QSIDE

REPORT

Title	**Collection of information for QSIDE (Action 1)**
Status	**Final**
Editors	**Erik Salomons, Yvonne de Kluizenaar**
Authors/contributors	**Frits van den Berg, Dick Botteldooren, Jens Forssén, Anita Gidlöf-Gunnarsson, Menno Hillebregt, Maarten Hornikx, Yvonne de Kluizenaar, Martin Knape, Mikael Ögren, Evy Ohrström, Timothy van Renterghem, Erik Salomons, Carlo Schoonebeek.**
Deadline contributions	**28 February 2011**
Deadline final report	**30 July 2011 (originally 30 June 2011)**
Deliverable number	**1**

PROJECT

Acronym	QSIDE
Project title	The positive effects of quiet facades and quiet urban areas on traffic noise annoyance and sleep disturbance
Project start date	1 September 2010
Duration of the project	36 months

Coordinating partner	TNO Delft	TNO	NL
Other partners	Universiteit Gent	UGENT	BE
	Chalmers Teknsika Högskola AB	CUT	SE
	University of Gothenburg	UGOT	SE
	VTI, Statens väg- och transportforskningsinstitut	VTI	SE
	Gemeente Amsterdam	AMS	NL
	City of Gothenburg	GOT	SE

FUNDING

Funding	Project funded by the European Commission
Funding program	LIFE+ program Environment and Eco-innovation
Project number	LIFE09 ENV/NL/000423

Summary

Instigated by the growing body of evidence of potential harmful effects of environmental noise, the EU has set the objective of substantially reducing the number of people affected by noise exposure. An important element of European policy with respect to environmental noise is the protection of quiet areas in cities. This was formulated in the 1996 EU Green paper on future noise policy, which has led to the Environmental Noise Directive 2002/49/EC (END). The END states that major EU cities (defined as agglomerations with more than 100 000 inhabitants) have to

- produce noise maps, noise exposure distributions, and noise action plans,
- protect quiet urban areas,
- determine numbers of people with access to a quiet façade.

However, an accurate engineering method for calculating noise levels at quiet facades and in quiet areas is not available at present. Current engineering methods tend to underestimate sound levels at quiet facades, leading to an overestimation of the number of people with access to a quiet facade. Furthermore, an accepted method for estimating the expected beneficial effects of quiet facades and quiet areas on people is also not available.

An objective of the project QSIDE is to provide a more accurate method for calculating noise levels at quiet facades and in quiet areas, and a method for estimating the hypothesized beneficial effects on people. Moreover, example calculations will be performed and a document for European cities will be prepared that describes how cities can effectively reduce harmful effects of traffic noise (annoyance and sleep disturbance) by creating and protecting quiet facades and quiet areas.

Creating quiet façades and areas may reduce effects of noise by offering an ‘escape’ from the noise to the inhabitants, for example by the option to reside or sleep at a quiet side of the dwelling. Consequently, inhabitants may be less annoyed and/or sleep disturbed (on average). Quiet facades and quiet areas can be created in new urban areas, but they can also be created by modifying existing urban areas, for example by modifying traffic flows (see illustration below) or by choosing specific orientations of houses with respect to roads.

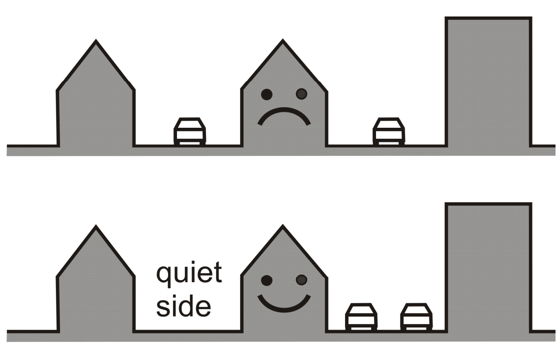


Illustration of the creation of a quiet side of a house in a city.
Top: with traffic flows on both sides of the house, inhabitants are annoyed.
Bottom: with all traffic flow on one side of the house, inhabitants have access to a quiet side and are less annoyed.

This report presents the results of QSIDE Action 1 - Collection of information. Available scientific information with respect to quiet facades and areas is described, both in the field of urban acoustics and in the field of effects of noise on people. Chapter 1 presents an introduction, with general aspects of the QSIDE project, the related European project QCity, and the role of quiet sides and quiet areas in the Environmental Noise Directive. Chapter 2 describes the structure of the report. Chapters 3 and 4 describe available information in the fields of urban acoustics and human response to noise, respectively. Chapter 5 describes information on current practical approaches to quiet facades and quiet urban areas in European cities.

Contents

1. About QSIDE, QCity, and the END

The QSIDE project has two main objectives.

1) Development of an integral method for assessing: i) noise exposure at quiet facades and in quiet areas, and ii) the benefits of quiet facades and quiet areas, with respect to urban traffic noise.
2) Preparation of practical guidelines for European cities on the implementation of these methods in urban traffic noise policy and urban planning.

The objectives are relevant for environmental noise control in Europe. The results of the project will be useful for noise control activities in the framework of the Environmental Noise Directive.

Sections 1.1 and 1.2 of this report describe elements of the Environmental Noise Directive and the EU project QCity. Section 1.3 presents a broad scope on the assessment of effects of urban traffic noise. Section 1.4 describes the structure of QSIDE with seven Actions.

Sections 2-5 of this report describe results of Action 1.

1.1. Environmental Noise Directive and quiet facades and quiet areas

The Environmental Noise Directive (END) [1] indicates that major EU cities should draw up noise maps and calculate exposure distributions of the inhabitants, based on the noise levels L_{den} and L_{night} at the most-exposed facades of dwellings.
In addition, the END pleads for protection of *quiet facades* and *quiet areas* in cities (see Figure 1-1). A quiet façade is defined in the END as a façade where the L_{den} level is 20 dB lower than the L_{den} level at the most exposed façade. The END states that major EU cities should indicate how many persons live in dwellings with a quiet façade (this has not yet been done by all cities in the 2007 noise mapping round). The END also states that quiet areas should be protected by means of noise action plans. A definition of a quiet area is not provided, although it is suggested that L_{den} or another appropriate noise indicator could be used.

Thus, the END emphasizes the importance of quiet facades and quiet areas. However, current standard methods for assessing noise exposure are not specifically suited for application to quiet facades and quiet areas, and the benefits of quiet sides and areas have not yet been thoroughly quantified. Consequently, there is a need for:

- More accurate methods for predicting traffic noise levels at quiet facades and in quiet areas in cities.
- Methods for assessing the hypothesized positive effects of quiet facades and quiet areas on the inhabitants of a city.
- Practical guidelines for policy implementation.

An objective of QSIDE is to provide such methods and guidelines.

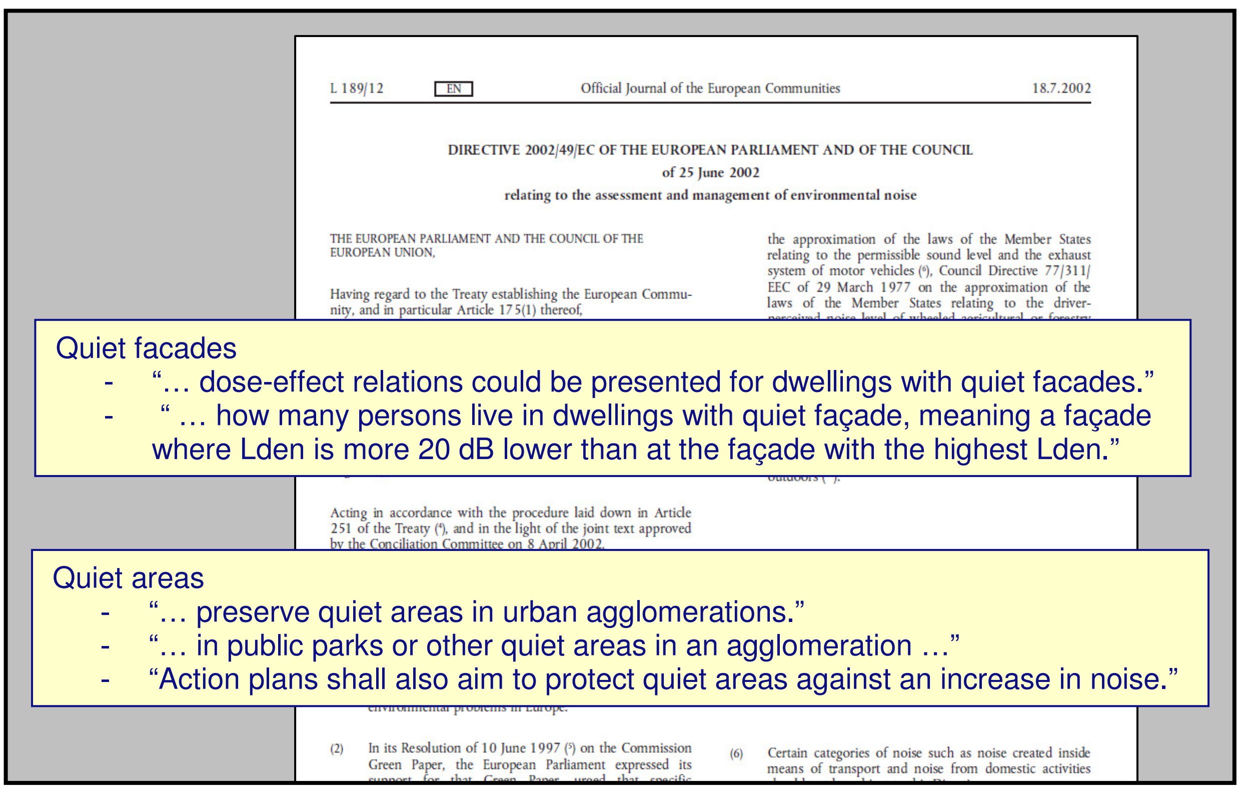


Figure 1-1. Quiet facades and quiet areas are mentioned in the END [1] at several places. The excerpts shown here are more or less directly reproduced from the END text.

1.2. Exposure-response relations and the QCity noise rating method

Adverse effects of urban traffic noise include annoyance and sleep disturbance. Numbers of annoyed and sleep-disturbed people can be estimated as follows (see Figure 1-2):

- First the traffic noise map of the city is made by acoustical modeling, and corresponding exposure distributions of the levels L_{den} and L_{night} are derived (levels at the most-exposed façade of dwellings);
- Next the expected numbers of annoyed and sleep-disturbed people are derived with exposure-response relations [2,3,4].

This approach has been elaborated in the European project QCity [5]; see also Ref. [6]. In addition, QCity has provided a possible approach for refinement of existing exposure-response functions, taking into account the effects of the following three acoustic elements of a dwelling:

- acoustic insulation
- quiet façade
- quiet area in the neighborhood.

In QSIDE we focus on two of these elements: quiet façade and quiet area.

A quiet façade offers the possibility to escape from the noise, for example by choosing a bedroom at the quiet side of a dwelling, or by relaxing in a quiet backyard. Similarly, a quiet area such as a park in the neighborhood of one's dwelling provides the possibility for a quiet walk, for example.
In QSIDE we use the QCity approach to quiet facades and quiet areas as a possible starting point. The basic idea is that the sound level at the most exposed façade is replaced by an *effective* level that includes contributions from the level at the least-exposed façade and the (ambient) level in quiet areas in the neighborhood of a dwelling. This is illustrated in Figure 1-3.

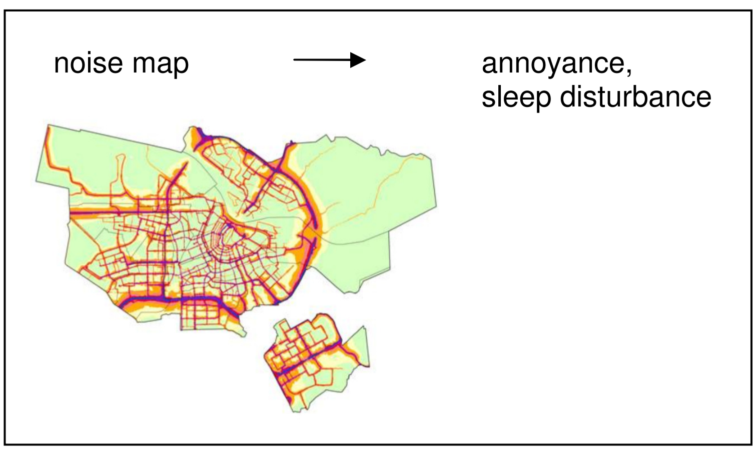


Figure 1-2. Illustration of assessment of annoyance and sleep disturbance by traffic noise.

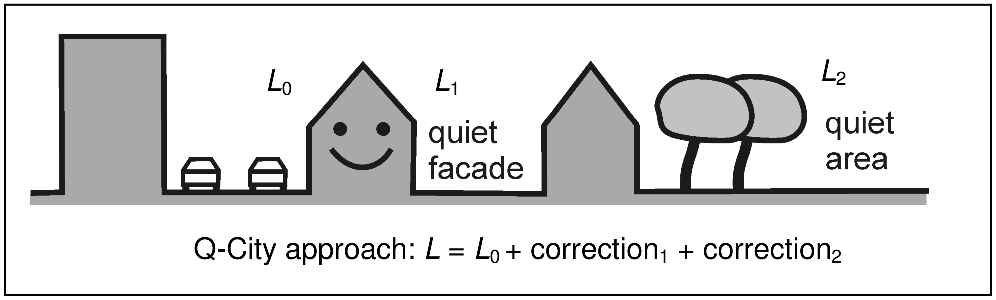


Figure 1-3. Illustration of the Q-City approach to a quiet facade and a quiet area. The *effective* level at the most-exposed façade is equal to the sum of the *real* level at the most-exposed façade (L_0) and two correction terms depending on the level L_1 at the least-exposed façade and the (ambient) level L_2 in a quiet area (Q-City's preliminary proposal was to define the level L_2 as the lowest 25 percentile of levels within a radius of 200 m from the dwelling; in QSIDE we may deviate from this). Correction term 1 is a function of the level difference L_0-L_1 and correction term 2 is a function of level L_2. The functions are specified in the Q-City project [5], and an objective of QSIDE is to determine the numerical parameters in the functions.

1.3. Assessment of effects of traffic noise

Traffic noise has harmful effects on people (annoyance, sleep disturbance), but one may also focus on the positive effects that a pleasant urban soundscape with limited traffic noise may have on the people. In this section we consider both types of effects.

Traditionally, focus has been on the harmful effects of traffic noise. The effects may be assessed by an approach illustrated in Figure 1-4, *i.e.* the causal chain from noise-generating activity to impact on people. Cars on the roads generate noise, which propagates through the urban environment and causes noise exposure of the inhabitants. The exposure is commonly represented by the noise levels (L_{den}, L_{night}) at the most-exposed facades of dwellings, but the exposure may be refined depending on sound levels at other facades of dwellings and in the neighborhood of dwellings (see Section 1.2).[1] This refinement is an objective of the QSIDE project.
From the exposure distributions of the inhabitants of a city, the expected numbers of (highly) annoyed and sleep-disturbed people can be derived, and finally these numbers may be expressed in impact parameters such as DALY's (disability adjusted life years) or Euros (net costs for the society), or QALY's (quality-adjusted-life-years).

Positive effects of a pleasant urban soundscape may be determined by means of surveys among inhabitants of cities on the perceived quality of the living environment. Recently such a study has been performed in the city of Ghent [7]. This study has shown that traffic noise exposure of inhabitants during trips around the house has a significant effect on the perceived quality of life in the neighborhood, as rated by the inhabitants in large-scale surveys. The quality of life is rated higher if traffic noise exposure during trips is lower.
The city of Amsterdam has performed a survey among inhabitants on the attractiveness of quiet urban areas in the city [8,9]. The survey has generated positive responses from the inhabitants, in contrast to the usually more negative reactions to noise. Various types of attractive quiet areas were mentioned by the inhabitants (parks, courtyards). It was found that the acoustic quality is an important aspect of a quiet urban area, but non-acoustic factors also play an important role (for example, the presence of vegetation or water).

The QSIDE consortium covers the full area of traffic noise and the effects on people. The project team includes both experts on urban acoustics and experts on human response to noise. Consequently, QSIDE disposes of the knowledge to develop an integral assessment method for the effects of quiet facades and quiet areas.

[1] Inhabitants are exposed to varying noise levels during their indoor and outdoor activities. The effect of noise depends on the type of activity (for example, sleeping) and time of the day. Consequently, it is difficult to define or determine a 'true' noise exposure of inhabitants.

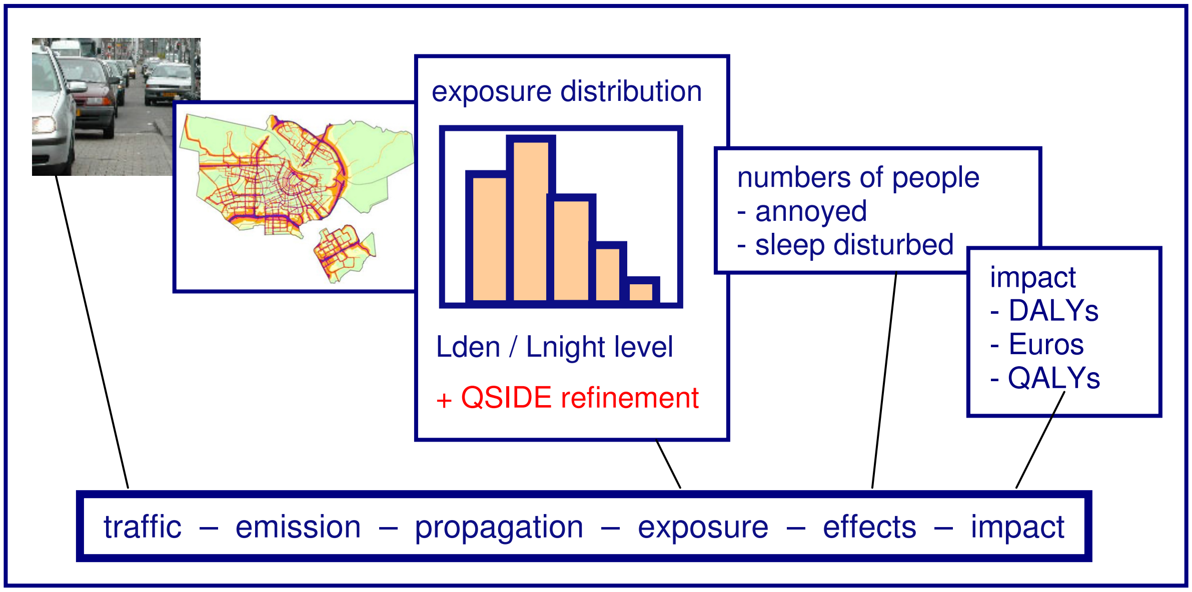


Figure 1-4. Causal chain of harmful effects of traffic noise.

1.4. Structure of the QSIDE project

Figure 1-5 shows the structure of QSIDE. The work is divided into seven actions (work packages). Some actions provide input for other actions, as indicated by the arrows in the figure.

In Action 1 we collect or describe available information and data with respect to quiet facades and quiet areas, both for acoustics and human response. Which of the information and data will actually be used for QSIDE will be decided later in Actions 2 and 3. The results of Action 1 are described in this report.

In Actions 2 and 3 we develop the integral QSIDE assessment model, consisting of an acoustic model (Action 2) and a human response model (Action 3).

In Action 4 we apply the QSIDE model. We calculate noise maps and human-response indicators for (parts of) two cities, for example Amsterdam and Gothenburg,

- first with an existing noise model (for example, the Dutch or Scandinavian standard traffic noise models)
- next with the same model supplemented with the QSIDE model.

From the results we derive expected *local effects* from quiet facades and quiet areas: some dwellings will be better off with respect to quiet facades or areas and some dwellings will be worse off. In addition, we perform scenario studies to demonstrate the expected positive effects of measures that enhance the numbers of quiet facades and quiet areas (for example, traffic flow measures).

In Action 5 we prepare a document that describes how EU cities may employ the QSIDE results, and how the positive effects of quiet facades and quiet areas may be taken into account in urban noise policy and urban planning.

Action 6 deals with dissemination of the QSIDE work. Dissemination tools include the QSIDE website www.qside.eu, and a workshop for EU city authorities to be organized at the end of the QSIDE project.

Action 7 is management of the project.

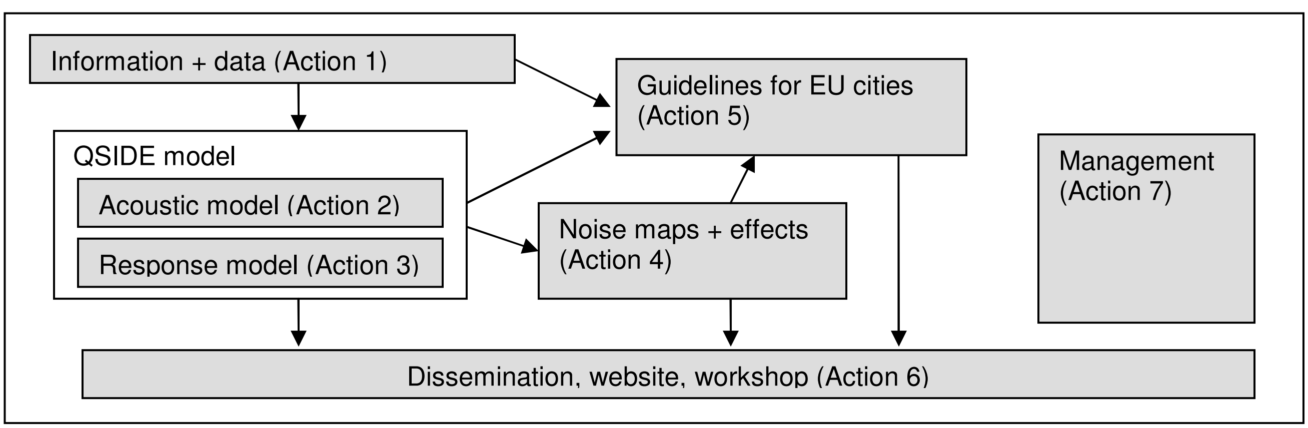


Figure 1-5. Structure of QSIDE with Actions 1-7.

2. About Action 1: Collection of information

The first action of the QSIDE project is Action 1 – Collection of information. In this Action we collect or describe three types of information:

a) scientific information and data for the QSIDE acoustic model
b) scientific information and investigation of existing data for the QSIDE human response model
c) information about current approaches of EU cities to quiet facades and quiet areas.

Part of the information is used in Actions 2-5 (see Figure 1-5).

For the information of types a and b, we consult the scientific literature and information available at the QSIDE partners. With respect to data sets, in particular human-response data sets, we only *describe* the available data sets in Action 1. In Actions 2 and 3 we will decide which data sets will actually be used, so only then it is necessary to get access to the data (and deal with protection of the data).

For the information of type c, we consult several European cities about their current approach to quiet facades and quiet areas.

To reflect the three types of collected information, we have divided Action 1 into three sub-actions:

sub-action 1.1: urban acoustics
sub-action 1.2: human response
sub-action 1.3: quiet facades and quiet areas in European cities

The results of the three sub-actions are described in Sections 3-5.

3. Urban acoustics – results of Action 1.1

In this section we describe available information and data about the acoustic representation of quiet facades and quiet areas in cities. The information and data is used in Action 2 for the development of the QSIDE acoustic model.

The QSIDE acoustic model is not a complete traffic noise model, but rather an extension of existing engineering models specifying how quiet facades and quiet areas may be dealt with. An example is the flat-city model developed at Chalmers University [1], which takes into account a fixed canyon-to-canyon propagation attenuation. Another example is the street-canyon model developed by TNO [2].

It should be noted that we may decide later in the project to develop two versions of the QSIDE acoustic model in Action 2:

1. A detailed version, intended for small scale calculations.
2. A less-detailed, more efficient version, applicable for large-scale urban noise mapping calculations.

Version 1 may take into account more parameters, such as dimensions of street canyons, than version 2.

3.1. Current engineering models

Since the QSIDE acoustic model is an extension of complete traffic noise models, we describe in this section current traffic noise engineering models, focusing in particular on the approach of the models with respect to quiet facades and quiet areas. Among other things, the following elements are discussed: (expected) accuracy of the model for quiet facades and areas, and the number of facade reflections taken into account.

3.1.1. Nord2000

The development of a new Nordic prediction method for road and rail traffic noise was reported in 2001 by DELTA (Denmark, project leader), SINTEF (Norway), and SP (Sweden). A revision about five years later resulted in a method readily applicable to road traffic noise. The main descriptions of the method are contained in two comprehensive reports [3,4]. Later, a report was made with the aim to be better suited for numerical implementation [5]. The development of the Harmonoise model (see below) can to a large part be seen as a further development of the Nord2000 method.

The Nord2000 method uses a complete separation between the acoustic source emission and the point-to-point sound propagation, for a frequency range of 25 Hz-10 kHz. A set of point sources is used to model each vehicle, with frequency dependent source strengths taken from tabulated data on measured traffic noise and with possible directivity. The propagation modelling mainly takes its starting point in accurate analytical models, which enable the resulting engineering model to be applicable to different ground surfaces and terrain shapes (modelled as piecewise linear segments) as well as to different meteorological conditions due to wind and temperature profiles.

An investigation of the accuracy has been made for typical road and rail traffic situations, i.e. relatively flat situations (compared to e.g. wind turbine cases, where the accuracy is stated to be higher) [6]. The report states a 1 dB standard uncertainty of individual results for distances of propagation up to 400 m including situations with a noise barrier. The defined standard uncertainty is the standard deviation of the error in A-weighted sound pressure level when comparing with measurements or more exact models using a pink noise source spectrum. Without noise barrier and for flat ground propagation at ranges of 600 to 1000 m, the standard uncertainty increased to about 2 dB. For yearly average L_{den} due to road traffic at distances up to 300 m, a standard uncertainty less than 1 dB was shown.

Reflections in façades and other vertically oriented objects can be modelled as incoherent contributions. The modelling of a first order reflection is well described and the extension to higher order reflections is possible [5]. However, no validation was made for situations characterized by the importance of multiple reflections. It could be noted that the modelling of incoherent contributions results in impossibility to predict (low-frequency) resonant effects at e.g. road canyons and quiet façades.

An important difference between the Nord2000 and the Harmonoise methods concerns the modelling of downward refraction. The low height used for estimating the strength of the linear sound speed profile in Nord2000 seems to give an increased risk for large prediction errors, which could affect the calculated accuracy at in e.g. quiet areas.

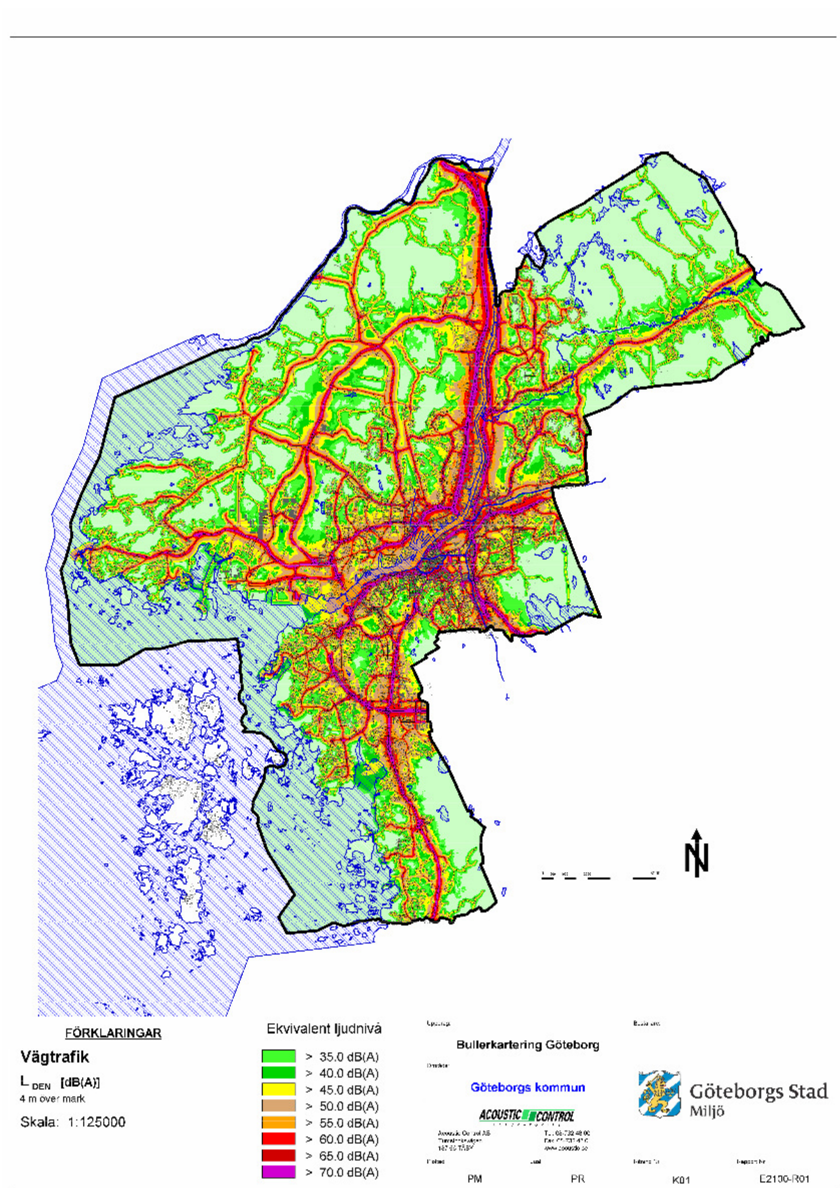


Figure 3-1. Road traffic noise in Göteborg from noise mapping finalized autumn 2007. The map shows L_{den} [dB] at 4 m height in steps of 5 dB (see colour legend). The effects of noise barriers and berms are not considered whereby the actual noise level can be lower at some points compared to what is shown by the map. Similar maps exist for noise due to tramway and rail traffic (where noise protections have been considered).

3.1.2. Dutch standard models

The Dutch standard model (SRM2) for road traffic noise [7] was developed about 30 years ago, and many elements of the model have been used later for the international ISO model [8]. An English translation of the SRM2 model description is available through the Electronic Physics Auxiliary Publication Service (EPAPS) of the American Institute of Physics [7]. A brief description of SRM2 is presented below.

The model distinguishes three types of vehicles: light vehicles (passenger cars), medium-heavy vehicles (light trucks and buses), and heavy vehicles (heavy trucks). A vehicle is represented as a point source at height 0.75 m. Different (speed-dependent) octave-band emission spectra are used for the three vehicle types, including spectral correction terms for road surfaces such as porous asphalt. Numbers of vehicles per unit road length are determined from vehicle intensities (numbers of vehicles per hour) and driving speeds for the three vehicle types. Day-evening-night levels L_{den} are determined from levels calculated for the day period (7-19h), evening period (19-23h), and night period (23-7h) [9], using appropriate vehicle intensities for the three periods.

Source lines are divided into small segments and source points are placed at the centers of the segments. The sound level at a receiver is calculated by logarithmic summation of contributions from sound rays between source points and the receiver. The model takes into account sound rays with zero or one facade reflection. Multiple facade reflections are (usually) ignored with SRM2. Ground reflections are taken into account indirectly by a ground attenuation term, which is similar to the ground attenuation term employed by the ISO model [8]. This term is valid for downward-refracting propagation conditions, and a meteorological correction term is included to account for upward-refracting conditions, so the result is an estimate of a long-term average sound level.

If the ground projection of a sound ray intersects one or more walls, then the model takes into account a screening attenuation based on the wall with the *largest* path-length difference δ_{STR}, while all other walls are ignored for the screening attenuation. The screening attenuation is calculated with a formula similar to Maekawa's empirical formula [12] (which can be derived from diffraction theory [13,14]):

$$A_{screen} = 10 \lg(20 N_F + 3) \quad (1)$$

with Fresnel number $N_F = 2\delta_{STR}/\lambda$, where

$$\delta_{STR} = \pm \left(|ST| + |TR| - |SR| \right) \quad (2)$$

is the signed path length difference illustrated in Figure 3-2, and λ is the wavelength. An upper limit of 25 dB is used for A_{screen}.

It should be noted that atmospheric wind may cause considerable deviations from Maekawa's formula [10,11], in particular in open areas near highways. In an urban environment, however, wind effects on barrier attenuation are smaller (downward-refracting wind speed gradients are larger near a single barrier in an open area than near a barrier that is close to several other barriers).

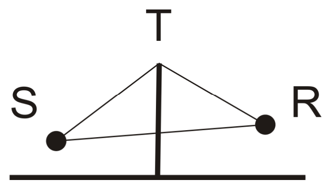


Figure 3-2. Geometry for the definition of path length difference δ_{STR}, with source S, receiver R, and barrier top.

For the calculation of noise maps in the framework of the END [9], a modified Dutch method SKM2 has been developed [7]. The noise map of Amsterdam for the first EU noise mapping round in 2007 has been calculated with this method. The noise map is shown in Figure 3-3.

The accuracy of the SRM2 model for quiet facades and quiet areas is not known. The (standard) number of façade reflections per sound path with SRM2 is one, while accurate results at quiet facades and quiet areas often require a considerably larger number (see Section 3.2.3). The modified SKM2 method employs a different approach to multiple reflections in built-up area than the SRM2 model does, but the accuracy of this approach is not known.

The Amsterdam noise map for the second EU noise mapping round in 2012 is calculated with the SRM2 model. This noise map will be finished somewhere in 2011, and can be used as a basis for the work in QSIDE. The QSIDE acoustic model (extension) for quiet facades and quiet areas will be applied.

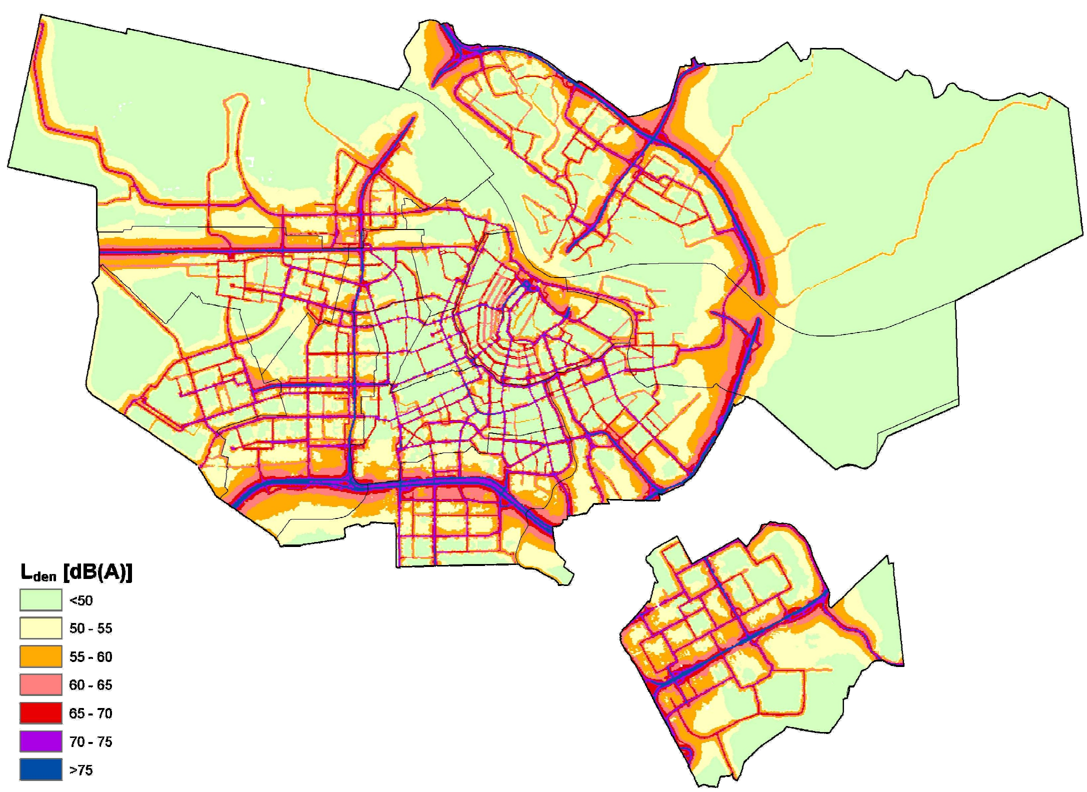


Figure 3-3. Road traffic noise map of Amsterdam for the first EU noise mapping round in 2007.

3.1.3. Harmonoise

The Harmonoise model was developed in the European projects Harmonoise and Imagine (2001-2006), and was partly based on the Nord2000 model. The Harmonoise model may be used as a basis for a future European harmonized noise mapping model, which is currently developed under coordination by the European Commission.

The Harmonoise model contains emission models for road and rail traffic noise, and a propagation model. The emission model for road vehicles differs from previous emission models: a vehicle is represented by two point sources at different heights, to account for tire-road noise and engine noise separately. For rail vehicles more than two point sources are used, to account for the various noise emitting parts of trains.

The Harmonoise propagation model differs considerably from the ISO 9613-2 propagation model. At present only a Harmonoise point-to-point propagation model is available; elements such as segmentation of roads and reflection by vertical surfaces still have to be defined. Here we briefly describe elements of the Harmonoise point-to-point model [15,16].

The model assumes a ground profile between the source and the receiver that consists of straight line segments, as shown in Figure 3-4. Obstacles such as buildings, noise barriers, and earth berms are included in the ground profile. All obstacles are taken into account in the point-to-point calculation as screening objects (this is an important difference from the ISO and SRM2 models, which take into account only one screening object). Barrier attenuations of obstacles and ground attenuations of ground sections between the obstacles are combined to obtain an overall excess attenuation. For the ground attenuations, the spherical wave reflection coefficient is employed (instead of empirical ground attenuation formulas used for ISO and SRM2).

For non-homogeneous ground surfaces a continuous solution is obtained by means of Fresnel weighting. For non-flat ground, a combination of a convex ground model and a concave ground model is used. The effect of atmospheric refraction is taken into account by a curvature of the ground profile (see reference 11, for example).

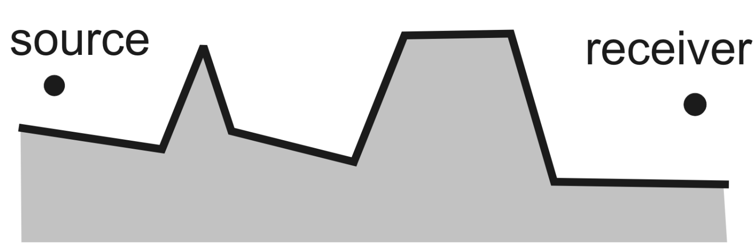


Figure 3-4. Example of a Harmonoise point-to-point propagation geometry, with a source, a receiver, and a ground profile with straight segments.

3.1.4. Other engineering models (ISO, NMPB)

ISO9613-2 uses a highly simplified diffraction formula for sound propagation over screens, and as an extension, thick screens or buildings. In case of single diffractions (thin screens), the barrier attenuation should be limited to 20 dB. The physics do not seem to be sufficiently captured and could lead to an over prediction of the barrier shielding, even when taking into account the meteorological correction term that is included in the formula. In case of double diffraction, this maximum screen efficiency should not exceed 25 dB for each separate octave band. The number of facade reflections needed is not defined. The user must choose the number of mirror sources to include multiple reflections between building facades.
There is also a specific attenuation term dealing with the presence of housings (A_{hous}). It has two contributions. A first one is proportional to the density of the buildings along the path, and the length of the dominant/direct sound path that crosses buildings. This attenuation term is increased in case of well-defined rows of buildings. This second term is proportional to the percentage of the length of the facades relative to the total length of the road. In all cases, this second term must be smaller than the insertion loss considered as a noise barrier.
It is clear that such very general and simplified calculation rules cannot be used to capture effects like the influence of street canyon geometry or façade details.

NMPB
The diffraction formula for NMPB (the French road traffic noise model) is similar to the one of ISO 9613-2. It is stated that the formula can be used for sound propagation over buildings. The effect of the presence of the ground at both the source and receiver side is treated in more detail compared to the ISO 9613-2 model, where it is assumed that there is no ground effect when sound propagation over a barrier is considered. Three diffraction paths are considered, namely from the source to the receiver, from the image source to the receiver and from the source to the image receiver. Care is taken to model the barrier performance in favorable and unfavorable propagation conditions. Curvature (delta h) of the ray is a separate parameter in the diffraction formula. A similar limit in screen efficiency of 25 dB is assumed. No specific information is found for sound propagation in streets or on the number of façade reflections needed to assess the shielding towards a quiet side.

3.2. Quiet facades - acoustics

For the quantification of the benefit of quiet facades the QCity approach will be used as a basis. This approach is based on the hypothesis that the benefit depends on the difference in sound level between the most-exposed façade and the least-exposed façade (quiet façade). Therefore, accurate calculation of levels at quiet facades with the QSIDE model is necessary. The level at a quiet façade depends on several parameters, such as:

- dimensions of the street canyons involved,
- absorption and scattering by the facades,
- openings in long facades along urban roads (‘leaky facades’),
- spectrum of the traffic noise.

In this section we collect information and data that are useful for developing the QSIDE acoustic model for quiet facades in Action 2.

3.2.1. Chalmers

Chalmers has developed models for prediction of levels at quiet façades both for the contribution of distant traffic sources, the flat city model, as well as for the contribution from nearby traffic, the ESM and the PSTD models.

The idea for the flat city model comes from the experience that the noise level, to a large extent, is invariant among different non-directly exposed positions within an urban area, which is due to the contribution of many traffic noise sources and the influence of the multiple façade reflections. The variation in equivalent noise level can be around 1-2 dB between different inner yards in an (homogeneous) urban area [1]. The general idea with the flat city model is to calculate the sound propagation from all sources to a receiver without the screening by buildings, which can be seen as if the traffic noise sources are lifted up to the roof level. As a second step, correction terms are applied for the screening and for the multiple reflections between building facades (see Figure 3-5). An approach similar to the flat city model was reported in the seventies, with an arbitrarily chosen correction term [17]. Commercial software can be utilized for performing noise map calculations with the flat city approach, as the buildings can be set to be acoustically transparent.

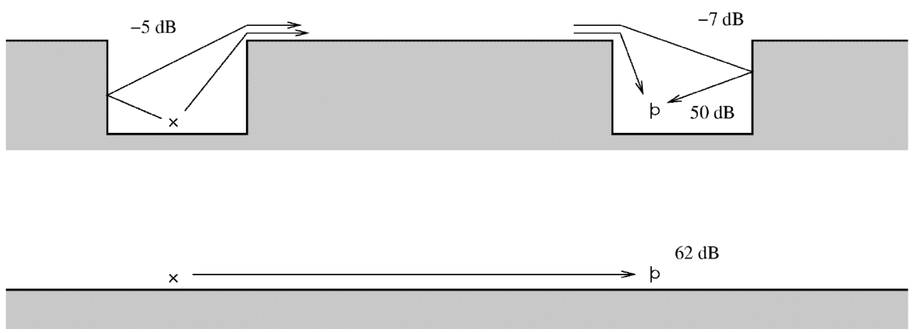


Figure 3-5. Example of correction factors for a case with two parallel urban canyons in the flat city model.

A number of case studies were carried out during the Swedish Soundscape Support to Health project for validation of the flat city model. For each case, involving multiple measurement points, a single correction term was fitted. The validity of the approach was shown for five different case studies, of which two were described in detail in Ref. [1]. It should be noted that each case contained a fairly homogeneous set of building structures.

Further work at Chalmers on the flat city model has been to predict the correction terms using numerical modeling, i.e. without having to base predictive noise maps on measurement results. For that purpose, the effect of an intermediate urban canyon (i.e. between the source canyon and the receiver canyon) was studied for various situations [18]. It was concluded that the resulting insertion loss of the intermediate canyon was a very even function of frequency and changed with geometry between 1–4 dB. It was also concluded that for realistic canyon depths (depth-to-width ratios exceeding 4:10 were studied), the insertion loss depends on neither the canyon depth nor the interior surface properties of the canyon. Furthermore, trials with up to eight canyons indicate that the total attenuation of multiple canyons can be estimated with reasonable accuracy as a sum of the individual canyon attenuation values.

Two numerical methodologies have been developed to predict levels at quiet façades from nearby traffic. Both methods incorporate detailed geometrical effects of building shapes and façade structure. The spectrum of road traffic noise as from tabulated values in the Nord2000 model can be incorporated in the models and omni-directional point sources have been modeled.
The equivalent sources method (ESM) solves the Helmholtz equation and was developed for two-dimensional (2-D) and 2.5-D applications[2] of parallel urban canyons [19,20]. One canyon contains road traffic and the other canyon is shielded from direct exposure to road traffic, i.e. a quiet façade. ESM was validated by the boundary element method and scale model measurements [21]. The method was further utilized to illustrate the influence of façade absorption and diffusion on the quiet façade noise levels with road traffic noise modeled as a coherent line source [19] or incoherent line source [21]. Various height-to-width ratios for the street canyons were also studied, as well the influence of atmospheric turbulence [22] and a downward refracting wind speed profile [21].
The pseudospectral time-domain (PSTD) method was developed to obtain a time-domain solution of sound propagation from road traffic noise in a street canyon to a roadside courtyard enabling to include the effects of a spatially dependent mean wind and temperature [23]. Figure 3-6 shows an example. The PSTD method allows for a relatively coarse spatial discretization thereby opening possibilities for implementation of 3-D geometrical situations. The method was validated by other numerical methodologies and results from a scale model study [23,24]. Calculations have been performed with PSTD to investigate the necessity to model the quiet façade by a 3-D environment with respect to the effects of noise abatement schemes as façade absorption and roof screens in 1/3 octave band computations up to 500 Hz [25]. Also, the effect of openings

[2] A 2.5-D geometry is here defined as a 3-D geometry which is invariant in one direction (here along the street canyon), yet where source and receiver positions can have arbitrary coordinates in the 3-D space.

to the façades of courtyards relative to the noise propagating over the roof level has been studied [25].

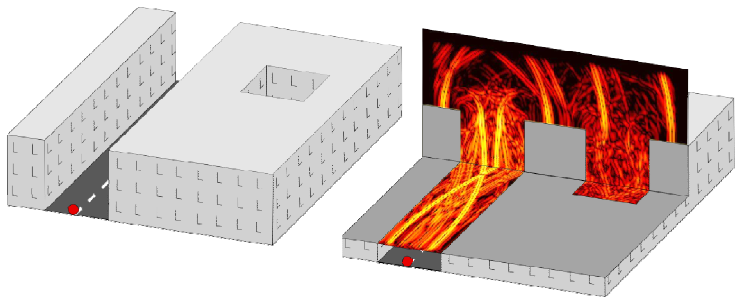


Figure 3-6. (Left) Geometry of an urban street canyon and closed courtyard. (Right) Snapshot of the sound field, generated by an impulsive source (indicated by the red dot) in the street canyon, computed by the PSTD method.

3.2.2. Ghent University

The finite-difference time-domain (FDTD) method is a full wave-based method, and all relevant aspects of sound propagation towards quiet sides can be included like multiple reflections in source and receiver canyon, multiple diffractions, façade details, roof details, and meteorological influences like refraction by wind speed and temperature gradients, and turbulent scattering. Given the rather large computational cost of such wave-based methods, extended simulation domains cannot be modeled - the number of computational cells that can be used is limited. Two approaches can be found. Either 3D situations are modeled with a limited maximum frequency, or 2D simulations are performed for a wider frequency range, covering an important part of a typical road traffic noise spectrum. Such a 2D simulation implies an infinitely long coherent line source, and invariance in the building configuration orthogonal to the cross section that is modeled. A closed row of buildings is simulated in this approach. However, when looking at relative effects of certain noise reducing measures, 2D simulations are often an accurate and computational efficient approach of the 3D situation.

Various parameter studies have been performed for sound propagation in 2D between adjacent, identical city canyons with the FDTD model. The shielding provided by very narrow and high canyons is large. With increasing width/height ratios, the predicted attenuation decreases and levels become less influenced by this parameter. A small amount of absorption at the façades can result in a large increase in shielding. The difference between fully reflecting and partly absorbing façades (e.g. with a normalized real frequency-independent impedance of 10) results in a gain of 20 dB over the full frequency range. Many researchers in urban acoustics see the promotion of diffuse reflection at building façades as an interesting approach to limit reverberation times in the source canyon. Furthermore, the radiation pattern of the source canyon is changed in an interesting way: more acoustic energy does not reach the diffraction edges of buildings. Other façade elements like balconies can be quite efficient, and could be helpful at lower frequencies too.

In case of identical source and receiver canyons, meteorological effects seem to be prominent. Downwind effects could lead to a strong decrease in shielding and to large sound pressure levels at an otherwise quiet side. Similar to what is observed near noise barriers, large gradients in the wind speed appear above roof level, although higher gradients might be expected for a barrier in an open field. The presence of buildings with an almost equal height is an important prerequisite to see such wind effects between adjacent city canyons. Measurements show that in case of large variations in building height, wind effects are much less pronounced. Of main importance are sound rays that leave the canyon almost horizontally after a number of reflections. If such rays are bent downwardly only a little, they are captured in the receiving canyon and might reach a shielded façade in the adjacent canyon. Wind effects are more pronounced in case of flat roofs. Temperature effects are rather limited given the short propagation length typically observed in case of canyon to canyon propagation. This effect could however become important for long distance propagation in an urban environment (similar for wind effects in case of non-equal building heights). Positive effects of upwind propagation between city canyons are often counteracted by turbulent scattering.

It has been shown that roof shape is an important parameter when looking at road traffic noise propagation between adjacent city canyons. A large variety of roof shapes is typically encountered in a city, ranging from flat roofs over ridge roofs, to curved roofs. Roof geometry was shown to be an important parameter based on numerical calculations in case of canyon-to-canyon propagation. The difference in median along a shielded façade, between the best and worst situation, exceeded 10 dBA, for a range of vehicle speeds from 30 to 70 km/h, for both light and heavy vehicles. An important condition in this study is that buildings with different roof shapes had an equal building volume. It was also observed that with increasing vehicle speed, roof shape becomes more important, since higher frequencies give a larger contribution to the total traffic noise level. Short wavelengths are more sensitive to the exact roof shape. Maximum roof height as a single parameter was shown to be a limited predictor of the shielding efficiency.

Green roofs are becoming more and more popular in an urban environment, and are often highly subsidized or even obliged by city authorities. Measurements and numerical calculations show that placing a green roof is beneficial to achieve quiet sides. The typical substrates that are used are porous, and yield an important reduction in intensity of waves diffracting over a roof compared to (classical) acoustical rigid roofs. Important parameters here are the green roof surface, substrate layer thickness, and water content in the substrate. Again, effects are more pronounced for higher road traffic vehicle speeds. Experimental work, where an identical source-receiver configuration was applied just before and just after the placement of a green roof, confirms the noise reducing properties of green roofs at shielded receivers. In case of fully shielded receivers, effects are significant in a wide frequency range. The type of green roof build-up has a significant effect on the noise reductions that are observed.

For the literature on this section, the reader is referred to Refs. [26]-[31].

3.2.3. TNO

TNO has various computational models for sound propagation in situations with obstacles such as buildings and noise barriers:

- FDTD model (Euler model)
- BEM model
- Hybrid models: FDTD-PE, BEM-PE
- ray model.

The FDTD model and the BEM model are numerical models, based on numerical solution of the Euler equations and the Kirchhoff-Helmholtz wave equation, respectively. These models are time-consuming, so in practice only the 2D versions of the models are used. When applying 2D FDTD and 2D BEM to 3D situations, we rely on the quasi-2D approximation, i.e. the calculation is performed in the vertical plane through the source and the receiver. The FDTD model is a time-domain model and BEM is a frequency-domain model.
For computational efficiency we have also developed and applied the hybrid models FDTD-PE and BEM-PE. FDTD and BEM are applied in a source region, for example a street canyon with multiple sound reflections. At the boundary of the source region a transition is made to the PE model for efficient calculation of one-way sound propagation to distant receivers.

A 3D ray model, based on the geometrical-acoustics theory of reflection and diffraction of spherical sound waves, has been developed and applied to various traffic noise situations. The user should specify which sound rays between the source and the receiver are taken into account. In relatively simple situations, for example a highway with barriers on both sides, the number of (significant) sound rays to a receiver is limited, so the ray model works well. In more complex urban situations, application of the 3D ray model is not practical.

TNO has also implemented a Fresnel-zone ray model developed by Chalmers for canyon-to-canyon propagation. The finite heights of the canyons are taken into account by Fresnel weighting. Calculations indicate that a large number of zigzag reflections in the canyons must be taken into account to achieve sound levels close to levels predicted by a BEM model, which is considered an accurate reference model in this case since all reflections are implicitly taken into account (see Figure 3-7).

This type of model calculations for canyon-to-canyon propagation has been the basis for the development of a practical engineering model for canyon-to-canyon propagation, referred to as Street Canyon Model (SCM) [2]. The SCM model is a modification of the SRM2 model, and is expected to give more accurate results at quiet facades and in quiet areas than the SRM2 model. The flat-city model developed at Chalmers has also provided a basis for the SCM model, in the sense that it shows that conventional engineering models underestimate sound levels at shielded locations in cities.

The idea of the SCM model is that all zigzag reflections in canyon-to-canyon propagation are taken into account by *halving* the screening attenuation of the building between the source and receiver canyons. This simple approach was found to give results that agree better with reference (BEM) results than conventional engineering models do, since the conventional models are limited to typically 1 reflection per sound path. The conventional engineering models underestimate sound levels at quiet facades, and the SCM model and reference models give considerably higher levels, typically 5 to 10 dB higher. The higher levels are confirmed by measurements underlying the flat city model.

The SCM model is closely related to the flat city model. The SCM model replaces the complex ground attenuation functions of the SRM2 model by a constant ground attenuation of -3 dB, while the meteorological correction term of the SRM2 model is not taken into account in the SCM model. The meteorological correction term is 3.5 dB, except for small distances, so effectively the SCM model assumes a ground attenuation of -6.5 dB, which is close to the ground attenuation of -6 dB assumed in the flat city model (this is the first step of the flat city model calculation, where sources and receivers are placed at height zero on a flat ground surface, or equivalently, sources and receivers are lifted to rooftop level).
The screening attenuation of the SCM model ('half Maekawa') can be interpreted as correction terms for the flat city model. However, these correction terms derived from SCM are not constants, but depend on dimensions and building heights through the (half) Maekawa formula. In Action 2 of QSIDE we will investigate the dependence of the flat city correction terms on various geometrical and meteorological parameters, so there the comparison with the correction terms derived from SCM may prove to be useful.

Figure 3-8 shows results of traffic noise measurements in a street in Delft [32]. The graph shows spectra for microphone 6, which was located in a closed courtyard. The source was a passing city bus, and the red dot is the source position corresponding to the spectrum. Broadband levels are given in the legend. The level predicted by the SRM2 model (indicated as SRM in the graph) is considerably lower than the measured level and the levels obtained from the BEM calculation and the scale model measurement.

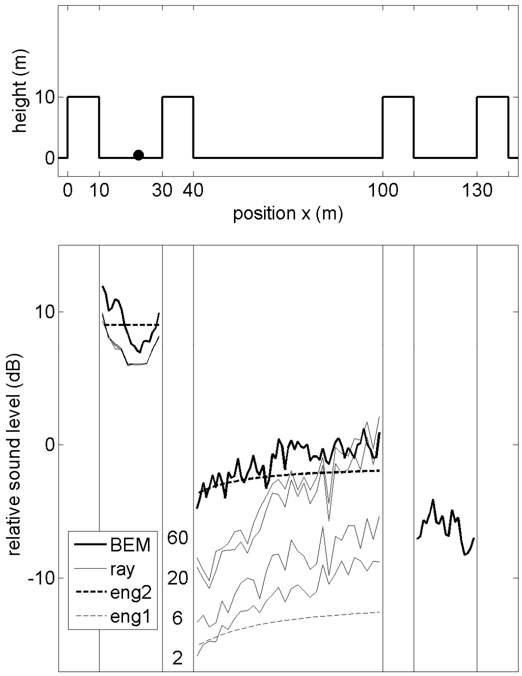


Figure 3-7. Illustration of (broadband) relative sound levels calculated with BEM, a Fresnel-zone ray model with 2, 6, 20, and 60 canyon reflections, and two engineering models: eng1 = SRM2 and eng2 = SCM. The geometry is shown in the upper graph.

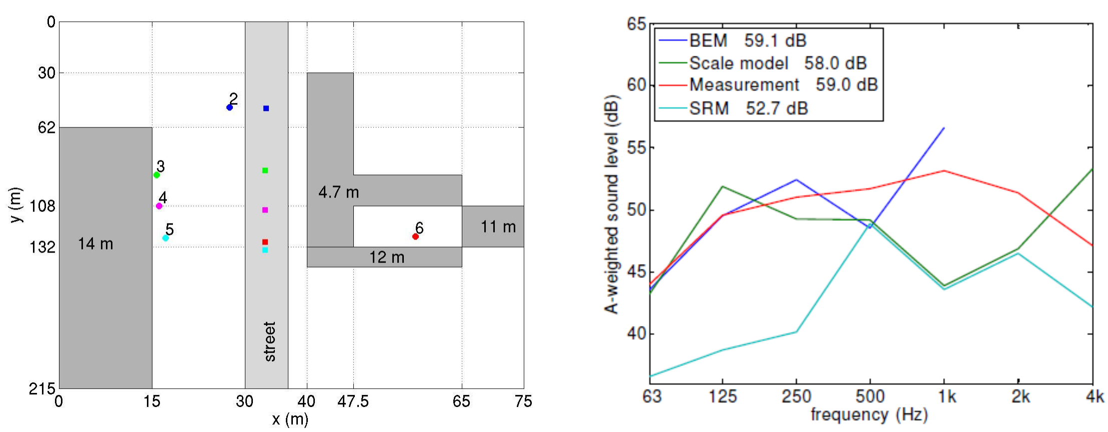


Figure 3-8. Results of traffic noise measurements in a street in Delft. The left graph shows the geometry with buildings (heights are indicated), a street (dots are source positions), and microphones 2-6. The right graph shows a measured octave-band spectrum at microphone 6, spectra calculated with BEM and SRM2 (=SRM), and a spectrum measured on a scale model of the experimental configuration.

3.2.4. Information from other sources (literature)

It is shown in [1] that the (older) Nordic prediction method [33], which is still the legal one in Sweden, gives accurate predictions on the directly exposed side compared with measurements; however, inside the courtyards the errors were between 11 and 14 dB.

It is shown in Ref. [34] that good accuracy can be achieved between measurements and ray modeling for a situation with multiple reflections (near to a road). There, reflections up to order 64 were used and fully correlated contributions were modeled for each single vehicle.

To study the effect of wind on the sound propagation from road traffic noise to a quiet façade, the FDTD model was implemented in a 3-D geometry and results computed at a frequency of 250 Hz by Heimann [35].

3.3. Quiet areas - acoustics

The approach to be followed for quiet areas is less clear than the approach for quiet facades. For quiet areas, it was proposed in QCity to use the lowest 25 percentile of the noise levels within a certain radius around the dwelling, say 200 m.[3] In this section we collect information and data relating to the general question how a quiet area may be represented *acoustically*. As an example we mention the criterion L_{day} < 40 dB for *non-urban* quiet areas; for urban quiet areas a limit of 40 dB may be too low.
Another problem to be solved in QSIDE is how we calculate (traffic) noise levels in urban quiet areas. For closed courtyard a canyon-to-canyon propagation term is probably appropriate, while for quiet urban parks this is not the case. For a quiet area the relevant levels must be estimated at a height of about 2 m (height of people's ears in the outdoors). In this section we collect information and data that is useful for solving this problem in Action 2.

3.3.1. Chalmers

A model, based on the linear transport theory, has been developed to predict urban noise levels due to traffic on a macroscopic level rather than in a deterministic way. Noise propagation through cities is a process of multiple reflections of sound waves with (irregularly placed) houses and obstacles. Theories of wave propagation through random scatterers and the behaviour of molecules in a perfect gas are then analogous to urban sound propagation and can be used to calculate the background noise. Kuttruff [36] presented a method to calculate the sound pressure level in urban areas at a macroscopic level. Averaged city parameter values were introduced, representing the density and the sizes of the buildings. His method is based on the linear transport equation for gases, the Maxwell-Boltzmann collision equation (BCE), which describes the distribution of particles as a function of space and time and assuming isotropic scattering and the probability for a particle to be absorbed when colliding. Whereas the molecules collide with each other in a gas, sound waves collide only with the building façades and other obstacles in urban sound propagation.
The BCE translates into a model for urban sound propagation which only requires two spatially dependent medium parameters: the mean free path length and an absorption coefficient. The BCE has been solved numerically by the finite element method allowing to assign different values of the coefficients depending on the properties of the underlying urban area. The method was originally proposed to compute sound propagation in the horizontal 2-D plane and has been extended to include the transmission over rooftops [1]. Figure 3-9 shows and example. The model candidates to compute the noise level in areas as urban parks.

---

[3] This level is indicated as the ambient level A in QCity. It is the level that is exceeded in 75% of the area within a radius of 200 m around the dwelling. This level excludes the noisy locations near a house, and focuses on quiet areas such as parks.

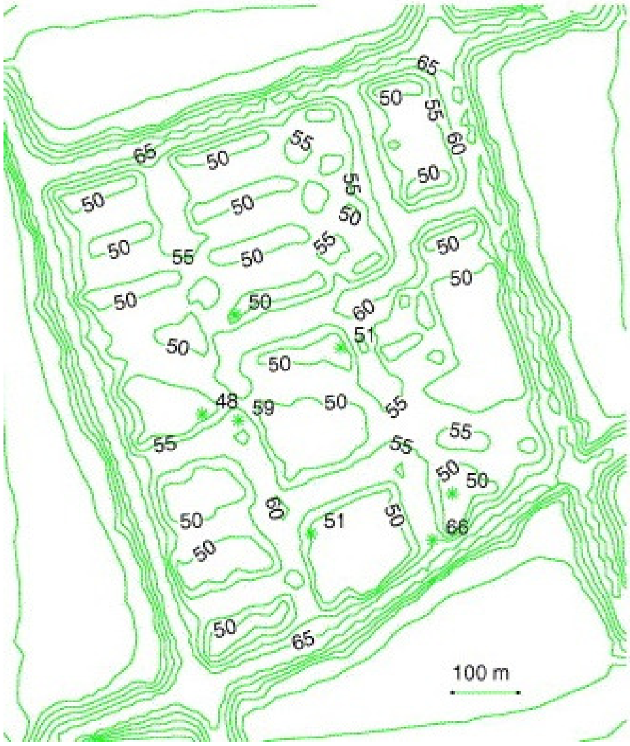


Figure 3-9. Equivalent levels in a residential area in Stockholm with existing traffic computed with the linear transport model [1].

3.3.2. Ghent University

Sound indicators that describe the perception of quietness could be quite different from indicators suitable for reported long term annoyance (De Coensel et al., 2006 [38]). The perception of quietness tends to require a low level of constantly present noise combined with only a limited number of disturbances. The latter are noise events that are perceived as non-fitting, e.g. an airplane pass-by over a natural area. In addition, the quality of the sonic environment in a quiet area may benefit from a suitable spectro-temporal dynamic that resembles the complex dynamics of natural sonic environments (Botteldooren et al., 2006 [37]). Accounting for the presence of natural sounds contributing to the quiet area soundscape in a statistical way is within reach of modern computers, but it is far from current practice in noise mapping. In contrast, it may be possible to calculate a statistical noise level such as L_{A50} of intruding traffic noise to characterize the continuously present noise that determines the perception of silence. L_{A50} of about 40 dBA might be suitable as a limit for good quality quietness. In addition counting the number of traffic related noise events – defined as the number of times the instantaneous sound level emerges more than 3 dBA above L_{A50} during at least 3 seconds – seems feasible in extended noise maps. Ten traffic noise events during a period of 15 minutes seem acceptable for a moderate quality quiet area.

A disadvantage in using indicators that are not based on long-term L_{Aeq} to characterize quiet areas might be the need to know detailed traffic pass-by timings. However, it turns out that in many situations independent passages may be assumed and a microscopic traffic model is not needed. However, shielding by buildings and noise barriers should be taken into account with sufficient detail.

Detailed sound propagation calculations in parks are possible. Many aspects influence sound propagation in (urban) parks, like e.g. the presence of typical (soft) soils and variations in the soil properties, elevations/depressions of the ground surface, small barriers, the presence of trees and low-growing vegetation. Furthermore, the location of the traffic noise source is important (whether traffic noise is surrounding the park or only present at one side). General conclusions or guidelines as for the noise levels in parks will therefore strongly depend on a particular situation.

Given the fact that the soil characteristics could be a major effect when considering road traffic noise propagation, numerical calculations with FDTD or PE could be useful. Both models can also take into account a succession of various types of soils along the propagation path. There is a lot of information on soils under vegetation to feed such models. Approaches for scattering by vegetation elements can be found as well. Small screens and undulating ground surfaces can be modeled as well. This could however lead to a high number of combinations, and some standard park configurations have to be defined. Prediction of such effects is highly linked to work in the FP7 project HOSANNA.

A detailed dataset of noise measurements near a small park (botanic garden) bordered by a busy street is available at UGent [39]. A first microphone is located at the border of the park, very close to a two-lane road and is therefore highly representative for the road traffic source level. A second microphone is placed inside the vegetation, at about 40 m from the first one. Simultaneous, continuous 1/3 octave band levels measurements were made at both locations, on a 1-s basis. The measurements lasted for near 2 years, including periods with a smaller amount of data. However, this park cannot be considered as a quiet area. The main intention of this study was to look at seasonal variation in the attenuation by vegetation, and to look at meteorological influences.

3.3.3. TNO

TNO has no specific information or data available relating to the predictions of sound levels in quiet urban areas. We only mention that the SCM model developed for quiet facades applies also to the prediction of sound levels in closed (or semi-closed) courtyards. One expects that conventional engineering models underestimate sound levels in closed courtyards, and that the SCM model yields an improved prediction.
In Section 3.2 we have described a measurement in Delft of sound propagation from a street to a closed courtyard.

3.3.4. Information from other sources (literature)

As recreational areas that could act as quiet areas often can be characterized by a large(r) area without buildings, the ground effects and meteorological conditions play an important role. Apart from the engineering methods as Harmonoise and NORD2000, accurate wave-based prediction methods suitable for prediction of road traffic noise levels do exist. The parabolic equation (PE) and fast field program (FFP) are such methods (see e.g. [11] for references) which are implemented at Chalmers and TNO. They are both efficient numerical methods with high accuracy when the problem envisaged concerns one-way sound propagation over an impedance ground surface and in the presence of arbitrary meteorological conditions. FFP is restricted to a height dependent sound speed profile only. Also, FDTD and PSTD methods, as used for the quiet façades, could be used here. These methods have been presented for application of sound propagation over larger distances [23,40].

4. Human response – results of Action 1.2

In this section we describe the results of the investigation of existing information and data (surveys and cohort studies on noise annoyance and sleep disturbance) that may be applied for further analysis in QSIDE. The data should allow an analysis of the effects of quiet facades and quiet areas.

Part of the information and data collected or described in Action 1 is used in Action 3 for the development of the QSIDE human response model, in particular for optimization of numerical parameters of the QCity approach.

4.1. Quiet facades – human response

The QCity approach to quiet facades is a starting point for the development of the QSIDE response model for quiet facades. The development and numerical optimization will be based on analyses of existing surveys and/or cohort studies of annoyance and/or sleep disturbance by urban road traffic noise. Of particular value for the development are studies with detailed information about the noise situation around the dwellings, to allow possible refinement of levels with the QSIDE acoustic model, and a sufficiently large sample together with adequate response data, to allow quantification of the effects. Also studies with information about the location of bedrooms in dwellings are valuable.
Of great interest for QSIDE are noise surveys and cohort studies that contain, for a considerable number of subjects:

- noise levels at the most-exposed façade and the least-exposed façade of the dwellings (or GIS data and traffic data to calculate these levels),
- self-reported annoyance and/or sleep disturbance of the inhabitants, preferably on a 11 point scale in accordance with the ICBEN/ISO guideline.

Other aspects of interest are:

- information on potential confounding variables,
- representativeness of the sample for the general population.

4.1.1. TNO

Existing databases that are potentially relevant for the quantification of the hypothesised beneficial effect of a quiet side on annoyance, have been investigated. A prerequisite of applicability of such a database was the availability of noise exposure at the least and most exposed façade, together with self-reported annoyance (preferably in line with the ISO guideline), and (preferably) relevant covariates.

4.1.1.1 Amsterdam

For the city of Amsterdam, both information on the environmental noise situation is available, as well as questionnaire data for a substantially sized sample on self-reported annoyance and covariates. This provides the opportunity to investigate the effect of a quiet side on annoyance in greater detail, and therefore seems very suitable for further analyses within the QSIDE project.

Study population

In the Netherlands, every municipality is responsible to stay informed on the health status of its population, to enable the development of an effective local health policy. One way in which this aim is achieved is by carrying out periodical surveys within the population. These surveys include questions on use of healthcare, health problems and lifestyle more in general. In Amsterdam, these surveys are carried out every 4 years, by the GGD Amsterdam (“Medical and Health Service Amsterdam”), the public health authority of Amsterdam. A random sample of inhabitants of Amsterdam over 16 years of age are invited to participate. The most recent survey dates from 2008. Over 13000 inhabitants of Amsterdam where invited to participate. The response rate was approximately 50%.

Noise annoyance response and covariates

This survey includes questions on noise annoyance, as well as potentially relevant covariates. The question on noise annoyance consisted of an 11 point scale following the ISO recommendations. On this scale zero is defined as equivalent to "not at all annoyed" and ten is equivalent to "extremely annoyed".
The English translation and the original question in Dutch (in italics between <>) are given below:

“Thinking about the last 12 months, which number from zero to ten best describes how much you are annoyed, disturbed, or bothered when you are at home, by the sources mentioned hereafter?”
<Als u denkt aan de afgelopen 12 maanden, welk getal van 0 tot 10 geeft het beste aan in welke mate u gehinderd, gestoord of geërgerd wordt door geluid van onderstaande bronnen als u thuis bent?>

This question consists of 11 sub questions for different source types, including road traffic, tram and metro, railways, aircraft, industry and neighbours.

Questions on covariates include those relating to demographics (e.g. age, gender), lifestyle (e.g. physical activity, body mass index, smoking, alcohol use) and socio-economic status. In addition information on ventilation and window opening behaviour was available, which is of interest as a potential exposure modifier.

Noise exposure

In Amsterdam in 2006/2007 noise mapping has been carried out, for different source types. The road traffic noise map is shown in Section 3.1.2. Currently, an update for road traffic noise levels in Amsterdam is in progress. Road traffic noise exposure of the subjects will be calculated at the most- and the least exposed façade of the home address with the Dutch standard method SRM2 in accordance with requirements of the EU Environmental Noise Directive (END). For the analyses the EU standard noise metric L_{den} will be used as a basis. L_{den} (day-evening-night level) is defined as the A-weighted “average” sound level over 24 hours in which sound levels during the evening and the night are increased by 5 dB and 10 dB, respectively (International Standards Organization, 2002) over a year. Noise levels will be assessed at the façades of a dwelling with the highest- and the lowest overall exposure respectively (i.e. most- and least exposed façade). SRM2 is the Netherlands’ standard method for noise modeling [1]. SRM2 is implemented in Urbis [2] that will be used here for the exposure calculations.

Noise calculations are carried out in two steps, calculating first the emission and then the transmission. Input data for the noise emission calculations is a detailed digital map describing the geographic location of roads and the traffic characteristics for each road segment (including traffic intensities for each vehicle category, speed, and road surface type), provided by Amsterdam. Traffic data is attached as attributes to the road segments for a dense network of roads, including highways, arterial roads, main streets and principal residential streets, and excluding quieter residential roads, cycle paths (also used by mopeds) and other roads with little motorized traffic.

Basis for the noise transmission calculations are digital maps with precise information on the geographic location of buildings and ground characteristics.

Other studies potentially of interest for studying effects of a quiet side

The GLOBE study is a prospective cohort study carried out in the Netherlands, with a primary aim of explaining socio-economic inequalities in health. GLOBE is the Dutch acronym for Health and Living Conditions of the Population of Eindhoven and surroundings [3]. In 1991, an a-select sample (stratified by age, degree of urbanization and socio-economic position) of 27 070 non-institutionalized subjects (aged 15 to 74 years) were invited to participate in the study. With a response rate of 70.1%, baseline information was collected from 18 973 individuals using a postal questionnaire. The area of study included the city of Eindhoven, the fifth largest city of The Netherlands in 1991. TNO has carried out noise calculations (including least and most exposed façade levels of the home addresses) for this study population (De Kluizenaar et al., 2009 [4]). An indication of environmental noise annoyance was available from the following question in the questionnaire: “This question concerns the dwelling and surrounding environment in which you live: In the past year, were you often confronted with annoying levels of sound <*in Dutch: lawaai*> from traffic, street noises, aircraft, businesses etc. (Y/N)?” The response format was: “Yes”, “No”. The data collection comprised a broad range of potential confounders including socio-demographic variables (age, gender, marital status, education), lifestyle factors (smoking, alcohol use, physical activity, body mass index), and living conditions (employment status, financial problems). Results of preliminary analyses indicate that residents may benefit from a quiet façade to the dwelling (De Kluizenaar et al., 2010 [5]).

4.1.2. University of Gothenburg

The University of Gothenburg has conducted a questionnaire study during May 2011 of a residential area (the so-called "Bomgatan study") where a quiet side and a quiet courtyard was created in Gothenburg in 2007. The study complements a study on human response to traffic noise performed in 2006 in this area, before the reconstruction took place.

The Bomgatan Study

Study area

The study site called "Bomgatan", with one case and one control area, is located in one of the central districts of Gothenburg, Sweden. In 2006, the case area consisted of three residential buildings linked to each other (U-shaped) forming a half-closed courtyard with the opening facing a busy road, which also has tram traffic. The buildings have 3-4 floors. The control area is located next to the case area and is made up with four buildings (similar to the case area) forming a closed courtyard. To create a quiet courtyard and a quiet side of the dwellings, the three buildings in the case area were built together in 2007 with a new building with 4-6 floors.

Noise exposure

The current noise situation in the area is complex with roads that run around, different types of traffic, height differences, and traffic signals creating an increased variation in the speed and acceleration of the road traffic. The main traffic goes on Mölndalsvägen and Framnäsgatan north of the case area. The highway E6/E20 is located ca. 300 m east of the area. For the case area, traffic noise was measured 10 min at four locations during an evening in May 2006. The noise in the case area courtyard was mainly coming from a ventilation source, but during measurement periods the road traffic noise was dominating. For the control area, two noise measurements were done in autumn 2006 at two positions. In October 2010, noise measurements were done at the same positions as in 2006 in both areas. Outdoor sound levels at both sides of *each* dwelling in both areas will be estimated as part of Action 4. Table 4-1 shows traffic noise levels (measured $L_{Aeq,24h}$ corrected for yearly traffic) in 2006 and 2010 for both study areas (Forssén and Hornikx, 2007 [6]; Forssén and Gustafson, 2010 [7]).

Table 4-1. Traffic noise levels ($L_{Aeq,24h}$ dB) in the case and control area in 2006 and 2010.

	Case area		Control area	
Position	$L_{Aeq,24h}$ dB, 2006	$L_{Aeq,24h}$ dB, 2010	$L_{Aeq,24h}$ dB, 2006	$L_{Aeq,24h}$ dB, 2010
Noise exposed side	64, 60	63, 58	67	65
Courtyard	53*, 52*	43**, 46**	49	49

*Ventilation was on; **Ventilation off

Study population and questionnaire

A questionnaire pre-study was conducted in April 2006 involving all residents between 18-75 years of age living in the case and control areas. 55 out of 105 individuals (54%) participated in the case area and 53 out of 105 individuals (52%) participated in the control area.

Questions for the QSIDE-project: (i) Windows facing roads/courtyard; (ii) Bedroom window facing roads/courtyard; (iii) Access to quiet rooms (living room, bedroom, kitchen, other) where traffic noise is not noticed; (iv) Access to a quiet outdoor place close to the dwelling where traffic noise is not noticed; (v) Nearby green areas; (vi) Annoyed by road traffic noise at home (ISO/ICBEN 5-point category scale); (vii) Annoyed by road traffic noise at home (ISO/ICBEN 11-point scale); (viii) Disturbance of sleep (falling asleep, awakenings, sleep quality, not being able to have bedroom window open) with window closed/open (summed 2-parts question assessing how often disturbed and degree of disturbance); and (ix) background variables (age, gender, civil status, employment, education, noise sensitivity).

After the intervention with the new building to create a quiet courtyard, a new study was conducted during May 2011 in the same case and control areas using a questionnaire with similar content.

Knowledge from the Swedish *Soundscape Support to Health project* (1999-2007):

One of the main aims of this large research project was to obtain knowledge on the relationship between individual noise exposures, including having access to a quiet side of the dwelling, and various health effects [8].

Study areas

Four city residential areas in Stockholm and Gothenburg, were selected based on a number of criteria, e.g. (a) half of the dwellings should have similar sound levels at the most exposed side, but about 10–20 dB lower sound levels at the quieter side ($L_{Aeq,24h}$ = 38–48 dB façade reflection included) and the other half of the dwellings should have similar sound levels at the most exposed side, but with no access to a quieter side; (b) no other dominating noise sources should be present (e.g. rail or aircraft noise and noise from ventilation in the courtyards); (c) similar houses according to height and type (block of flats only); (d) each dwelling should have at least two rooms in addition to a kitchen; (e) each dwelling should have access to a balcony or an outdoor space; and (f) the population's age and number of people born in other countries should not vary to a great extent.

For selection of dwellings and calculations of individual noise dose immission levels, study sites and buildings were examined by aerial photographs and documented in 1:4,000 scale map format with elevation contours. Plan drawings of dwellings and data from the questionnaire of stated floor level and the location of the balcony, bedroom windows, and living room windows were also used.

Noise Exposure

Outdoor sound levels at both sides of *each* dwelling were determined by: (1) long-term measurements (not on holidays); (2) short-term measurements (at least 30 min or 500 vehicles); (3) counting of traffic data, and (4) calculations of road traffic noise levels ($L_{Aeq,24h}$, L_{day}, $L_{evening}$, L_{night}, L_{AFmax}) based on traffic input and geometrical data for the site. The sound level values at the "quiet" side include the façade reflection according to the new calculation model developed in the research program "Soundscape Support to Health". These models are the flat city model and the ESM model described in Chapter 3. The particular storey was considered in the calculations.

Study population and questionnaire
Socio-acoustic surveys were conducted in spring or autumn 2000 to 2002. Out of 1 625 individuals between 18 and 75 years of age, 956 participated (59% response rate) and 458 had access to a "quiet" side of their dwelling while 498 had no such access.

Questions for QSIDE: (i) Windows facing roads/courtyard; (ii) Bedroom window facing roads/ courtyard; (iii) Green areas close to home; (vi) Annoyed by road traffic noise at home (ISO/ICBEN 5-point category scale); (vii) Annoyed by road traffic noise at home (ISO/ICBEN 11-point scale); (viii) Disturbance of sleep (falling asleep, awakenings, sleep quality, not being able to have bedroom window open) with window closed and open (summed 2-parts question assessing how often disturbed and degree of disturbance); and (ix) background variables (age, gender, civil status, employment, education, noise sensitivity).

Results
Figure 4-1 shows that percentage of annoyed (a) and highly annoyed (b) inhabitants are lower with access to a quiet side ($L_{Aeq,24h}$ dB ≈ 45 dB, free field value) than without this. Figure 4-1 also shows that percentage reporting disturbed sleep quality with open window (c=>3 disturbed and d=>4 highly disturbed, on a summed 0-6 scale) are lowest among those inhabitants that have a bedroom facing a quiet side (green dotted box).

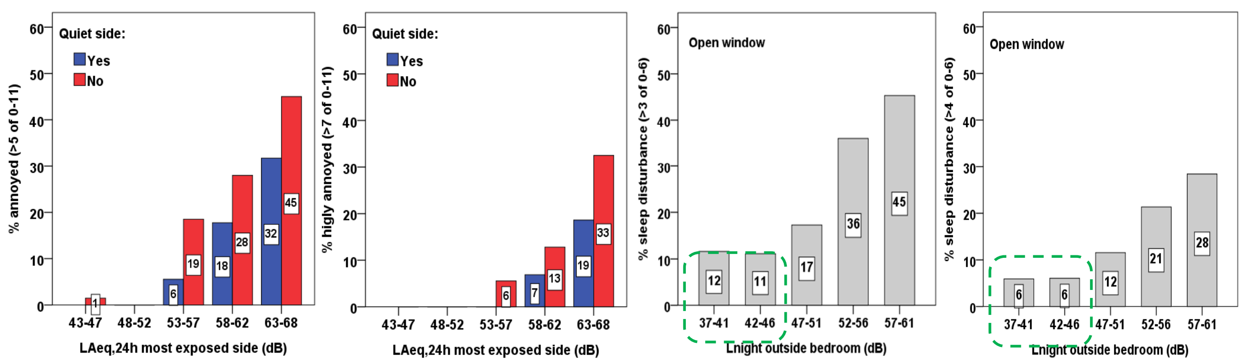


Figure 4-1. Graphs a,b: Percentage annoyed and highly annoyed (>5 and >7 on a 0-11-point scale, respectively) in relation to noise levels and access to a quiet side. Graphs c-d: Percentage with disturbed and highly disturbed sleep quality (>3 and >4 on a summed 0-6 scale, respectively) in relation to L_{night}.

Other studies of potential relevance for studying the effect of a quiet side

Table 4-2 shows studies conducted by the Occupational and Environmental Medicine (University of Gothenburg) that potentially can be used in the QSIDE-project. Although a majority of the studies don't have measured/calculated noise levels on the "quiet"/shielded side, questions on windows facing major/smaller roads, railway and courtyard, as well as on access to quiet rooms and quiet outdoor spaces were asked.

Table 4-2. Studies of potential relevance for the QSIDE-project.

	Studies of road traffic noise			
	Partille	***TVANE***	***Lerum***	***Södra Länken***
Location of residential areas	Gothenburg	Borås/Kungälv	Lerum	Stockholm
Type of study	Longitudinal, interventions to create a noise shielded side	Cross-sectional	Cross-sectional	Longitudinal, interventions
Year of the study	2004/2009	2007	2004	2003/2005
Number of participants (% response)	160(56)/153(47)	468 (48)	925 (71)*	758(58)/ 493(76)**
Noise levels exposed side L_{Aeq24h} dB	48-71/48-71	45-65	45-70	48-71
L_{day}	Yes/Yes	Yes	Yes	No
$L_{evening}$	Yes/Yes	Yes	Yes	No
L_{night}	Yes/Yes	Yes	Yes	No
Noise levels shielded side	Yes	No	No	No
Questions:				
Windows facing roads, railway and courtyard	Yes	Yes	Yes	Yes
Bedroom window facing roads and courtyard	Yes	Yes	Yes	Yes
Access to nearby green areas	Yes	Yes	Yes	Yes
Access to quiet rooms	Yes	No	Yes	Yes
Access to quiet outdoor places	Yes	No	Yes	Yes
Annoyance (ISO/ICBEN 5-point category scale)	Yes	Yes	Yes	Yes
Annoyance (ISO/ICBEN 11-point scale)	No	Yes	No	Yes
Disturbances of sleep with closed/open window (summed 2-parts questions)	Yes	Yes	Yes	Yes, but not split into closed/ open window
Background variables (age, sex, civil status, employment, education, noise sensitivity)	Yes	Yes	Yes	Yes

*This dataset (*n*=925) is selected from the original dataset of the Lerum study (*n*=1953) and consist of individuals who are exposed to varying noise levels from road traffic and low noise levels from railway traffic (L_{Aeq24h} <51 dB). **n=493 individuals participated in both the before and the after study.

Other relevant studies about "quiet" facades:
An article of Bluhm et al [9] on road traffic noise annoyance is also relevant for QSIDE. The article describes a cross-sectional questionnaire study conducted in Stockholm county (n=657, L_{Aeq24h} <45 – >55 dB). A question on bedroom window orientation (facing street or yard) was included. Effects on annoyance and sleep disturbance were found.

4.1.3. University of Ghent

In Flanders, Belgium, a survey on the quality of the living environment is conducted every 3 years. This survey contains a few questions that could be of relevance for investigating the influence of the presence of a quiet side. The first relevant question asks how pleased the resident is with the quality of the living environment, the second relevant question polls for noise annoyance in and around the house over the last 12 months and relates it to different noise sources. Three databases with 3 year intervals are available counting 13000 participants in total.

In a previous study (Botteldooren et al. 2011 [10]), a detailed assessment of the noise exposure for the subset of dwellings in Ghent was conducted. It included not only the noise level at the most exposed façade but also the level at the least exposed façade, the noise exposure within a 300 m distance from the house measured along the most probable routes for leaving the dwelling, etc. Logistic regression analysis revealed that the noise level at the least exposed façade had a small but significant effect on the prediction of reporting good quality of the living environment. It had no significant effect on the prediction of reporting poor quality of the living environment and no significant effect on the prediction of high or low street traffic noise annoyance. The noise exposure over the first 300 m of common trips was a significant predictor for poor and high quality of the living environment and for reported street traffic noise annoyance.

Although the above mentioned analysis may have suffered from poor prediction of noise levels at the least exposed façade, it gives some indication on the effects one may look for in future analysis. In particular the noise level in the neighborhood of the dwelling should be considered. Moreover, it seems useful to distinguish between positive and negative evaluation of the quality of the living environment in general and noise annoyance in particular. The presence of a quiet side may influence the positive perception (very low level of annoyance or positive appreciation of the living environment) more than the negative perception (high annoyance or strong dissatisfaction with the living.

4.1.4. Amsterdam

The (END) noise map 2006 for Amsterdam gives detailed information on the noise level on dwellings in Amsterdam. The main source is road traffic. A new noise map for the second tranche of the END is in progress.

In 2005 a questionnaire on noise nuisance was held by the Department of Research and Statistics of the city of Amsterdam under 1007 inhabitants. Noise from roads and neighbours caused the most nuisance.

> *One of every five inhabitants experiences heavy nuisance of noise.*

In 2010 the Health Service department of Amsterdam published a health monitor (www.gezond.amsterdam.nl / Scientific Research / Amsterdam-Health Monitor). Over 6600 inhabitants of Amsterdam joined this study.

> *Nearly one third of Amsterdam suffers from serious noise nuisance, mainly by construction and demolition activities, neighbours, mopeds and scooters.*

In both studies the results for individual addresses can be coupled with calculated (END) noise levels.

4.2. Quiet areas – human response

The QCity approach to quiet areas is a starting point for the development of the QSIDE response model for quiet areas.

In general, the assessment of the beneficial effect of quiet areas is more complicated than for quiet facades. A quiet (green) area near one's dwelling provides an opportunity for recreation such as walking or reading a book. A mechanism for the beneficial effect may be restoration of inhabitants from the harmful effects of traffic noise at home.

An objective in QSIDE Action 1.2 is to find noise surveys and cohort studies that include accurate information about access to nearby quiet areas. Coordination with the work in QSIDE on the *acoustical* characterization of quiet areas is essential.
A point that may be addressed in QSIDE is the role of other noise sources than traffic noise in the appreciation of a quiet area (this may also apply to quiet facades). An example is (low frequency) noise of air conditioning systems in quiet areas [11].

Of great interest for QSIDE is a recent paper by UGOT about the role of nearby green areas in noise annoyance [12]. Of interest is also a study of attractive quiet urban areas in Amsterdam [13]. This study has shown that closed courtyards and parks are popular among the inhabitants, and that non-acoustic parameters (vegetation, water, attractive buildings) play an important role in the appreciation of a quiet area.

4.2.1. TNO

In principle the studies mentioned in 4.1 are also of potential interest to study the effects of quiet areas. This however, requires calculating (and adding to the database) the needed additional indicators for ambient noise in the surroundings of the dwelling. The city of Amsterdam seems here of particular interest, as from the questionnaire data information is available on respondents perception of the urban green space in their neighbourhood (e.g. accessibility, quality of maintenance, visual attractiveness, safety, restorative quality, recreative function, walking distance, and 'abundance' of green spaces). Furthermore, the noise mapping currently in progress is expected to make calculation of the relevant (area) indicators of noise exposure in ambient surroundings possible. For the full study area of the GLOBE cohort study (which comprises 18 municipalities), currently no area covering noise data is available.

4.2.2. University of Gothenburg

The main objectives of the study were to explore whether green-area availability moderates resident's noise responses and whether the potential effect of green-area availability varies depending on access or not to a quiet side of the dwelling [12].

Study areas
The study was conducted in residential city areas in Stockholm and Gothenburg, Sweden. The selection of the different study sites was based on a number of criteria, for example, similar noise exposures, no other dominating noise source than road traffic, similar houses according to height and type (3-5 storied apartment buildings), similar dwellings according to layout (at least 2 rooms in addition to a kitchen, access to a balcony/outdoor space), and similar population characteristics (see [8]).

Noise Exposure
Outdoor sound levels at both sides of *each* dwelling were determined by: (1) long-term measurements (not on holidays); (2) short-term measurements (at least 30 min or 500 vehicles); (3) counting of traffic data, and (4) calculations of road traffic noise levels ($L_{Aeq,24h}$, L_{day}, $L_{evening}$, L_{night}, L_{AFmax}) based on traffic input and geometrical data for the site. The sound level values at the "quiet" side include the façade reflection according to the new calculation model developed in the research program "Soundscape Support to Health". The particular storey was considered in the calculations. No calculations of noise levels in the green areas were done at the time of the study, however, based on noise maps it will be possible to estimate this in 5 dB intervals..

Study population and questionnaire
Socio-acoustic surveys were conducted in spring or autumn 2000 to 2002. Out of 956 participants (59% response rate), a restricted dataset of 500 residents was selected and they were all exposed to *high road-traffic noise exposures*, i.e. $L_{Aeq,\,24h}$ = 60 to 68 dB at the most exposed facade of the dwelling (dB mean = 62, SD = 2.14; free field value). Of the 500 residents, 367 lived in dwellings with access to a quiet side ("noise/quiet"-condition) and 133 lived in dwellings with no access to a quiet side ("noise/noise"-condition).

Based on self-reported perceived availability to green areas, two groups were formed: residents with "poorer" availability (no/rather good) to green areas (*n*=354) and residents with "better" availability (very good) to green areas (*n*=146). To validate the construction of these two green-area groups, we examined recent aerial photographs over the study sites and their surroundings and approximately judged the distance between each of the sites and the nearest green area.

Table **4-3** shows the number of participants in two green area-groups ("poorer" and "better" perceived availability to green areas) and two noise conditions ("noise/quiet" and "noise/noise").

Table 4-3. Distribution of residents in two green area-groups (“poorer” and “better” perceived availability to green areas) and two noise conditions (“noise/quiet” and “noise/noise”).

Noise conditions	Green area-groups		Total
	Poorer access	Better access	
Noise/quiet	251	116	367
Noise/noise	103	30	133
Total	354	146	500

Questions relevant for QSIDE, see the JSV-study [8].

Results
The results indicate that the degree of perceived availability to nearby green areas affected the resident’s responses to road traffic noise (Figure 4-2) For both those with and without access to a quiet side of their dwelling, “better” availability to green areas decreased long-term noise annoyance experienced during the last 12 months, reports of noise as a neighborhood problem, and noise disturbance of outdoor stay. Furthermore, compared to the influence of having access to a quiet side of one’s dwelling, green-area availability seems, in general, to have a similar moderating effect on resident’s noise responses, and this effect did not varied significantly with the two noise conditions (i.e. no interaction effects).

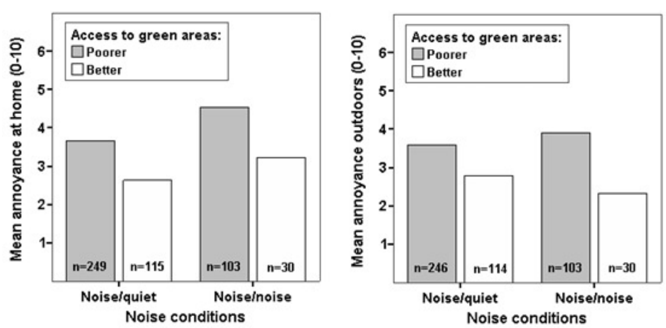


Figure 4-2. Mean road traffic noise annoyance “at home” (left) and “outdoors close to the dwelling” (right) in relation to perceived availability to green areas (“poorer” and “better”) and noise condition (“noise/quiet” and “noise/noise”).

Other studies potentially of interest for studying effects of quiet areas

This cross-sectional study is part of the TVANE-project, which investigates the effects of road traffic and railway noise on health and well-being. Specific analyses have examined the association between noise annoyance experienced at home and distance to the green areas as well as perceived green-area characteristics (good sound environment, high attractiveness and potentials for recreational activities) [14].

Study areas
Residential areas in two smaller Swedish cities (Borås and Kungälv) exposed to road traffic noise were surveyed using a socio-acoustic questionnaire. The selection of these study areas were based on a number of criteria set for the larger study, which compares effects of railway noise with road traffic noise (see [15]).

Noise Exposure
Sound levels from road traffic (e.g. $L_{Aeq,24h}$) were calculated with the Nordic Prediction Method based on traffic input data and geometrical data of the field site at individual façade positions 2 and 4 m above ground at the most exposed facade of each residential building. The calculations refer to incident-field values, i.e. without the impact of the "own" building facade, but with the impact of reflections in other nearby objects. Control measurements were done in both Borås and Kungälv.

Study population and questionnaire
The restricted dataset used in the study (*n*=468) is based on questionnaire data obtained from 1 188 residents (48 % response rate). Originally one individual between 18 and 75 years of age in each home was selected. The 468 residents were all exposed to road-traffic noise exposures between $L_{Aeq,24h}$= 45 to 65 dB at the most exposed facade of the dwelling. The remaining residents with lower and higher sound levels were excluded from further analyses. Two sound level categories were formed: 45-55 dB (*n*=297) and 56-65 dB (*n*=171).

Access to green areas was assessed with the following question: “Are there green areas (park or similar) within walking distance of your home or in the neighborhood?” (response categories=“Yes, within 400 m (within 5 minutes walking distance)”, “Yes, within 500-800 m”, Yes, but more than 800 m”, and “No”. Those who marked any of the “Yes”-categories were requested to answer questions about how they perceived the green areas regarding e.g. the sound environment.

Questions relevant for QSIDE, see Table 4-2.

Results
The results show that presence of a green area, a closer distance to it from the subject’s home, and perceived green-area characteristics (good sound environment, high attractiveness and potentials for recreational activities) significantly lowered noise annoyance. The perceived sound environment of the green area was of particular importance, see Figure 4-3.

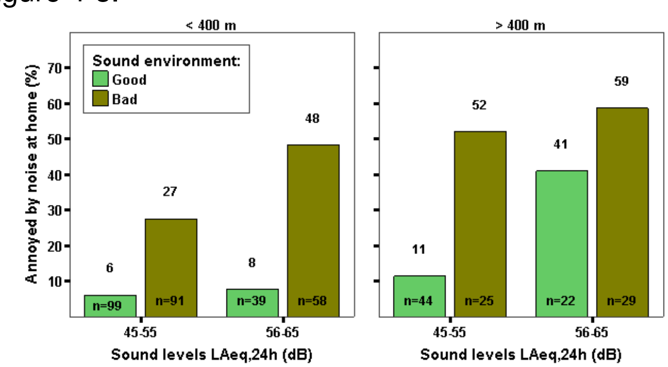


Figure 4-3. Percentage annoyed by road traffic noise at home in relation to perceived sound environment of the green area, sound levels ($L_{Aeq,24h}$), and distance to the green area (left panel < 400 m; right panel > 400 m).

Another relevant study about green areas and noise annoyance was reported by Li *et al.* in 2010 [16].

4.2.3. University of Ghent

From Action 2 noise data are expected to become available for Ghent for 400 respondents from the Flanders survey on the quality of the living environment. The size of this sample may increase if suburban areas of Ghent can be included. These data are potentially relevant for investigation of the hypothesized beneficial effects of quiet areas in Action 3.

4.2.4. Amsterdam

In 2008-2009 the 'Amsterdam quiet areas project' was performed [13]. This study was triggered by:

- the END, which pleads for protection of *quiet facades* and *quiet areas* in cities the European noise directive;
- An advice of the Dutch Health council, which emphasizes the importance of quiet areas in the city, to compensate for noise nuisance and other forms of stress.

The Amsterdam quiet areas study consisted of a survey under more than 1000 inhabitants and specific actions to get insight in the importance of existing quiet areas in Amsterdam. For instance: respondents were asked for their favourite quiet site in the city. This resulted in 1.280 responses. The main conclusions of the study are:

- Rest is important, as well at home (75%) as in the neighbourhood (51%).Most people (82%) know a quiet place in the neighbourhood and 50% visit a quiet place weekly. Respondents mentioned a quiet area 2315 times, covering 145 specific areas. In almost all these areas the calculated average daytime level (Lday) due to transportation noise was between 35 to 60 dB(A), with a possible preference for levels between 35 to 40 dB(A).
- In the areas where the level was above 40 dB(A) other characteristics like the presence of green, seem to compensate for the higher noise level and these areas are still considered as relatively quiet. In the Amsterdam quiet areas project, the presence of green or water was mentioned most often.
- There are no simple criteria for a quiet area. Internationally the criteria vary from 40 dB to 55 dB (Lden or Leq).
- Based on these results a target level of 40 dB(A) is recommended (the golden standard) and an upper limit of 55 dB(A) depending on the quality of the area (both in Lden). The upper limit of 55 dB(A) concurs with the lowest level of the present EU noise maps (Lden values are somewhat higher in main transport roads, so the upper limit is somewhat more ambitious).
- At higher noise levels (above 40 to 45 dB) a place can still be perceived as a quiet place if the sound level is well below the level of the surrounding area. As a rule of thumb an area can still be considered 'quiet' if the surrounding noise level differs 10 dB or more.

5. Quiet facades and quiet areas in European cities - results of Action 1.3

An important result of QSIDE will be a document prepared in Action 5 describing how the results of QSIDE can be employed by European cities for the development of effective environmental noise policy and urban development plans. The document will not have the character of a scientific report, but rather will be a practical guideline for city authorities responsible for urban noise control.

In Action 1.3 we have collected information from a number of European cities on current approaches to quiet facades and quiet areas. The information provides a starting point for the preparation of the document in Action 5.

QSIDE partner Amsterdam has coordinated the collection of the information from the cities, including QSIDE partner Gothenburg, and has also prepared the description in this section.

5.1. Introduction

One of the actions in Action 1 was to consult a small number of cities in the EU on plans or policies that pay attention to the quiet side of dwellings and/or quiet places in their city. To this end officials working at a number of cities have been contacted and requested to answer five questions (see section 5.2). Officials at ten cities have been contacted via personal contacts, of whom seven replied. A request to co-operate was also sent to members of the Working Group Noise of the EUROCITIES network (http://workinggroupnoise.web-log.nl), yielding three more. In a late stage input was provided by a representative of two Spanish cities. Including the QSide partners Amsterdam and Gothenburg we thus obtained response from 15 cities in 12 countries (BE, CH, DE, ES, FI, FR, HR, IT, NL, NO, SE, UK), including non-EU countries Switzerland, Norway, and Croatia. The Croatian city of Zagreb could not give any relevant information, indicating there is no such policy there and apparently is not foreseen.
In appendix A the cities are listed as well as the officials who actually gave the information.

5.2. Results

The general outcome of the consultation will be presented here. In table 5-1 the results are presented in a shorthand way. In appendix B the full response from each city is given, except for Bilbao and Zaragoza who only provided information for this summary. Mostly the response is in English, but some preferred their own language.
It must be kept in mind that the information has been requested and provided in an informal way and reflects the knowledge of an informed official or representative. It is not formally approved by any of the city councils. The summary below is an interpretation of the author, not of the officials.

The cities are: Amsterdam, Bilbao/Zaragoza, Bristol, Brussels, Florence/Pisa, Gothenburg, Hamburg, Helsinki, Oslo, Paris, Utrecht, Zagreb and Zürich.

1) Do quiet façades and/or quiet areas play a role in the noise policy and development plans of your city?
Façades. In seven cities quiet façades (or: "noise averting" façades) play a role in noise policies and/or plans, in Amsterdam, Utrecht, Hamburg, and Gothenburg based on strict noise levels. Usually this is the condition that if the noisy side is above the noise limit, then the other quiet side must comply with the limit. In Gothenburg this only applies within the central part of the city, in Helsinki this is recommended.
Areas. In one city only (Brussels) there are concrete proposals to designate quiet areas and integrate them into the noise action plans. The quiet areas are in well visited public spaces, but can also be in residential quarters. In three other cities (Amsterdam, Helsinki, Paris) it is foreseen that quiet areas will be part of the future noise policy. Amsterdam carried out a survey, Helsinki tried to create awareness for quiet areas in the first noise action plan, and Paris is in the process of defining and localizing quiet areas.

2) Do you have a practical definition of quiet façades and/or quiet areas as employed in your city?
Façades. In six cities a quiet façade is defined only if another façade is exposed above a certain limit (usually the standard façade noise limit). If so, quietness is defined as complying with the limit. In some cases this applies to traffic noise only, in other cases this also applies to railway noise and/or industrial noise. Only in Helsinki the noise limits also apply to the garden or balcony.
In Brussels and Helsinki a quiet façade means that the sound level there is at least 20 dB below the level at the noisy side. In Helsinki also the sound level must not exceed the noise level guidelines ($L_{Aeq7-22} < 55$ dB and $L_{Aeq22-7} < 50$ dB).
Areas. Four definitions are given, of which two have a formal status (the others are proposed). In Finland there is a national definition, only in terms of equivalent sound level. The Brussels definition includes an Lden limit, but for quiet public spaces also other criteria (green, accessibility, area size). The other proposed definitions also combine acoustic and non-acoustic criteria (Amsterdam) or are entirely non-acoustic (Oslo).

3) Does traffic noise play a role in the management of or policy on usually quiet urban areas such as parks and courtyards?
Three cities pay attention to this aspect. In Brussels the possibility of traffic reduction (by parking fees or toll) is investigated if the noise exposure exceeds the limit. This is also the case in Florence, though perhaps with different means. In Paris the noise exposure is measured and noise sensitive activities are preferably placed in a low exposure zone.

4) Do you think that non-acoustic parameters are important in the appreciation of quiet areas? Do you have any ideas what parameters should be used and how?
In all cities (except Hamburg where this item was not answered) non-acoustic parameters are considered important. Most often mentioned features are: presence of green and/or water, well kept, clean and safe, accessible and available to a variety of users. The area must have quality and be attractive. Also mentioned were: the presence of (sufficient but not too many) people and suitability for different uses (such as sitting, walking or exercise). Acoustically a *relatively* (compared to the surrounding area) low noise impact is important.

5) What approach did your city follow for quiet façades and quiet areas in the first round of noise mapping and action plans for the Environmental Noise Directive? Do you expect this will be different in the next round?

Façades. Hamburg, Gothenburg and Amsterdam have a quiet façade policy that is one of the instruments in their action plans. Hamburg formulated a new policy to protect them if there is a noisy front façade. Amsterdam, Gothenburg, and Zürich already had a policy for this. In the other cities no attention was paid to quiet façades. In two cities (Brussels, Helsinki) there may be some attention for quiet façades in the next round of action plans. Bristol has no input of its own into the action plan as in the UK noise mapping and action plans are centralised at the national government.

Areas. Most cities did pay at least some attention to quiet areas. Brussels already formulated a policy for quiet areas and this will likely be continued in the next round of noise action plans. Paris is working on the definition and localization of quiet areas and public consultation, which may find its way in the next round. Four more cities (Amsterdam, Gothenburg, Helsinki and Oslo) are paying attention to the topic, but as yet without a clear vision. In Bilbao and Zaragoza only the noise mapping results have been used for the declaration of quiet areas. Nevertheless both municipalities have identified the necessity of considering other aspects in the evaluation of the quality of environmental sound in these areas that are more in relationship with the soundscape concept.

Table 5-1. Overview of policies and plans in European cities.

City	*Quiet **façades** in policy and development plans*	*Quiet **areas** in policy and development plans*	*Definition quiet **façade***	*Definition quiet **area***	*Traffic noise policy on quiet areas*	*Importance of non-acoustic parameters: ideas*	*Quiet **façades** in noise mapping and action plans*	*Quiet **areas** in noise mapping and action plans*
Question #	*1*	*1*	*2*	*2*	*3*	*4*	*5*	*5*
Amsterdam	yes	not yet	< standard limit (48 dB Lden road traffic, 55 dB railway noise, 50 dB industrial noise)	proposed: <55 dB Lday/Lden, relatively noise free, visual/ spatial quality, "clean, unbroken and safe"	no	yes: green and/or water, well kept, clean, safe, easily accessible and in every neighbourhood, fit for intended or actual use	Yes: only implicitly in first round, possibly as a correction on predicted noise annoyance from the noisy façade in the next round.	A dedicated project in the first round. Possibly a practical pilot in the second round.
Bilbao	no	no	quiet side < noisy side - 20 dB (Directive 2002/49/CE)	Lday < 60 dBA, considering all environmental noise sources (road/rail traffic, industry)	yes, traffic management.	yes: public space/area to be preserved (from the development point of view) and used by the citizens (parks, squares, peri-urban green, natural areas). Municipality considers that a quiet area next to a dwelling is a citizen right	no: not enough detail in definition of dwellings in cartography to consider this approach in noise mapping	yes: analyzed in noise map and prioritized in action plan: 2 of 16 actions refer to quiet areas. Municipality will declare one quiet area per district (8 in total)
Bristol	no	no	none	none	not yet	yes: quality, access, uses	national, not local authority	national, not local authority
Brussels	yes	yes	quiet side < noisy side - 20 dB	<55 dB Lden + criteria [4]	traffic reduction (parking fees, toll)	yes: access, big enough, green, limited acoustic and visual impact of surface transport, popular (but not too), well kept, quality equipment	--	yes, definition and first applications; integration into sustainable development plan

[4] residential areas: <55 dB Lden due to surface transport and few industrial, recreational activities; public spaces: green and wooded, publicly accessible spaces of > 1 ha and >100 m from roads, with Lden< 55dB over at least 50% of surface

City	*Quiet **façades** in policy and development plans*	*Quiet **areas** in policy and development plans*	*Definition quiet **façade***	*Definition quiet **area***	*Traffic noise policy on quiet areas*	*Importance of non-acoustic parameters: ideas*	*Quiet **façades** in noise mapping and action plans*	*Quiet **areas** in noise mapping and action plans*
Florence /Pisa	yes	action plan should consider back façades [5]	no	issued by Italian legislation	traffic restriction if above limit	yes	yes, quiet façades mapped, protection considered in action plans	study of soundscape applications
Gothenburg	yes, in central city	No	preferably <45 dBA Leq; obligatory < 50 dBA Leq for traffic noise	none	not yet	yes: visual (natural scenery, light), social, safety, attractiveness	measurements performed in courtyards related to very noisy façades (>65 dBA Leq)	measurements performed in parks
Hamburg	yes	No	<49 dB Lnight in residential, <54 dB in mixed areas for traffic noise	none	--	--	yes, new guideline	proposed guideline, not implemented in first round
Helsinki	partly	No	< standard limit (55 dBA Leq7-22; 50 dBA Leq22-7 (on façade and garden/balcony)	national: <50 dBA Leq7-22 and < 45 dBA Leq22-7	no	yes: important to public, distant from noise sources , peaceful, suitable for rest/walking/activities, locally available and accessible for all	estimate of number of residents with quiet side<noisy side - 20 dB	raising awareness, quiet areas (<50 dBA Leq7-22) identified
Oslo	no	no	none	recreational and/or cultural quality, shielded or distant from dominating noise sources	not yet	yes: locally available and accessible for all	no	proposal for quiet areas

[5] roads with different traffic flow have different limit

City	*Quiet **façades** in policy and development plans*	*Quiet **areas** in policy and development plans*	*Definition quiet **façade***	*Definition quiet **area***	*Traffic noise policy on quiet areas*	*Importance of non-acoustic parameters: ideas*	*Quiet **façades** in noise mapping and action plans*	*Quiet **areas** in noise mapping and action plans*
Paris	no	not yet	no	not yet	zoning based on acoustic study of public space	yes: e.g. cleanliness	no	low-noise mapping, definition of typology/descriptors, public consultation, council approval
Utrecht	yes	No	< standard limit (48 dB Lden road traffic, 55 dB railway noise, 50 dB industrial noise)	no	no	yes: green, water, tidy, safe	No (END did not apply in first round)	No (END did not apply in first round)
Zagreb	no	No	no	no	no	--	no	no
Zaragoza	no	no	quiet side < noisy side - 20 dB (Directive 2002/49/CE)	Lday < 60 dBA, considering all environmental noise sources (road/rail traffic, industry)	no	yes: public spaces used by the citizens (parks, squares, peri-urban green, natural areas)	no: not enough detail in definition of dwellings in cartography to consider this approach in noise mapping	yes: analyzed in noise map and considered in action plan: 5 quiet areas declared in city
Zurich	yes	no	<standard limit	no	no	yes: green	not applicable (non-EU)	not applicable (non-EU)

5.3. EU review

After the first round of noise maps and action plans resulting from the Environmental Noise Directive 2002/49/EC, the European Commission commissioned a project reviewing the implementation of the Noise Directive. This project entailed three tasks, including a review of the implementation of the key provisions of the Directive by the Member States and the possible development of proposals for the amendment of the Directive. This has been reported in the “Final Report on Task 1: Review of the Implementation of Directive 2002/49/EC on Environmental Noise” of May 2010. One of the topics is the definition of quiet areas. An overview of the solutions taken from the 27 Member States to define quiet areas is given in Table 5-2, taken from the report (table 5.6 in report).

Table 5-2. Approaches adopted towards the definition of quiet areas in the EU Member States

Solutions adopted by Member States in defining quiet areas	**Member State**
Cross-reference surface of the quiet area and low noise values: >3ha and Lden <=50db >4.5ha and Lden <= 55db	Estonia Romania
Cross-reference: - open spaces and low noise value (i.e. <55db) - open-spaces and amenity value (i.e. open-space size, low noise value, etc.)	UK
Wish to preserve or improve quietness “external space remarkable for their limited exposure to noise” Use of previous local noise assessments	Denmark France Sweden
National/Regional studies launched	Belgium, Brussels Administration
Protection around fragile spaces (i.e. hospitals, schools, etc.) Protection of recreation areas Public accessible space Areas for special protection (ZEPQA)	Italy Bulgaria Sweden Denmark Spain
Use of previous existing legislation: - policy for silent rural areas - “Plan Sectoriel Paysage” for the protection of landscapes under the European Landscape Convention - Use of previous noise indicators (i.e. LAeq, LAmax, etc.)	Belgium, Flemish Administration Luxembourg Slovakia (but supplementary to Lden)
Creating quietness in the vicinity of noise sources by designating quiet areas	Lithuania
Taking into account the current and the future land use on the site and in the vicinity Area free of road, rail, air, industry and recreational noise	Poland
Use of the noise indicator L_{den}: Within agglomerations Outside agglomerations	Denmark, Portugal, Brussels Region, Italy, Romania, Poland, Estonia, Latvia, Bulgaria, the Netherlands, Lithuania Bulgaria, Poland, the Netherlands

In the report the reviewers conclude that, "in general, member states made little progress towards the inclusion of quiet areas in both strategic noise maps and in action plans, with few having actually included any measures to protect quiet areas in action plans."
They propose several solutions to problems raised by the member states (text quoted from report pages 198 and 200):
1: More detailed definition of quiet areas
The development of a more detailed definition of quiet areas for inclusion in the Directive is proposed, with specific inclusion of possible criteria against which to identify quiet areas. A working group, drawing on Member States' best practices, could refine the definition.
Regarding quiet areas in agglomerations, a definition could include both acoustic and non-acoustic criteria, such as:

- the protection of vulnerable areas (schools, hospitals, etc.);
- areas free of any industrial and transport interference; and
- the protection of areas used for recreational use (parks, public spaces, etc.).

2: Specify the requirement to map quiet areas in agglomeration in Article 7
Article 7 could explicitly include a requirement to map quiet areas in agglomerations, so as to facilitate the implementation of protective measures and send a consistent regulatory message.

3: Strengthen requirements regarding the protection of quiet areas in action plans
The Directive could include, in its Article 8 on action plans, a specific paragraph on the purpose of the designation of quiet areas, both in agglomeration and in open country. Annex V could then provide further details, requiring Member States to set up protective measures with a view to keep noise levels in quiet areas under a certain limit (i.e. 50-55db).

4: Focus on quiet areas in agglomerations
The Commission could propose to the Parliament and the Council an implementing strategy on the protection of quiet areas in agglomerations (and not in open country). References to quiet areas in open country could be deleted from the END.

References

References for chapter 1

[1] Environmental Noise Directive 2002/49/EC, http://ec.europa.eu/environment/noise/
[2] H.M.E. Miedema, C.G.M. Oudshoorn, "Annoyance from transportation noise: Relationships with exposure metrics DNL and DENL and their confidence intervals." *Environ. Health Perspect.* **109** (2001) 409-416.
[3] H.M.E. Miedema, H. Vos, "Associations between self-reported sleep disturbance and environmental noise based on reanalyses of pooled data from 24 studies." Behavioral Sleep Medicine **5** (2007) 1-20.
[4] World Health Organization. Burden of disease from environmental noise: Quantification of healthy life years lost in Europe. WHO publication 2011. Available from www.euro.who.int.
[5] H.M.E. Miedema and H.C. Borst, "Rating environmental noise on the basis of noise maps", report for EC project Quiet City Transport (QCity), 2007. A short version of the work presented in this report was presented at the Euronoise conference in 2006, in Tampere, Finland (available on the CD-ROM).
[6] H.C. Borst and H.M.E. Miedema, "Comparison of noise impact indicators, calculated on the basis of noise maps of *DENL*", Acta Acustica united with Acustica **91** (2005) 378-385.
[7] D. Botteldooren, L. Dekoninck and D. Gillis, "The influence of traffic noise on appreciation of the living quality of a neighborhood," Int. J. Environ. Res. Public Health **8** (2011), 777-798.
[8] F. van den Berg and H. Booi, "The need for quiet in Amsterdam: a survey," Proceedings Euronoise 2009, October 26-28, 2011, Edinburgh, Scotland.
[9] F. van den Berg and A. Brand, "Recommendations for public quiet places in Amsterdam" Proceedings Euronoise 2009, October 26-28, 2011, Edinburgh, Scotland.

References for chapter 3

[1] P. Thorsson, M. Ögren, and W. Kropp, "Noise levels on the shielded side in cities using a flat city model", Appl. Acoust. **65** (2004) 313-323
[2] E.M. Salomons, H. Polinder, W.J.A. Lohman, H. Zhou, H.C. Borst, and H.M.E. Miedema, "Engineering modeling of traffic noise in shielded areas in cities," J. Acoust Soc. Am. **126** (2009) 2340-2349.
[3] B. Plovsing and J. Kragh, "Nord2000. Comprehensive Outdoor Sound Propagation Model. Part 1: Propagation in an Atmosphere without Significant Refraction", DELTA Akustik & Vibration, Rapport AV 1849/00, revised Hørsholm, (2006).
[4] B. Plovsing and J. Kragh, "Nord2000. Comprehensive Outdoor Sound Propagation Model. Part 2: Propagation in an Atmosphere with Refraction", DELTA Akustik & Vibration, Rapport AV 1851/00, revised Hørsholm, (2006).
[5] B. Plovsing, "Proposal for Nordtest Method: Nord2000 – Prediction of Outdoor Sound Propagation," DELTA Akustik & Vibration, Rapport AV 1106/07, (2007) revised (2010).
[6] B. Plovsing, "Nord2000. Validation of the Propagation Model", DELTA Akustik & Vibration, Rapport AV 1117/06, (2006).
[7] Dutch standard model for road traffic noise ("Calculation and measurement method for road traffic noise 2002"), regulation LMV 2002 025825 of Dutch Ministry of Environment (in Dutch). The model provides a non-spectral method SRM1 and a

spectral method SRM2; for this study the method SRM2 has been used. For the calculation of noise maps in the framework of the END, a simplified Dutch method SKM2 has been developed; the description of SKM2 is not yet sufficiently unambiguous for use in a scientific study. The model descriptions can be downloaded from URL http://www.stillerverkeer.nl. (maintained by the Dutch public authorities). An English translation of the model description has been prepared, which is available through the Electronic Physics Auxiliary Publication Service (EPAPS) of the American Institute of Physics.

[8] ISO 9613-2, *Acoustics - Attenuation of sound during propagation outdoors - Part 2: General method of calculation*, ISO, 1996. URL: http://www.iso.org.

[9] European Directive on Environmental Noise, 2002/49/EC, URL: http://ec.europa.eu/environment/noise/home.htm (website of the European Commission).

[10] E.M. Salomons, “Reduction of the performance of a noise screen due to screen-induced wind-speed gradients. Numerical computations and wind-tunnel experiments”, J. Acoust. Soc. Am. **105** (1999) 2287-2293.

[11] E.M. Salomons, *Computational atmospheric acoustics* (Kluwer, Dordrecht, 2001), p. 289-295.

[12] Z. Maekawa, “Noise reduction by screens,” Appl. Acoust. **1** (1968) 157-173.

[13] E.M. Salomons, “Noise barriers in a refracting atmosphere”, Appl. Acoust. **47** (1996) 217-238.

[14] U.J. Kurze, “Noise reduction by barriers”, J. Acoust. Soc. Am. **55** (1974) 504-518

[15] D. van Maercke and J. Defrance, “Development of an analytical model for outdoor sound propagation within the Harmonoise project”, Acta Acustica united with Acustica **93** (2007) 201-212.

[16] E.M. Salomons, D. van Maercke, J. Defrance, F. de Roo, “The Harmonoise sound propagation model”, Acta Acustica united with Acustica **97** (2011) 62-74.

[17] K. Yeow, W. Popplewell and J.F.W. MacKay, “Method of predicting Leq created by urban traffic,” J. Sound Vib. **53**, (1977) 103-109.

[18] M. Schiff, M. Hornikx and J. Forssén, “Excess attenuation for sound propagation over an urban canyon,” Appl. Acoust. **71** (2010) 510-517.

[19] M. Ögren and W. Kropp, “Road traffic noise propagation between two dimensional city canyons using an equivalent sources approach”, Acta Acustica united with Acustica **91** (2004) 293-300.

[20] M. Hornikx and J. Forssén, “The 2.5-dimensional equivalent sources method for directly exposed and shielded urban canyons”, J. Acoust. Soc. Am. **122** (2007) 2532-2541.

[21] M. Hornikx and J. Forssén, “Noise abatement schemes for shielded canyons”, Appl. Acoust. **70** (2009) 267-283.

[22] M. Ögren and J. Forssén, "Modelling of a city canyon problem in a turbulent atmosphere using an equivalent sources approach", Appl. Acoust. **65** (2004) 629-642.

[23] M. Hornikx, R. Waxler and J. Forssén, “The extended Fourier pseudospectral time-domain method for atmospheric sound propagation”, J. Acoust. Soc. Am. **128** (2010) 1632-1646.

[24] M. Hornikx, “Numerical modeling of sound propagation to closed urban courtyards”, PhD Thesis, ISBN 978-91-7385-298-2. Department of Civil and Environmental Engineering, Division of Applied Acoustics, Vibroacoustics Group, Chalmers University of Technology, Sweden, (2009).

[25] M. Hornikx and J. Forssén, “Modelling of sound propagation to three-dimensional urban courtyards using the extended Fourier PSTD method”, *Submitted for publication in Appl. Acoust.* (2010).
[26] T. Van Renterghem, D. Botteldooren, "Meteorological influence on sound propagation between adjacent city canyons: a real-life experiment"; Journal of the Acoustical Society of America, 127 (6), p. 3335-3346, 2010.
[27] T. Van Renterghem, D. Botteldooren, "The importance of roof shape for road traffic noise shielding in the urban environment", Journal of Sound and Vibration, 329 (9), p. 1422-1434, 2010.
[28] T. Van Renterghem, D. Botteldooren, "Reducing the acoustical façade load from road traffic with green roofs", Building and Environment, 44 (5), p. 1081-1087, 2009.
[29] T. Van Renterghem, D. Botteldooren, "Numerical evaluation of sound propagating over green roofs", Journal of Sound and Vibration, 317 (3-5), p. 781-799, 2008.
[30] T. Van Renterghem, E. Salomons, D. Botteldooren, "Parameter study of sound propagation between city canyons with coupled FDTD-PE model", Applied Acoustics, 67 (6), p. 487-510, 2006.
[31] T. Van Renterghem, D. Botteldooren, "In-situ measurements of sound propagating over extensive green roofs", Building and Environment, 46 (3), p. 729-738, 2011.
[32] A. Randrianoelina and E. Salomons, “Traffic noise in shielded urban areas: comparison of experimental data with model results”, proceedings ASA-EAA meeting Acoustics 08, July 2008, Paris.
[33] H. Jonasson and H. Nielsen, “Road Traffic Noise – Nordic Prediction Method”, ISBN 92 9120 836 1, TemaNord 1996:525, Nordic Council of Ministers.
[34] J. Forssén and M. Hornikx, “Statistics of A-weighted road traffic noise levels in shielded urban areas”, Acta Acustica united with Acustica **92** (2006) 998-1008.
[35] D. Heimann, “Three-dimensional linearised Euler model simulations of sound propagation in idealised urban situations with wind effects”, Appl. Acoust. **68** (2007) 217-237.
[36] H. Kuttruff, H., “A mathematical model for noise propagation between buildings,” J. Sound Vib. **85** (1982) 115-128.
[37] Botteldooren, D., De Coensel, B., and De Muer, T. (2006). "The temporal structure of urban soundscapes," Journal of Sound and Vibration 292, 105-123.
[38] De Coensel, B., and Botteldooren, D. (2006). "The quiet rural soundscape and how to characterize it," Acta Acustica United with Acustica 92, 887-897.
[39] T. Van Renterghem, D. Oldoni, D. Botteldooren, "Sound propagation in a park over the year," Proceedings of the 39th international congress and exposition on noise control engineering (Internoise 2010), Lissabon, Portugal.
[40] D. Heimann, “On the Efficiency of Noise Barriers Near Sloped”, Acta Acustica united with Acustica **96** (2010) 1003-1011.

References for chapter 4

[1] Dutch Ministry of Environment VROM (2006). Meet- en rekenvoorschrift geluidhinder 2006 (Prescribed measurement and calculation methods for noise annoyance 2006). Staatscourant 21 december 2006a: 249, 84. See www.stillerverkeer.nl.
[2] H.C. Borst and H.M.E. Miedema (2005). “Comparison of noise impact indicators, calculated on the basis of noise maps of DENL,” Acta Acust. 91, 378–385.
[3] J.P. Mackenbach, H. van de Mheen, and K. Stronks (1994). “A prospective cohort study investigating the explanation of socioeconomic inequalities in health in The Netherlands,” Soc. Sci. Med. 38, 299–308.

[4] Y. De Kluizenaar, S.A. Janssen, F.J. van Lenthe, H.M. Miedema, J.P. Mackenbach. "Long-term road traffic noise exposure is associated with an increase in morning tiredness." J Acoust Soc Am 2009 August;126(2):626-33
[5] Y. de Kluizenaar, E.M Salomons, S.A. Janssen, F.J. van Lenthe, H. Vos, H.M.E. Miedema, J.P. Mackenbach "Urban traffic noise and annoyance: the influence of quiet facades" Proceedings Internoise 2010.
[6] J. Forssén and M. Hornikx (2007). Förstudie av trafikbuller vid kvarteret Örlen i Göteborg. [Pre-study of traffic noise at the block Örlen in Gothenburg]. Report S-07-01, Chalmers University of Technology, Applied Acoustics, Gothenburg, Sweden.
[7] J. Forssén and A. Gustafson. (2010). Efterstudie av trafikbuller vid kvarteret Örlen i Göteborg. [After-study of traffic noise at the block Örlen in Gothenburg]. Report S10:02, Chalmers University of Technology, Applied Acoustics, Gothenburg, Sweden.
[8] E. Öhrström, A. Skånberg, H. Svensson, and A. Gidlöf-Gunnarsson, "Effects of road traffic noise and the benefit of access to quietness", J. Sound Vib. **295** (2006) 40-59.
[9] G. Bluhm, E. Nordling, and N. Berglind (2004). Road traffic noise and annoyance – an increasing environmental health problem. *Noise & Health, 6*(24), 43-49.
[10] D. Botteldooren, L. Dekoninck and D. Gillis, "The influence of traffic noise on appreciation of the living quality of a neighborhood," Int. J. Environ. Res. Public Health **8** (2011), 777-798.
[11] K. Persson Waye et al, "A descriptive cross-sectional study of annoyance from low frequency noise installations in an urban environment", Noise and Health **5** (2003) 35-46.
[12] A. Gidlöf-Gunnarsson and E. Öhrström, "Noise and well-being in urban residential environments: The potential role of perceived availability to nearby green areas", Landscape and Urban Planning **83** (2007) 115–126.
[13] Amsterdam quiet areas project, see
- F. van den Berg, Proceedings Euronoise 2009, Edinburgh, Scotland.
- *Stille gebieden en gezondheid* (Quiet areas and health -in Dutch), DMB-Amsterdam, published by the Health Council of the Netherlands, The Hague, 2006;
- Report in Dutch available from the website: http://www.rijksoverheid.nl/documenten-en-publicaties/brochures/2009/07/01/stille-gebieden-in-de-stad.html
- Also interesting: www.cpre.org.uk/campaigns/landscape/tranquillity/our-tranquillity-map-explained; a research report is available via a link.

[14] A. Gidlöf-Gunnarsson *et al.*, "Good sound environment in green areas modify road-traffic noise annoyance at home", Proceedings Euronoise 2009, Edinburgh, Scotland.
[15] Öhrström, E., Gidlöf-Gunnarsson, A., Ögren, M. & Jerson, T. (2010). Comparative field studies on the effects of railway and road traffic noise. *Proceedings InterNoise 2010*, June 13-16, Lisbon, Portugal.
[16] Li, H.N., Chau, C.K. & Tang, S.K. (2010). Can surrounding greenery reduce noise annoyance at home? *Science of the Total Environment, 408*, 4376-4384.

Appendix A: Cities that responded to our information request (Action 1.3)

City	(name of city representative and affiliation)
Amsterdam	(Carlo Schoonebeek, Dienst Milieu en Bouwtoezicht; Frits van den Berg, GGD)
Bilbao/Zaragoza	(Itziar Aspuru, TECNALIA Research and Innovation)
Bristol	(Steve Crawshaw, Programme Coordinator Bristol City Council)
Brussels	(Fabienne Saelmackers, Bruxelles Environnement – IBGE, Division Autorisations, Département Bruit)
Florence/Pisa	(Gaetano Licitra, Arpat)
Gothenburg	(Martin Knape, Miljöutredare, Miljöförvaltningen, Stadsmiljö)
Hamburg	(Uwe Schacht, Behörde für Stadtentwicklung und Umwelt, Abteilung Lärmbekämpfung)
Helsinki	(Anu Haahla, Environmental Inspector, City of Helsinki Environment Centre)
Oslo	(Ellen Espolin Johnson, Department of Urban Environment)
Paris	(Kévin Ibtaten, Mairie de Paris / DEVE / AEU / Pôle Bruit)
Utrecht	(Reinier Balkema, StadsOntwikkeling, Team Milieukwaliteit, Geluid, Lucht en Externe Veiligheid)
Zagreb	(Sandra Hamin, City Office for Energy, Environmental Protection and Sustainable Development, Sector for Environmental Protection and Waste Management, Department for EIA and Air Protection)
Zurich	(Hans Huber, Umwelt- und Gesundheitsschutz Zürich (UGZ), Fachstelle Lärmschutz und NIS)

Appendix B: Full response from cities (Action 1.3)

Questions posed to city representatives

1) Do quiet façades and/or quiet areas play a role in the noise policy and development plans of your city?
2) Do you have a practical definition of quiet façades and/or quiet areas as employed in your city?
3) Does traffic noise play a role in the management of or policy on usually quiet urban areas such as parks and courtyards?
4) Do you think that non-acoustic parameters are important in the appreciation of quiet areas? Do you have any ideas what parameters should be used and how?
5) What approach did your city follow for quiet façades and quiet areas in the first round of noise mapping and action plans for the Environmental Noise Directive? Do you expect this will be different in the next round?

Response

I. Amsterdam

1) Until (about) 1970 in Amsterdam houses were built mostly with closed housing blocks. This proved to be an effective means to keep the noise out and tot create a quiet side. Since appr. 1990 more open constructions were chosen and these positive effects were lost partly.
In Amsterdam there is a policy for quiet sides since appr. 1990:

- For newly built houses where the noise exposure exceeds the legal preference value a quiet side (48 dB) is required.
- This is done by urban planning or by facility's at the houses
- Deviations on this general rule are possible but the higher the noise exposure the heavier the motivation duty.
- For buildings with a "deaf façade" a quiet side is always obligatory.

There are no scientific data to support this policy. And we hope that the Qside results support this policy.
2) Quiet façade: level below standard limit (48 dB Lden for road traffic noise, 55 dB for railway noise and 50 dB for industrial noise). The proposed definition for a quiet area includes a noise level <55 dB Lday or Lden, relatively noise free, visual/spatial quality, "clean, unbroken and safe".
3) No
4) Yes: a survey showed that the presence of green and/or water is of major importance; also for over 50% of the respondents a quiet area should be well kept and clean, and otherwise attractive (with nice colors and odours, spacious) and designed for the intended use (or redesigned to accommodate actual use). Also, it must be/feel safe and easily accessible. People in every neighbourhood should have a quiet area nearby. Acoustically it should be relatively quiet (compared to neighbourhood), noise free and with nice sounds.
5) Quiet façades were already part of the Amsterdam noise policy, and mentioned in the first round of noise maps and action plans. If it is not feasible to build buildings for living,

education and health care complying with the standard noise limits on the most exposed façade, then a higher noise level can be allowed if there is another façade that does comply with the limits. In the Life+ Q-side project we try to establish the effect on annoyance from the noisy façade and use this to reduce annoyance, thus giving proof of the effectiveness of the quiet façade policy. Quiet areas: in the first round the city committed itself to a study of the presence, relevance and policy implications of quiet areas. The result was the 'Amsterdam quiet areas project'. In the second round we hope to move a step further, either by paying more attention to acoustic quality or in a practical pilot project.

III. Bristol

1) Quiet facades and quiet areas are not explicitly included in our local development framework or transport plans.

2) The UK is at an early stage of developing quiet area policy and although Bristol have helped UK government with research on how quiet areas can be considered by local authorities, we have not yet designated any quiet areas. There is no definition used in Bristol for Quiet facades.

3) Not currently although this may change as quiet areas are designated and bought within the local development framework

4) Yes, the quality, access to, and uses of the quiet area are important.
We have submitted a report to UK gov. on the factors we believe are important when deciding what areas to designate. I am currently working on a project to help understand user experiences in a quiet area with regard to the soundscape and other factors.

5) The UK approach for noise mapping and action plans is centralised, with national government leading on mapping and action plans. Hence Bristol had no input into the END noise mapping or action planning processes. We did produce a noise map for the city as part of the SILENCE project, but this did not explicitly consider quiet areas or facades.

IV. Brussels

Conformément aux recommandations de la Directive 2002/49/CE et comme exposé lors des ateliers de Paris fin 2009, Bruxelles Environnement, administration régionale de l'Environnement, a entrepris une réflexion et des enquêtes de terrain en matière de zones calmes et rédige aujourd'hui (pour juin 2011) ses conclusions pour la Région de Bruxelles-Capitale.

A ce stade de finalisation, il est encore prématuré de répondre de manière officielle au nom de la Région de Bruxelles-Capitale. En effet, les principes retenus n'ont pas encore été approuvés par les instances politiques. Les réponses reprises ci-dessous n'engage que l'administration et sont à traiter comme telles. **Il vous est donc demander de**

mentionner explicitement dans vos documents le caractère provisoire de ces informations.

1) Oui, le 2ème Plan Bruit (2008-2013), approuvé par le Gouvernement de la Région de Bruxelles Capitale en date du 02 avril 2009, reprend explicitement plusieurs prescriptions sur ces concepts :

- Prescriptions 1b : Définir des « zones calmes »
- Prescriptions 14 : Etablir et protéger les zones calmes
- Prescriptions 15 : Recréer des zones de quiétudes dans les parcs et les espaces verts bruyants ;

ces prescriptions devant servir de référence dans le cadre de l'élaboration des plans d'aménagement du territoire et dans le cadre de l'attribution de permis d'urbanisme.
Voir Plan Bruit sur http://www.leefmilieubrussel.be/Templates/Particuliers/-Niveau2.aspx?id=4226&langtype=2067

2) Façade calme : le bâti bruxellois est organisé la plupart du temps en immeubles mitoyens ou en îlots fermés, de telle manière qu'un bâtiment peut être ainsi soumis à des bruits élevés en “façade avant”, mais bénéficier d'une ambiance calme en “façade arrière”, sa cour ou son jardin étant isolé des bruits de l'extérieur. Un logement est considéré comme ayant une façade “calme” si la différence de niveaux sonores entre deux façades est supérieure à 20 dB(A).
(Commentaire: La définition d'une façade calme est reprise de l'annexe VI de la Directive 2002/49/CE, à savoir : "Il conviendrait en outre de préciser, le cas échéant et si les données sont disponibles, combien de personnes, au sein des catégories susmentionnées, vivent dans des habitations ayant une façade calme, c'est-à-dire dont la valeur Lden à 4 m au-dessus du sol et 2 m à l'avant de la façade est, pour le bruit émis par une source spécifique, inférieur de plus de 20 dB à la valeur Lden la plus élevée mesurée en façade.
Il n'y a pas de limite pour de nouveaux bâtiments. Cette formule est juste utilisée pour faire un survey.)
Zone calme (définition du concept en cours) : zone verte, d'une superficie > 4 ha, présentant un niveau de bruit Lden sur au moins 50 % de sa superficie < 55 dB(A) et présentant certaines caractéristiques d'aspect écologique et sociale.
Zones de quiétude dans les quartiers d'habitation : zone d'habitation présentant des niveau de bruit Lden < 55 dB(A) selon cartes du bruit des transports terrestres + une faible densité d'activités industrielles, horeca, commerciales et en soirée (filtres).
Zones de quiétude dans les espaces publics : zones d'espaces majoritairement verdurisés et bois, d'accès public, d'une superficie > 1 ha (>100 m pour les chemins) et présentant un niveau de bruit Lden sur au moins 50 % de sa superficie < 55 dB(A).

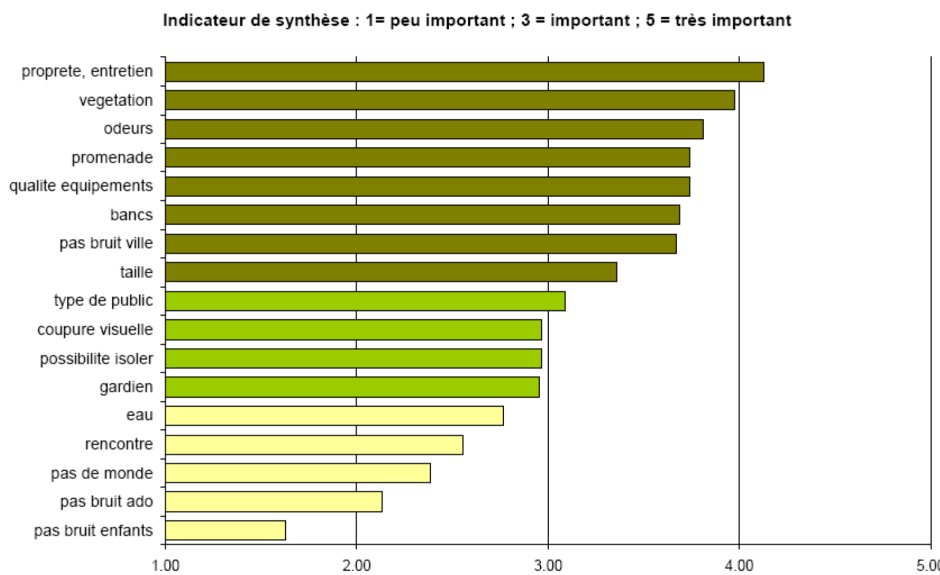
3) Très certainement. Comme le montrent les cartes reprises dans notre « Atlas du bruit des transports : Cartographie stratégique en Région de Bruxelles-Capitale », le bruit routier influe fortement l'ambiance acoustique générale de notre territoire. En outre, la modélisation d'un scénario volontariste de réduction du trafic en 2015, avec notamment tarification du stationnement en voirie et péage urbain, montre une réduction des niveaux de bruit du Lden de 2 à 8 dB(A) et une diminution de 60% de la population soumise à 65 dB(A).
Voir Atlas du bruit des transports : Cartographie stratégique sur http://documentation.-bruxellesenvironnement.be/documents/Bruit_atlas_Cartographie_2010.pdf?langtype=2060

Lors de la Journée Sans Voiture, les niveaux du bruit de fond mesuré aux stations de mesure diminuent de 3,6 à 24,9 dB (A), en fonction des sites.
Nous avons par ailleurs réalisé de nombreuses mesures acoustiques dans les parcs de la Région et dans la plupart des cas, c'est le bruit des voiries limitrophes qui influe le niveau acoustique à l'intérieur de ces espaces.

4) Oui. L'enquête réalisée dans le cadre de l'étude zones calmes, dans 10 quartiers différents de la Région et auprès de 600 personnes a mis en évidence que les Bruxellois vont, pour trouver le calme, essentiellement dans des espaces qui sont :

- accessibles à tous
- grands et où il est possible de se promener
- verdurisés, pour contraster avec l'environnement minéral de la ville
- où l'impact des transports terrestres est limité visuellement et acoustiquement
- Bien fréquentés et pas trop fréquentés
- Bien entretenus
- La présence d'équipements de qualité constituent également un atout

Voir tableau ci-dessous.



5) Quelle approche avez votre ville suivre pour façades calmes et les zones calmes dans le premier tour de cartographie du bruit et des plans d'action pour la directive sur le bruit? Pensez-vous que cela sera différent dans le prochain tour?
Notre deuxième Plan Bruit 2008-2013 a inscrit dans ses objectifs la définition des zones calmes, la définition d'indicateur éventuel et leur protection. Les cartes de bruit nous ont permis d'élaborer un concept et de définir des zones calmes et des zones de quiétude, ainsi que de repérer les endroits où se trouvent les habitations présentant des façades calmes.
Dans les prochaines années, ces outils et concepts devraient être mis en œuvre, utilisés et servir de référence dans le cadre de projets concrets d'aménagement (nouveaux quartiers, zones de carences, zones à améliorer, etc.) Il est également prévu que la politique qui découlera de ces concepts soit intégrée dans notre nouveau plan de

développement régional, à savoir le Plan Régional de Développement Durable (ou PRDD) prévu pour 2011-2012.

V. Florence/Pisa

1) Not in a direct way. We have in the Italian (Legge 447/95) and regional legislation (in Tuscany Legge regionale 89/98) specific rules for zoning. So it is possible that some buildings have two sides with different roads.
In Italy for road noise there are different limits considering the type of the road in the urban area too. No special indications came from implementation of END.

2) Not in a direct way again. But in the zoning process we have different limits for protected areas, so we could save this areas and to promote action plan for them.
We made studies and proposals: if you are interested we publish a paper in a Conference in New Zealand.
G. Licitra, C. Chiari, E. Ascari, D. Palazzuoli Neighbourhood quiet area definition in the implementation of European Directive 2002/49/EC ((Peer reviewed) in Proceeding of Sustainaility in Acoustics, Auckland 29-31 Agosto 2010.

3) Yes, because in zoning process road noise is considered in the definition of different zones. Restrictions on traffic are set.

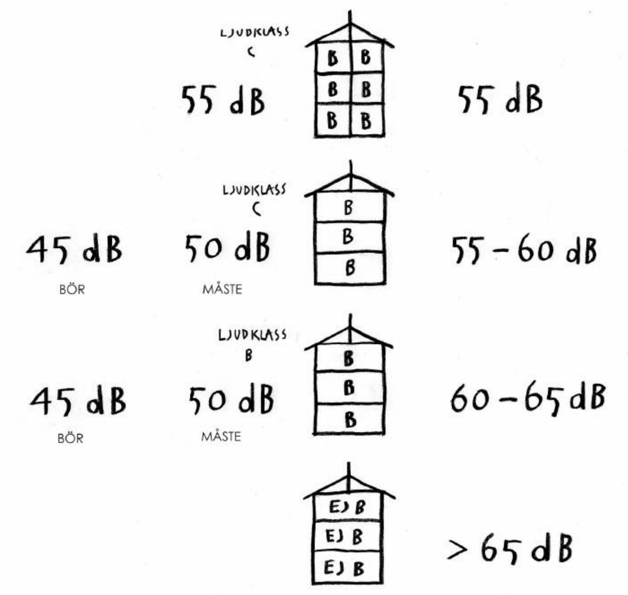
4) Yes, sure. We are studying in a quiet area (Il Giardino Sonoro in Florence) http://www.architetturasonora.com/video/id/19/ new installations and indicators able to describe the reaction and perception of visitors. Some datails are in G. Licitra, M. Cobianchi, L. Brusci Artificial soundscape approach to noise pollution in urban areas Proceedings of Internoise 2010, Lisbona 13-16 Giugno 2010 (Invited paper).

5) I live in Pisa and work in Florence. Pisa made the first round without obligation (lesser than 100.000 inhabitants) , Florence respected the obligation.
Pisa didn't develop a special process for quiet area, Florence received funds by Tuscany Region and is working on action plan. A LIFE project is on (HUSH) and ARPAT is busy to study applications as Giardino Sonoro to masking environmental noise and to improve soundscape in area including schools or squares.

VI. GOTHENBURG

1) Yes, quiet façades do. In Gothenburg quiet façades is an important part of the noise policy of the city, at least regarding new dwellings in central areas if the city. The policy only applies within 4 km of central core of the city and close to junctions of public transport.
If noise level at the exposed façade are somewhere between 55dBA (Leq) and 65 dBA (Leq) this could be compensated with a quiet façade where the levels should preferably be below 45 dBA (which we call a quiet façade) and must be below 50 dBA (called a "silenced" side). This could be seen in the figure below

Note that the demands regarding indoor noise levels are higher if traffic noise levels are above 60 dBA (Leq) (26 dBA (Leq) and 41 dBA (Lmax), as opposed to 30 and 45 when below 60). If traffic noise levels are above 65 dBA (Leq) no dwellings should be built.
Quiet areas are not yet a part of the cities formal policy or development plans. Our noise policy is more aimed at new dwellings in areas with high noise levels and when and how the national guideline limits (55 dBA (Leq), 70 dBA (Lmax)) can be surpassed.



2) Yes: a quiet façade should be below 45 dBA (Leq) and must be below 50 dBA (Leq). Although, as mentioned above, we call it “quiet side” (< 45) and “silenced side” (< 50 dBA).

3) Yes and no. In the action plan from 2009 it is concluded that measures in the upcoming five year period must be aimed mainly at indoor noise and quiet façades because very little is to be done about noise emissions. The action plan does however point out that special action plans for the following should be developed:

- A plan regarding measures to ensure quiet façades
- action plans for parks (such parks where silence should be considered important)
- A more detailed action plan

This work has started, the first two within the work of the detailed action plan, and our aim is to make both courtyards and parks/recreation areas a part of our upcoming action plan for 2014-2018.
When it comes to management of such areas, traffic noise has not played as an important role as one might wish for. Noise in parks has not been prioritized at all until now.
Noise in courtyards has mainly been about ensuring that noise from installations, such as fans and so forth, is not too high. This work is done by the Environmental Administration as a part of our supervision of Swedish environmental legislation.

4) Yes, absolutely. Generally there is much more to noise and quietness than just the levels of sound. The way you perceive your surroundings is also important as to how you perceive noise or quietness. An example, which is quite common here, is when a row of trees blocking the view to a road is removed. Many residents perceive an increase in noise although the levels of noise hardly have been affected.
Parameters to be used could be; natural scenery, social aspects, feelings of safety, light and so forth. Simply things that make the quiet area an attractive place to be, as a whole.

5) In the first round of noise mapping we included about 700 indicating noise measurements made in courtyards. We also made an improved estimation on the

number of residents living where the noise levels exceeds 65 dBA (Leq) and connected this result to the courtyard measurements which resulted in us having a good idea of as to which extent these inhabitants had access to a quiet façade.
Within the work with noise mapping we also made indicating measurements in about 20 parks. These measurements are a basis for the upcoming work on parks and recreations which is mentioned earlier.
Quiet courtyards and façades will most likely play a more important role in the upcoming mapping projects.
Overall the city is more into soundscapes now, which probably and hopefully will be shown both in upcoming noise mapping and action plans.

VII. Hamburg

1) Quiet facades do play an important role in Hamburg's urban development policy, the city has imposed an noise guideline for town planning ("Leitfaden Lärm in der Bauleitplanung"). This is published in internet, unfortunately only in German language (see here: http://www.hamburg.de/laermleitfaden-2010).

2) A practical definition of a quiet façade is a noise level less than 49 dB(A) at night in residential areas and less than 54 dB(A) in mixed industrial/housing areas. The noise guideline rules, that in cases of new constructions bed- and living-rooms have to be placed at the "quiet façade" while kitchen, bathroom and staircase are orientated to the noisier side.
Some years ago, Hamburg began to develop a former port site as "Hafencity", an area where even the above mentioned noise levels were exceeded at night. Therefore, a new criteria was created of 30 dB(A) in interior room (especially the bedroom) of the building at night. This level has to be achieved by special windows and construction features (f.i. double facades). For details please view the guideline.

3) ---

4) ---

5) Quiet areas in terms of European Environment Noise directive may play an important role for reducing annoyance by noise, however Hamburg has not specified yet which areas are considered as "quiet". In 2007 a consultant (Mr. Richard from Aachen) drafted an guideline for implementation of noise actions plans ("Leitfaden zur Aufstellung des Lärmaktionsplans"), which is also available in internet (see: http://www.hamburg.de/laermaktionsplanung/144140/start.html). Chapter 3.4 contains proposals for identification of quiet areas, some of which are non acoustic. In a quiet area, the noise level should be less than 55 dB(A) and it should extend at least 320 m at the shortest side. There are also definitions for "urban free spaces", "quiet axis" and "urban oasis" developed in this guideline which are not really quiet in the sense of noise (they should be less noisy than the surrounding), but meant as a retiring space in a loud environment.
As far as noise mapping is concerned, neither the quiet façades nor the quiet areas played a special role. We simply have not enough precise data to identify how many people benefit from a quiet façade and the same is true for the second round of noise

mapping. The noise guideline for town planning is part of the strategic noise action plan, which Hamburg released in 2008, the identification of quiet areas will be part in the second step of the action plan, which will be finished until the end of 2012.

VIII. Helsinki

1) There has been a lot of discussion about quiet facades during the past few years especially related to planning new housing.
In Finland there are no official regulations or demands for quiet facades. But if noise level is very high on the most exposed facade then the recommendation is that dwellings should also have a quiet facade on the other quieter side. Environmental authorities usually try to speak for the importance of quiet facades but often city planners are not so interested in.
Quiet areas do have some role. In Noise Action Plan we have tried to raise the value of quiet areas. But the question of quiet areas is difficult because there is no good definition for quiet areas or established methods for defining those areas at least in Finland.

2) In Finland we have guideline values for noise levels. Outdoor daytime noise level guideline (LAeq 7-22) is 55 dB for residential areas and recreation areas and outdoor night time noise level guideline (LAeq 22-7) is 50 dB. In residential areas these guideline values are applied on yards and balconies where residents spend time. Guideline values are not usually applied on facades.
When environmental authorities speak about quiet facades it means that noise level on quiet facade not exceed noise level guidelines 55 dB / 50 dB.
The Government Decree on Noise Mapping and Action Plans for Noise Abatement Required by the EC defines that quiet area in an agglomeration is an area where daytime noise level do not exceed 50 dB and night time noise level do not exceed 45 dB. In City of Helsinki we do not have any other practical definition even I think it would be necessary.

3) When speaking about parks and recreation areas the target is that traffic noise do not exceed guideline values (daytime < 55 dB). But in practise this is not always possible and the aim is that at the least playgrounds and the most used parks and recreation areas are as quiet as possible.
When planning new residential buildings and area there has to be a place in the outside (e.g. garden) that traffic noise is < 55 dB.

4) I think non-acoustic parameters can be just as important as acoustical parameters. But at least in Helsinki we have not yet very good tools to appreciate those other parameters.
I think quiet areas have to be those areas which are important to the public but of course it is good that areas have preferably good distance from significant noise sources and the soundscape is peaceful.
Areas should be suitable for rest, walking or physical activities...
A quiet area offers usually qualities for recreational, nature or cultural activities.
Areas have to be locally available and easily accessible for all user groups.

5) We estimated number of people living in buildings which have a quiet facade. And facade was “quiet” if its value of Lden / Lnight was more than 20 dB lower than at the facade having the highest Lden / Lnight level, for the same building. We did not have the information where dwellings were located. So not all the dwellings necessary are located so that they have a facade on the quiet facade. I am not sure, but I think will use the same approach in the second round.
We just used noise mapping to identify quiet areas (LAeq 7-22 < 50 dB). I think this approach is not enough. And for the second round I really hope that we get more advise from EU or from national government how to define quiet areas.

IX. Oslo

1) This will most probably be an important issue in our work with Oslo’s next action plan.

2) Not for quiet facades. For quiet areas, see 4).

3) So far our quiet areas do not have any legal protection against increased traffic noise, but we’re working on it!

4) Our definition of a quiet area: “A quiet area offers qualities for recreational and/or cultural activities, in surroundings shielded or in distance from dominating noise sources.”
A quiet area should be locally available, easily accessible and include all age- and usergroups.

5) Tore Mauseth in Oslo’s plan- and building department presented our work on quiet areas in the first round of noise mapping and action plans.

X. Paris

1) We are in the middle of the decision process for defining and localizing quiet areas in Paris

2) Not yet (end of 2012)

3) We manage acoustic studies before the creation of gardens for example. The studies are not mandatory but systematically done by our team.
Selon les résultats le paysagiste peut installer les activités les plus bruyantes (jeux d’enfants, jeux de ballons) dans les zones les plus bruyantes. Il peut aussi modeler le jardin pour y créer des zones préservées du bruit.

4) Yes, we think that non-acoustic parameters are important and we will certainly keep some of them in our definition of quiet areas (for example cleanliness)

5) 1. acoustic evaluation with maps : < 55 dB, noise gradient, mapping address from books dealing with calm in Paris

2. work group : definition of acoustic and non-acoustic parameters, definition of different typology of quiet areas, first localization of possible quiet areas
3. consultation of the Parisians about propositions of the work group
4. validation by the City Council

XI. Utrecht

1) Yes
2) Quiet façade: ≤48 dB road traffic noise; ≤55 dB rail traffic noise; ≤50 dB industrial noise. No definition for quiet areas.
3) No
4) Yes. Green, water, tidy, safe.
5) None. No.

XII. Zagreb

Zagreb does not have such kind of info nor we did some research of this kind.

XIV. Zürich

1) „Leise Fassaden“, oder wie wir sagen, „lärmabgewandte Fassaden“, spielen im Baubewilligungsverfahren eine relativ grosse Rolle. Sollen lärmempfindliche Nutzungen, zum Beispiel Wohnbauten, an Strassen oder Eisenbahnlinien gebaut werden, bei denen die Immissionsgrenzwerte überschritten sind, muss die Bauherrschaft dafür sorgen, dass mit baulichen oder gestalterischen Massnahmen diese Grenzwerte eingehalten werden. Bauliche Massnahmen sind Massnahmen auf dem Ausbreitungsweg des Lärms, zum Beispiel Lärmschutzwände, gestalterische Massnahmen sind Massnahmen am Gebäude selber. Im Sinne einer gestalterischen Massnahme wird auch das Anbringen von (zusätzlichen) Fenstern an einer lärmabgewandten Fassade akzeptiert. „Leise Orte“, also allgemein zugängliche Aussenbereiche spielen im aubewilligungsverfahren aber keine Rolle.

2) „Lärmabgewandt“ bedeutet in unserer Vollzugspraxis, dass die Immissionsgrenzwerte eingehalten sind. Da diese Grenzwerte definitionsgemäss die Grenze zur Schädlichkeit darstellen, wird mit Fenstern an einer lärmabgewandten Fassade sichergestellt, dass dort keine schädlichen Lärmbelastungen auftreten.

3) Das schweizerische Lärmschutzrecht schützt nur Räume in Gebäuden, Aussenbereiche wie Balkone, Terrassen oder Plätze werden nicht geschützt.

4) Ich glaube schon, dass auch nicht-akustische Parameter wichtig für das Wohlbefinden der Leute sind, die sich zum Beispiel in einem leisen Hinterhof oder Park aufhalten. Spontan würde ich sagen, dass die Bepflanzung eine wichtige Rolle spielt.

5) Die Stadt Zürich arbeitet nicht im Rahmen von Europäischen Lärmschutz-Richtlinien. Lärmabgewandte Fassaden oder leise Orte spielen in der Lärmbekämpfung aber keine zentrale Rolle.