26025	10903	27855	27338	10028	11938	8755	5929	7919	7919	27378	5889	7998	7998
≥ 54	53	61501	41285	38405	35631	39898	39845	37338	60861	41925	36271	35791	37445	67795	69982	70035
≥ 55	66	16682	35957	81883	85272	36422	37153	40343	17546	85140	92783	89260	93647	97435	88662	92052
≥ 56	80	184959	113411	104577	99643	193236	195385	190690	184164	143176	141107	144848	163312	115799	113968	113172
≥ 57	93	108873	310786	259656	266548	116975	126103	127220	110642	232740	232740	234137	136440	240750	246245	242333
≥ 58	106	175855	65029	163423	153860	199231	190943	190731	311226	138134	131546	131971	270742	295500	300069	294225
≥ 59	120	320594	359769	243920	245357	309093	326584	326584	166646	264286	250988	249431	155744	40973	50317	62178
≥ 60	133	149144	112456	100891	103284	123223	95973	91055	158449	92916	87333	89726	206169	265853	263461	257612
≥ 61	146	249022	250623	252954	265041	253682	259798	268390	295477	288341	282516	281205	215673	293438	281351	281351
≥ 62	159	250380	297177	343019	329330	305931	310706	318665	204538	283169	337925	337925	219978	144689	162516	158377
≥ 63	173	216418	211237	161148	161148	226090	196728	184292	230581	209855	191719	191719	211755	261325	241463	243190
≥ 64	185	245125	215458	259773	259773	212491	259773	259773	232888	222504	209710	209710	168176	112550	123304	135913
≥ 65	199	151215	135297	107044	106845	135297	106845	106845	136491	134501	148429	138481	200160	231199	229807	225230
≥ 66	213	321533	256504	263942	264154	252253	263517	263517	366586	221014	205288	215914	258416	137496	141321	135158
≥ 67	226	110562	121844	121618	121618	126357	122295	122295	60696	189535	189760	189760	119136	276405	274149	274149
≥ 68	239	221331	365064	353842	353842	344053	358618	359811	208915	305613	305374	305374	239476	74493	74493	74493
≥ 69	252	171316	38855	38855	38855	62320	35071	33809	171316	17914	19175	19175	44154	67366	67114	67114
≥ 70	265	20969	74320	74320	74320	71932	71666	71932	20969	69277	66888	66888	87592	34771	28401	32382
≥ 71	353	101559	55364	55364	55364	55011	57480	57127	105086	53248	53601	53601	33500	31032	36322	31032
≥ 72	375	43459	18358	18358	18358	20606	18358	18358	49079	14611	13113	13113	72682	7868	11614	11614
≥ 73	397	69416	6743	0	0	6743	51963	8330	59500	51963	51963	51963	20626	62673	68623	68623
≥ 74	419	19698	78791	85496	85496	78372	30594	76695	23889	31013	37300	37300	55740	33528	26822	26822
≥ 75	442	202665	196042	196484	196484	196484	196484	196484	198250	196042	189419	189419	143941	167784	168225	168225
Sum		3432474	3397751	3356248	3358771	3402427	3382230	3383292	3392761	3316220	3304927	3306689	3192917	3085923	3087131	3084550

Intervention scenario noise costs per Year

Low-noise tyres for electric vehicles

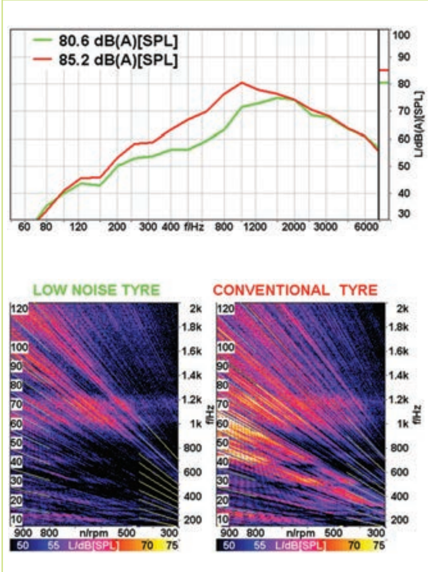
At higher speeds above 50 km/h, electric cars are just as noisy as usual cars due to the fact that the overall noise is dominated by tyre and road noise. Within CityHush, a prototype tyre specifically addressing the issue of noise has been developed for compact electric vehicles.

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 Luxemburg 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.



Color maps of airborne noise. Speed range 100-30 km/h. 1/3 octave spectra averaged over full speed range.

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

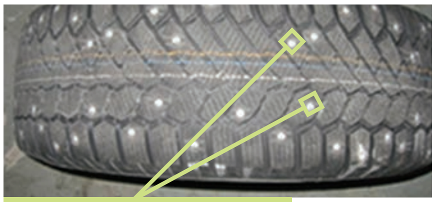
Measurements have been performed on studded and non-studded tyres as well as on the reference tyre (normally used for CPX-measurements), using the single wheel trailer (see image below).

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

In Europe, a number of countries allow the use of studded tyres on their roads: Belgium, Denmark, Estonia, Finland, France, Italy, Latvia, Lituania, 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.

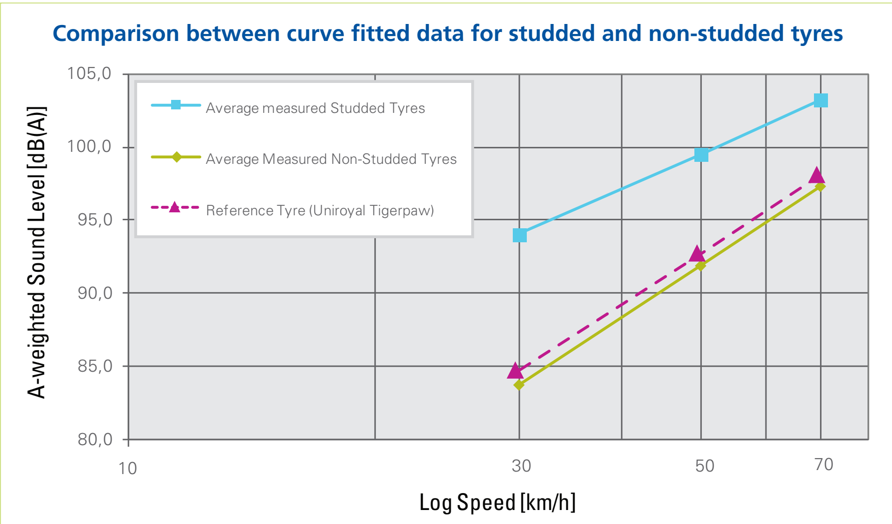

Studs for improved grip on icy roads

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


Single wheel trailer used for CPX-measurements.

Winter Tires chosen for testing. #1-2 represent non-studded tyres and #3-4 represent studded tyres.

Reference tyre.



Averaged measured tyre noise studded for studded, non-studded tyres and reference tyre.

All Images: Tyrens

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 speed 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 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.

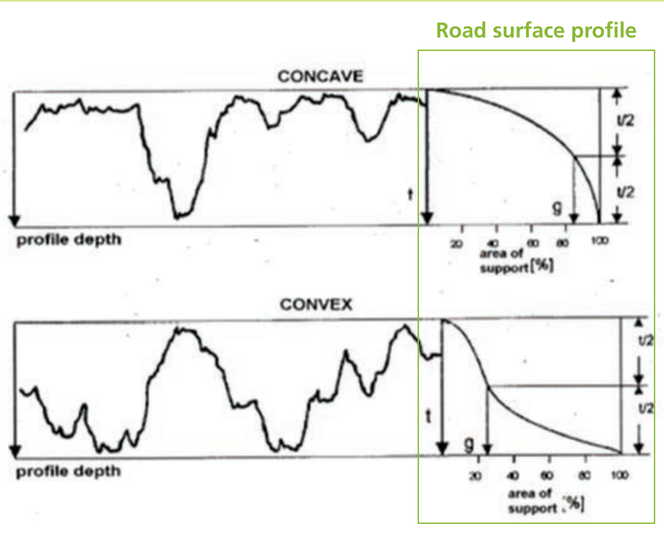


Figure 1: Concepts for evaluating road texture profiles. A road surface can be convex or concave. A concave type of road surface is a surface mainly consisting of a number of dips in the surface, while a convex one mainly has a number of protruding elements (stones). The supporting areas differ consistently 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.

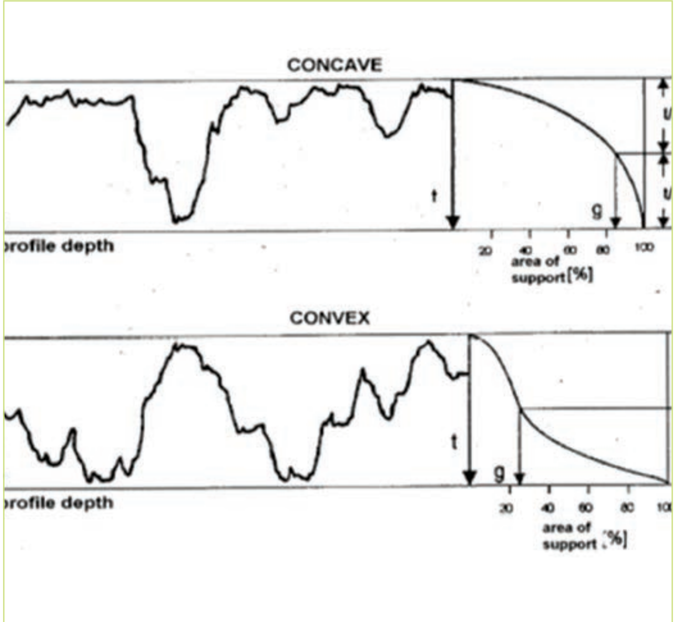


Figure 2: Measured road surface profile for three tested road surfaces in Gothenburg. The surface mainly has a concave behaviour of the surface profile which gives rise to a convex support area curve.

All Images: Tyrens

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 façades 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 en 63 Hz.

In the CityHush project, a façade has been designed that has a high insulation value at low frequencies. It is a double façade consisting of an inner façade, an air gap and an outer façade. 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 façades 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 façade 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 façades are also added in this figure.

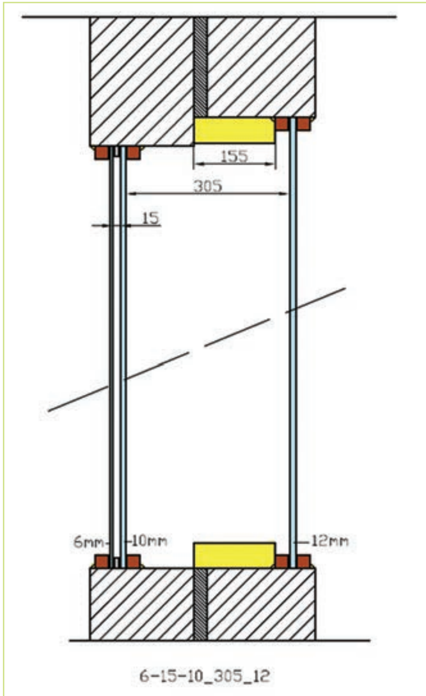
From the validation of the predicted with the measured results, it can be concluded that the prediction method (based on the three chamber model) gives an accurate prediction of the insulation values of a double façade. Based on the model, the dimensions of the double façade that produces the best low-frequency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

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

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

By adding a second façade 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.

Figure 1: Set-up 3: laboratory configuration



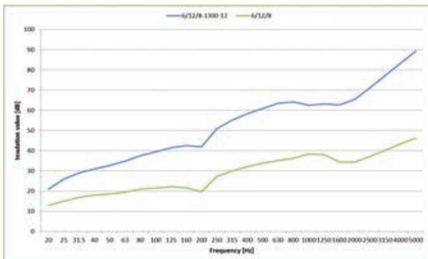
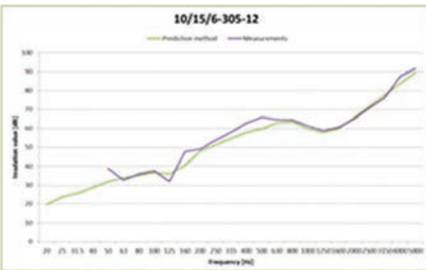


Figure 3: Predicted insulation value of designed double façade and standard single façade (frequency in Hz versus insulation value in dB)

Set-up	Inner side			Cavity [mm]	Outer side Glass pane [mm]
	Glass pane [mm]	Cavity [mm]	Glass pane [mm]		
1	10	15	6	155	12
2	10	15	6	305	12
3	10	15	6	305MW	12

Table 1: Measurement set-ups



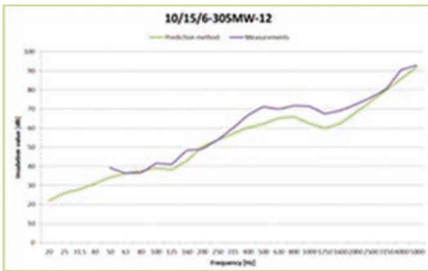


Figure 2: Set-up 1 – 2 – 3: predicted insulation values versus measurement results

All Images: APT

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**

External Events

Date	Event	Place
19-22 March 2012	38th German Conference on Acoustics (DAGA2012)	Darmstadt, Germany
10-12 June 2012	Euronoise, incl. CityHush session "Acoustically Green Road Vehicles and City Areas"	Prague, Czech Republic
18-20 June 2012	Joint Baltic-Nordic Acoustics Meeting	Odense, Denmark
08-12 July 2012	19th International Congress on Sound and Vibration (ICSV19)	Vilnius, Lithuania
19-22 August 2012	InterNoise 2012	New York, USA
17-19 September 2012	International conference on Noise and Vibration Engineering (ISMA 2012)	New York, USA

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