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FINAL Report

Covering the project activities from 01/09/2010 to 31/08/2013

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31/10/2013

LIFE+ PROJECT NAME

QSIDE

The positive effects of quiet facades and quiet urban areas on traffic noise annoyance and sleep disturbance

Data Project

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Data Beneficiary

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1. List of content

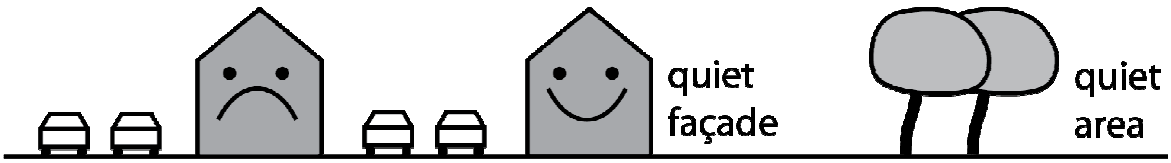
2. Executive Summary

Traffic noise in European cities is a major source of annoyance and sleep disturbance. A good approach to reduce the harmful effects of traffic noise is to create ***quiet façades and quiet urban areas****. The project QSIDE has provided strategies and tools to put this approach in practice.*

The main objective of the project QSIDE was to demonstrate how European cities can effectively reduce harmful effects of traffic noise (annoyance and sleep disturbance) by offering *refuges* to the inhabitants:
- *quiet façades of dwellings,*
- *quiet urban areas such as parks and quiet residential areas.*

For example, a quiet façade offers the possibility to choose a bedroom on the quiet side of a house, thereby reducing the chances on sleep disturbance by traffic noise. The refuges can be created in new urban areas, but they can also be created by modifying existing urban areas, for example by modifying traffic flows or by choosing specific orientations of houses with respect to roads.

In the project the general term *quiet places* was introduced, which includes both quiet façades and quiet urban areas. The figure below illustrates the beneficial effects of quiet places.



Quiet façades and quiet areas are good for inhabitants.
The general term 'quiet places' is used for quiet façades and quiet areas.

Three key deliverables of the project are:
1. A document with recommendations and guidelines for EU cities on quiet places,
2. An engineering method for calculating sound levels at quiet places,
3. A method for estimating the beneficial effects of quiet places.

These deliverables are briefly described below.

Key deliverable 1: document for EU cities
A document has been prepared with recommendations and guidelines for EU cities on quiet places. The document was primarily prepared as a website consisting of several webpages, but a single pdf-version of the complete website has also been prepared.
The website has the internet address www.qside.eu and will remain accessible after the end of the project. The text describes various aspects of quiet places, such as:
- indications of benefits of quiet places in terms of reduced annoyance,
- recommendations for (limiting) noise levels at quiet façades and in quiet areas,
- descriptions of other qualities than low noise levels at quiet places, such as vegetation or nice architecture,

- examples of quiet places, with videos and pictures,
- traffic noise control and quiet places in relation to sustainable urban planning,
- brief descriptions of scientific QSIDE work supporting the recommendations.

The intention is that cities will find material on the website that is helpful for the implementation of quiet places in the noise policy of the city. In this way, the website should be considered as a tool that supports the protection and creation of quiet places in cities, which is an important element of European environmental noise policy as formulated in the Environmental Noise Directive 2002/49/EC.

In April 2013 a QSIDE workshop was held in Lyon, where the website was presented to representatives of cities and to researchers of projects that are related to QSIDE.

The screen dump below shows the top of the welcome screen of the website, including a pull down menu with various items.

Illustration: top of the welcome screen of the website www.qside.eu.

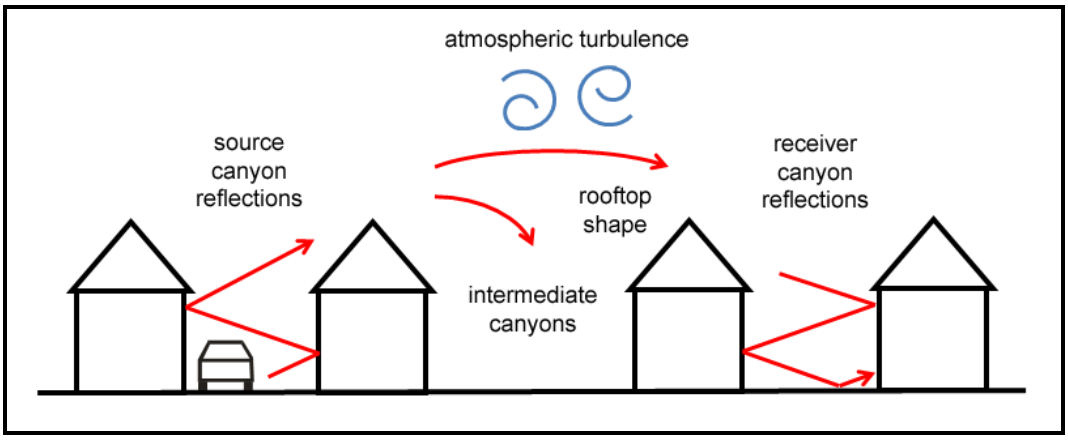
Key deliverable 2: engineering method for calculating traffic noise levels at quiet places

The Environmental Noise Directive 2002/49/EC indicates that cities should provide information on quiet places, but quantitative methods for obtaining this information are not specified. This is a problem, since it is known that noise levels at quiet places are in general underestimated by standard engineering models – including the EU harmonised engineering model Cnossos which is intended for the next EU noise mapping round in 2017.

As a first step to solve this problem, QSIDE partners have developed an engineering model for calculating noise levels at quiet places. The model takes into account:

- effects of multiple reflections between buildings in a street
- scattering of sound waves by turbulence in the atmosphere.

This is illustrated schematically in the figure below.



The QSIDE engineering model gives an accurate prediction for propagation of traffic noise from a street to a different street. Effects of multiple reflections, rooftop shape, and atmospheric turbulence are taken into account.

The QSIDE engineering model is an *extension* of standard engineering models such as Cnossos. This means that one should first calculate a noise maps with a standard method and next add an improvement calculated with the QSIDE model. Thus:

standard noise map + QSIDE correction = improved noise map

This is illustrated in the figure below, showing standard and improved noise maps for a small area of the city of Gothenburg. It should be noted that the practical implementation of the QSIDE model for engineering noise mapping has not been addressed in QSIDE.

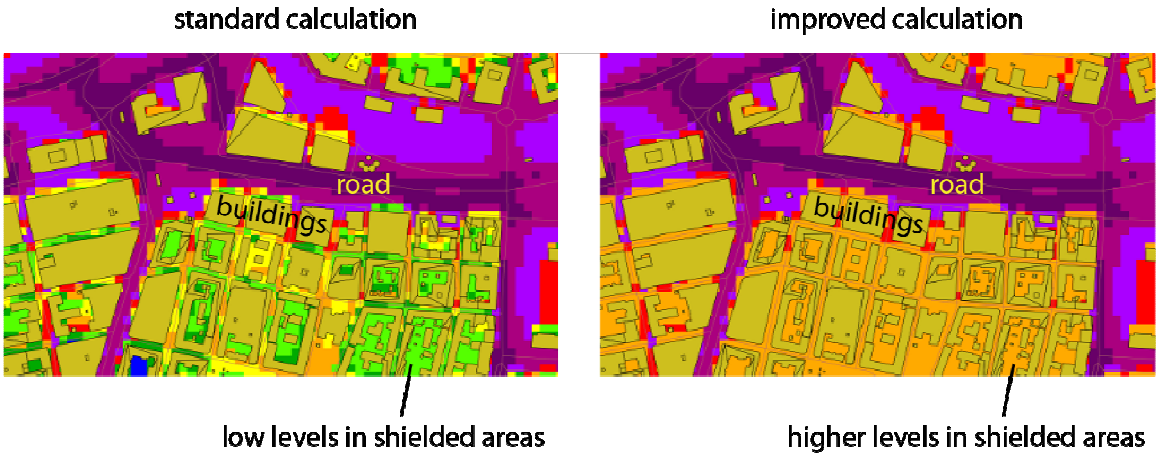


Illustration of the effect of an improved calculation model for shielded urban locations. The noise map on the left was calculated with a standard model and the noise map on the right shows the improvement obtained the QSIDE model. On the roads and in nearby areas, the noise levels are high (purple). In areas that are shielded by buildings (yellow), the standard noise map shows low levels (green) while the improved noise map shows higher levels (orange).

Key deliverable 3: method for estimating the beneficial effects of quiet places.

Annoyance and sleep disturbance by traffic noise in a city are conventionally estimated by means of exposure-response relations. For example, about 25% of all people living in

dwellings with a traffic noise level of 60 dB at the most-exposed façade of the dwelling consider themselves as *annoyed* by the traffic noise. In QSIDE various possible methods have been explored for refining this approach, taking into account the beneficial effects of quiet façades and quiet areas.

The figure below illustrates one of the possible methods explored in QSIDE. The idea is that some houses in a city have a relatively quiet 'back side' (blue) while other houses have a relatively less quiet back side (red). The method yields a positive annoyance correction for the red houses (higher annoyance) and a negative annoyance correction for the blue houses (lower annoyance). The correction is zero for houses (green) that have a back side with an average noise level at the back side.

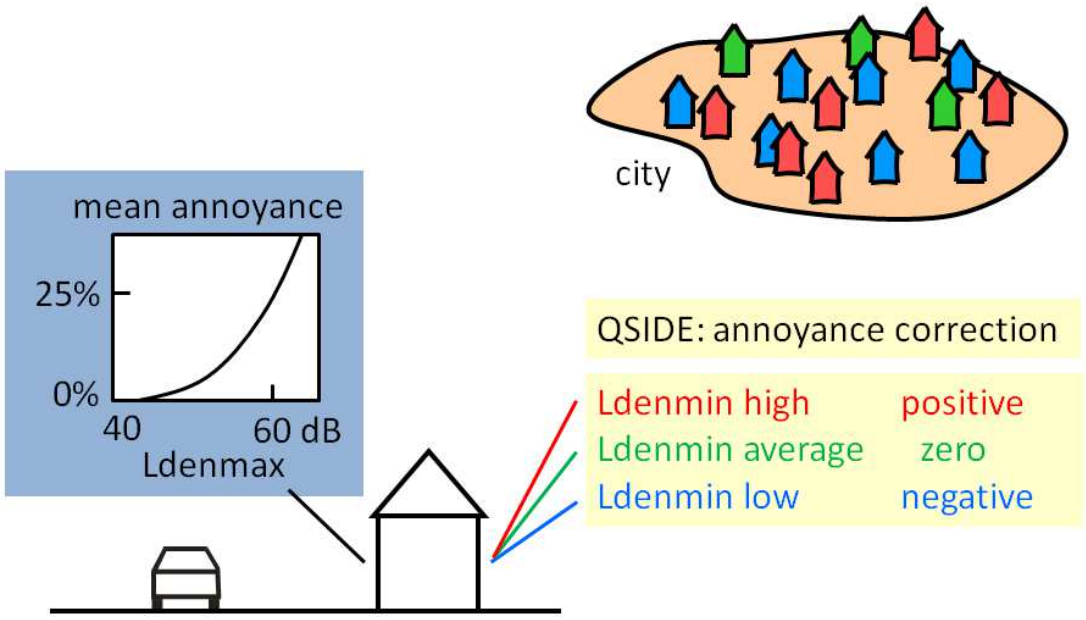


Illustration of one of the methods explored in QSIDE for estimating the effect of a quiet façade on traffic noise annoyance. Mean annoyance is predicted with an exposure-response function from the noise level at the most-exposed façade of the dwelling (Ldenmax). The QSIDE method yields an annoyance correction, which is positive or negative if the noise level at the least-exposed façade (Ldenmin) is higher or lower than average.

The explorations in QSIDE of the various possible methods are based on extensive studies of annoyance and sleep disturbance in several cities: Amsterdam, Antwerp, Ghent, Gothenburg, and Stockholm. Results of surveys in the cities have been related to noise levels at the most and least exposed façades, and also to quiet or green areas near the dwelling. Some of these analyses showed clear effects of quiet façades along the method illustrated above, while other analyses showed no significant effects. Swedish and Dutch results indicated a significant effect of a quiet façade on traffic noise annoyance. Further, Swedish and Belgian results indicated significant effects of a quiet façade, and also of the location of the bedroom on the quiet façade, on sleep disturbance.

Consequently, a single method for estimating the effect of a quiet façade on annoyance and sleep disturbance has not been formulated in QSIDE. However, the analyses and

surveys have been described in various articles in scientific journals and at international conferences, including the International Journal of Environmental Research and Public Health (2012), the Journal of the Acoustical Society of America (2011), and the international conference Internoise in New York (2012) and Innsbruck (2013). People interested in these results can consult the journals and proceedings of the conferences.

3. Introduction

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, by which major EU cities are required to produce periodically noise maps of the cities and action plans. The Environmental Noise Directive indicates that quiet areas should be protected (see figure 3.1). However, an appropriate calculation method for quiet façades and quiet areas is not available at present. Moreover, current engineering methods tend to underestimate sound levels at quiet facades, leading to an assessment of noise annoyance that is often too optimistic.

The noise maps produced by EU cities are used as input for assessments of numbers on inhabitants exposed to different traffic noise levels, and also numbers of inhabitants that are annoyed and sleep-disturbed by the noise. The assessments are based on noise levels (Lden, Lnight) at the most-exposed façades of dwellings, which are derived from the noise maps. Noise levels at least-exposed façades or in quiet areas are ignored for the assessments.

An objective of QSIDE was improve the END noise mapping and assessment of effects, by taking into account also the noise levels on the least exposed façades and in quiet areas. This means that improved calculation methods had to be developed for: i) noise levels at quiet places, and ii) effects of noise levels at quiet places on annoyance and sleep disturbance.

In addition to these scientific developments, QSIDE has also focused on practical issues that cities deal with when they want to take into account the effects of quiet places in their noise policy. In particular, the following two basic questions have been addressed in QSIDE:

- what is a practical definition of a quiet façade?
- what is a practical definition of a quiet area?

The Environmental Noise Directive defines a quiet façade as a façade that has a noise level that is at least 20 dB lower than the noise level at the most exposed façade.
A result of QSIDE is that a quiet façade is better defined in terms of absolute noise levels rather than level differences. Values of limiting noise levels at quiet façades and in quiet urban areas have been proposed in QSIDE. In addition, it is recommended that quiet façades and quiet areas should also have *other qualities*, such as vegetation or nice architecture. A quiet park is more attractive than a quiet industrial site or a quiet parking lot!

Presently, some cities in Europe do take into account the effects of quiet places in their policy, while other cities don't take the effects into account. In QSIDE an investigation has been performed of current approaches in several European cities with respect to quiet places. Different approaches are employed in different cities. An intention of the QSIDE recommendations mentioned above is to bring more uniformity in the approaches of the different cities, although cultural or local differences between cities will always remain. The recommendations might be included in future versions of the Environmental Noise Directive.
The recommendations in QSIDE include not only the limiting noise levels at quiet places, but also good examples of quiet places. The examples are presented as pictures and videos, illustrating the importance of 'other qualities' of quiet places than low noise levels.

The examples also illustrate that quiet urban areas are not only parks and courtyards but include also quiet residential quarters. In other words, quiet-area protection by cities should not be directed at parks and courtyards only, but should also consider residential areas. In

many cities, high traffic noise levels are concentrated in narrow bands near busy roads, while there are large residential quarters with low-intensity streets between the busy roads. This is illustrated in figure 3.2.

A consequence of this is that quiet-area protection in cities is related to the broad concept of sustainable urban planning. Many cities make plans for urban developments in the next decades, in response to expectations or ambitions of increasing urban populations. These plans take into account many elements that affect the quality of life of the inhabitants, including economic, social, and environmental elements. The QSIDE recommendations for quiet places have been put in perspective, by relating them to sustainable urban planning.

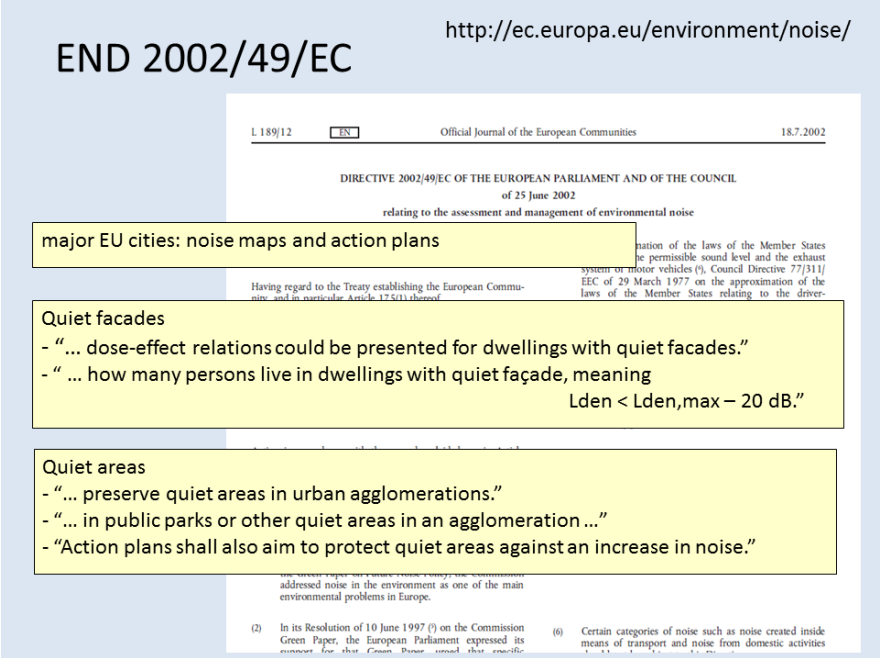


Figure 3.1. Excerpts of the Environmental Noise Directive relating to quiet places.

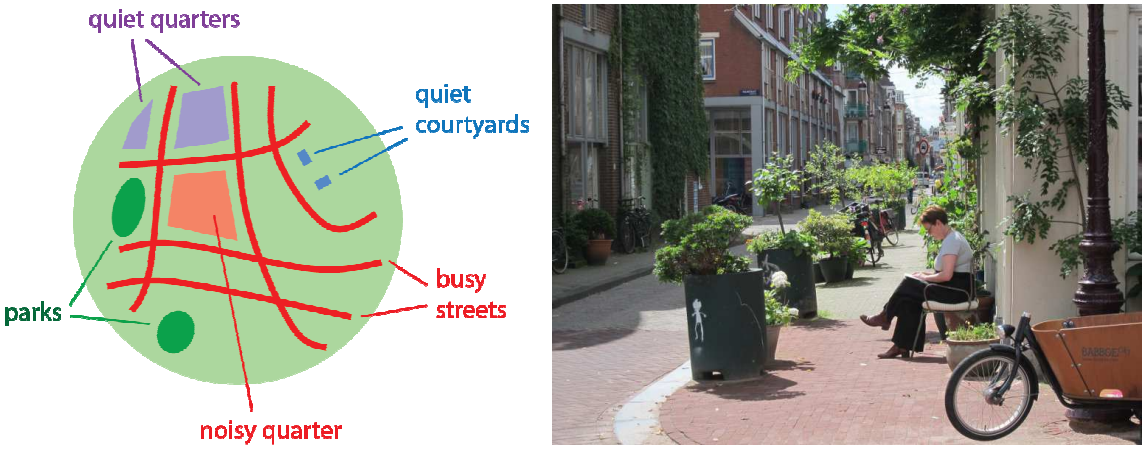


Figure 3.2. Schematic illustration of three types quiet areas in a city: parks, courtyards, and quiet residential quarters. The picture on the right shows a quiet residential quarter in Amsterdam.

4. Administrative part

4.1 Description of the management system

Coordinating beneficiary of QSIDE is TNO. Responsible project manager is TNO employee Erik Salomons. He is primarily responsible for the operational project management, communication between the partners, and reporting to the EC. For financial issues, he is assisted by colleagues with knowledge on financial and legal issues in the framework of European research projects.

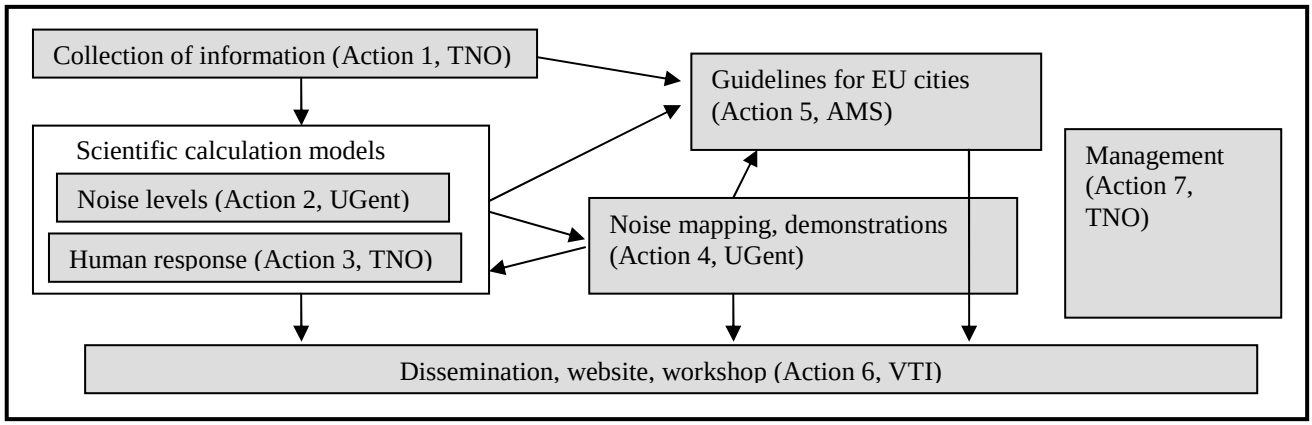
The seven partners are listed below, together with their specific expertise brought into the project.

partner	*expertise*
TNO Delft (TNO)	calculation models of traffic noise and effects of noise on people
Ghent University (UGent)	calculation models of traffic noise and effects on people of noise
Chalmers University of Technology (CUT)	calculation models of traffic noise
University of Gothenburg (UGot)	effects of noise on people
VTI Gothenburg (VTI)	calculation models of traffic noise
City of Amsterdam (AMS)	practical aspects of traffic noise, urban noise policy, and effects of noise on people
City of Gothenburg (GOT)	practical aspects of traffic noise, and urban noise policy

Kick-off meeting in Delft.

Actions

The QSIDE project is organized in seven Actions, which are related as indicated schematically below. Leaders of the Actions are indicated.



Action 1

TNO was leader of Action 1. The objective of Action 1 was to collect information to be used in subsequent Actions, both scientific information and practical information on current approaches in EU cities.

Action 2

UGent was leader of Action 2. The objective of Action 2 was to develop an engineering model for calculating noise levels at quiet places in cities.

Action 3

TNO was leader of Action 3. The objective of Action 3 was to develop a method for calculating effects of quiet places in cities on traffic noise annoyance and sleep disturbance.

Action 4

UGent was leader of Action 4. The objective of Action 4 was: i) to develop noise levels for the analyses performed in Action 3, and ii) to develop demonstration material for the Action 5 deliverable 'Guidelines for EU cities'.

Action 5

AMS was leader of Action 5. The objective of Action 5 was to develop a document with recommendations and guidelines for EU cities on quiet places.

Action 6

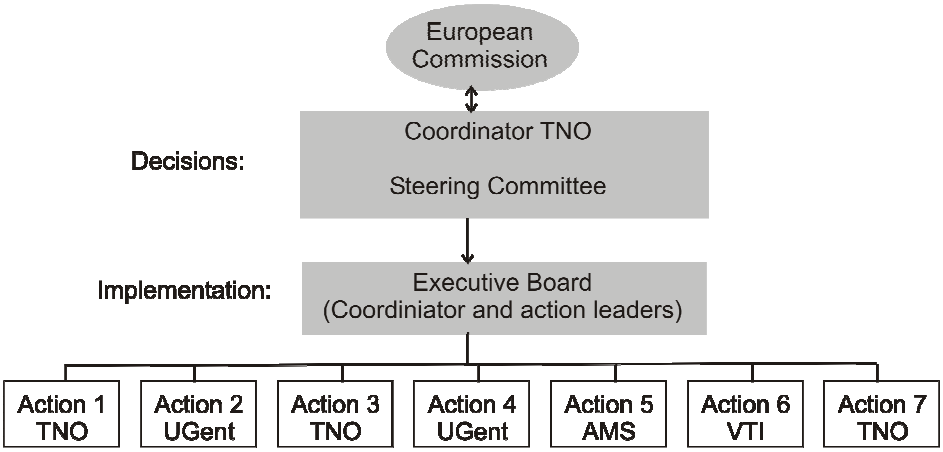
VTI was leader of Action 6. Objectives of Action 6 were to develop and maintain the QSIDE website, and to organize a workshop for EU cities on practical QSIDE results.

Action 7

TNO was leader of Action 7. The objective of Action 7 was to coordinate the overall project.

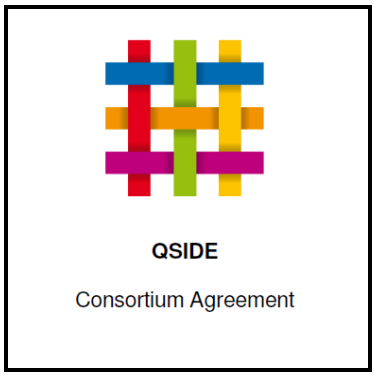
Meetings and sub-meetings
The following meetings have been organized during the projects.
Kick-off meeting 27 Sep 2010, Delft. Organized by TNO.
Consortium meeting, 8-9 Dec 2011, Gothenburg. Organized by VTI and TNO.
Consortium meeting, 14 June 2012, Prague. Organized by TNO.
Consortium meeting, 31 Jan – 1 Feb 2013, Amsterdam. Organized by AMS and TNO.
Action 2 meeting, 7 March 2011, Ghent + video link Sweden. Organized by UGent.
Action 2 meeting, 14 June 2011, Ghent + video link Sweden. Organized by UGent.
Action 3 meeting, July 2011, ICBEN London. Organized by TNO.
Workshop for EU cities, 24 April 2013, Lyon. Organized by VTI and TNO.

Management structure
The management structure of QSIDE is illustrated by the figure below.



The Coordinator is the legal entity acting as the intermediary between the parties and the European Commission. TNO acts as Coordinator and represents the consortium to the European Commission. *The Steering Committee* is the ultimate decision making body of the Consortium. The Steering Committee consists of one representative of each Beneficiary including the Coordinator. *The Executive board* is the supervisory body for the execution of the project, and consists of the Coordinator plus all Action leaders.
The tasks of the Coordinator, Steering Committee, and Executive board are described in detail in the grant contract.

Consortium agreement
A signed copy of the QSIDE Consortium Agreement (35 pages), dated 15/12/2011, was sent around to the partners on 15 December 2011. The original is kept at TNO.



Cover page of the QSIDE consortium agreement (15/12/2010).

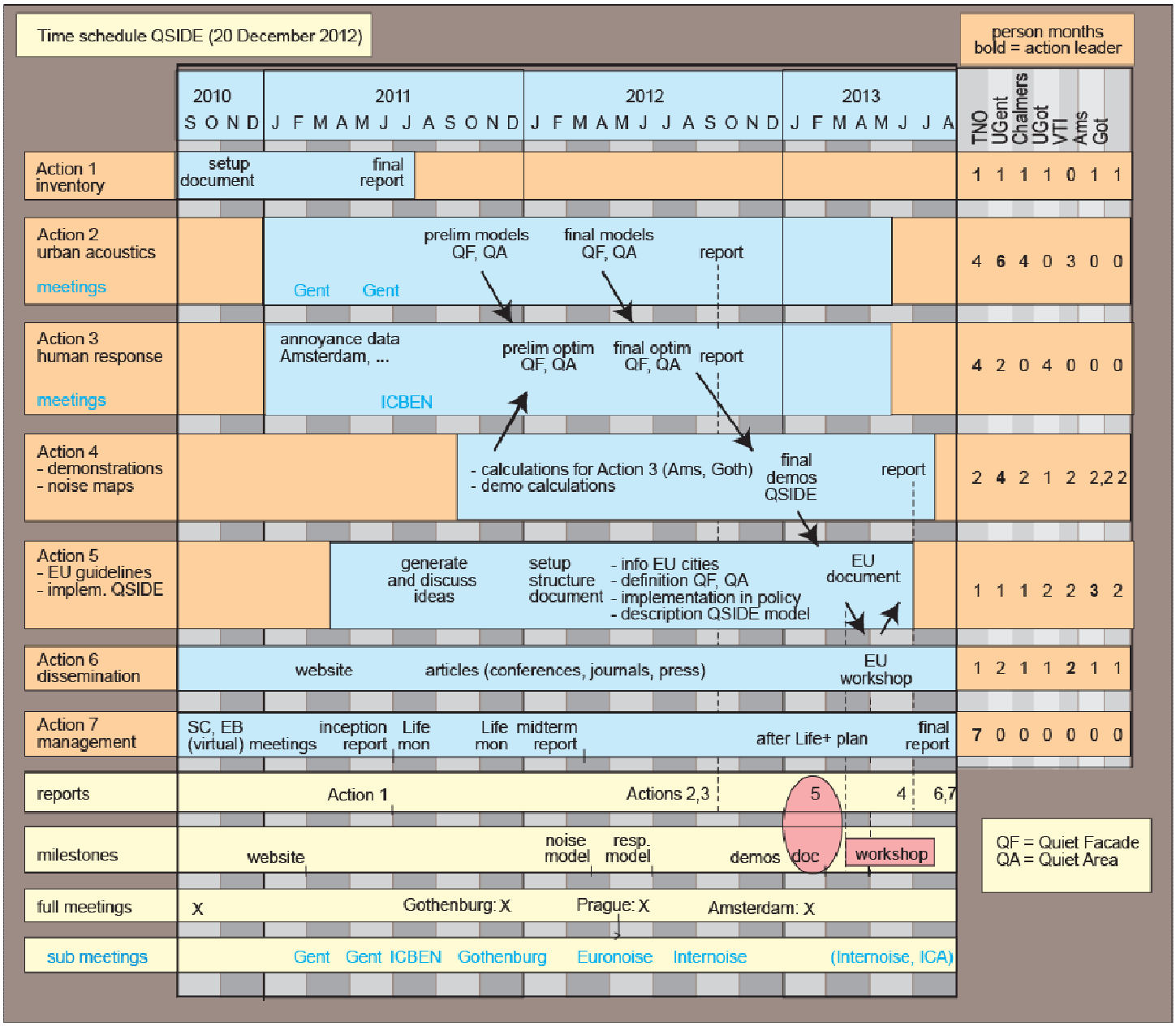
The Consortium Agreement is based on the DESCA model.
The following issues are covered.

- Definitions
- Purpose
- Entry into force, duration, and termination
- Responsibilities of parties
- Liability towards each other
- Governance structure
- Financial provisions
- Foreground
- Access rights
- Non-disclosure of information.

Background knowledge of partners CUT and UGot are listed as an attachment of the Agreement.

Planning

During the project the time planning was updated several times. The planning was regularly updated by TNO, and uploaded to the project website for communication with the partners. The Gantt chart below shows the planning version of 20 December 2012.



4.2 Evaluation of the management system

The management system set up for the project worked in general quite well. The organization of the project into seven Actions made it clear to the partners what their roles were. The annual consortium meetings were essential in the process for various reasons:

- updates on progress achieved by partners,
- plenary discussions on various topics of broad concern for the project,
- subgroup discussion on technical aspects of the work in the various Actions.

As an example we mention here a lively discussion on the recommendations to EU cities, in particular on the issue of the definitions of the concepts of quiet façade and quiet urban area. Different partners had different opinions on the limiting noise levels. Some partners were in favour of recommending relatively high noise levels, based on the assumption that a limited amount of traffic noise is an inevitable element of modern city life. Other partners were in favour of recommending lower levels, based on the fact that noise levels are already quite low at quiet places in cities, and we should avoid allowing an increase of noise levels at these places. The final outcome of this discussion is reflected in the recommendations to EU cities on limiting noise levels at quiet places, as described in the document/website for EU cities.

A problem during the project was that the calculation models to be developed in Actions 2 and 3 were delayed beyond the initial deadlines. This was partly caused by the fact that partners of Actions 2 and 3 were primarily partners from universities, which have a tendency to continue their research until the result is 'perfect'. The QSIDE objective to develop practical *engineering* methods was sometimes a bit forgotten, and the project coordinator had to remind the partners about this. It was realized early in the project that the initial ideal process of subsequently developing different project results (Action 2 noise model => Action 4 improved noise maps => Action 3 calculation method => Action 5 recommendations to EU cities) was not a feasible approach, so instead it was decided that there would be partial overlap between the research in the different Actions.

Also within the sub-teams working on the Actions there was not always consensus among the partners, in particular in Actions 2 and 3. In Action 2 the different opinions on the calculation model for quiet places were discussed in various meetings, which ultimately led to a model that satisfies the requirements for more accurate prediction of noise levels in quiet places. In Action 3 there were also different opinions on the calculation scheme for the effects of quiet façades on traffic noise annoyance. Consequently, no single final calculation scheme was recommended here, but rather different possible approaches were described in the various documents and scientific articles produced by Action 3 partners.

Project results have been disseminated in various ways. Dissemination through presentations and papers at scientific conferences has been very effective. The workshop for EU cities and other interested people in Lyon on 24 April 2013 was also successful, although the attendance was lower than expected. However, the material presented at the workshop largely coincides with the material presented on the QSIDE website for EU cities, and this website can be accessed by all EU cities at all times, also after the project. We have already received various reactions on the website. As described in the after-Life plan for QSIDE, the website ensures that EU cities will have access to the QSIDE results in the future.

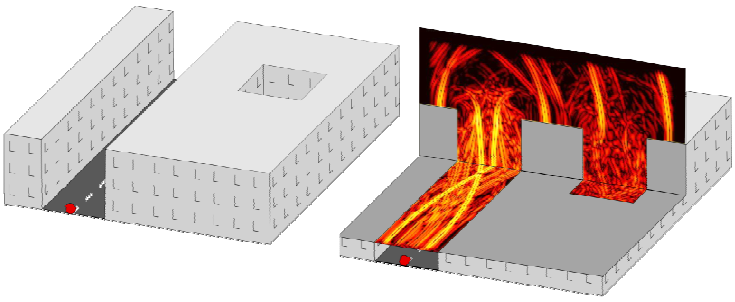
5. Technical part

5.1. Task by task - description

In this section the technical activities and outputs of the Actions of the project are described.

Action 1: collection of information
The Action 1 report has been completed in July 2011. All partners have contributed to this. The report consists of information collected in three relevant areas: i) Urban Acoustics, ii) Human Response, and iii) Current approaches in European cities with respect to quiet façades and quiet areas.

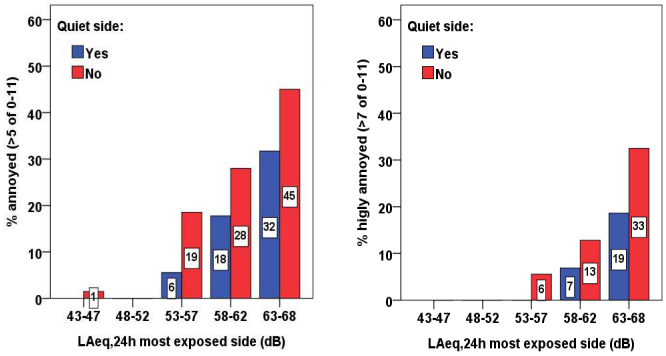
i) Urban Acoustics
For Urban Acoustics, information has been collected and described on current engineering models, and also information and data on sound levels at quiet façades and in quiet areas.
As an example, we reproduce below a graphical representation of the sound field near an urban street and closed courtyard, as calculated with an advanced numerical calculation method. These types of calculations have been used later in the project for the development of the practical engineering model for sound levels at shielded locations (Action 2).



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

ii) Human Response

For Human Response, the partners have described available information and survey data on the effects of quiet façades and quiet areas on traffic noise annoyance and sleep disturbance.
As an example we reproduce below a figure that shows results from the Swedish Soundscape for Health study. The graphs illustrate that the percentage of people that is annoyed or highly-annoyed by traffic noise is lower if one has access to a quiet façade of the dwelling. For details the reader is referred to the Action 1 report.



Graphs illustrating the effect of access to a quiet side on traffic noise annoyance, from the Swedish Soundscape for Health project. For details, see the Action 1 report.

iii) Current approaches in European cities with respect to quiet façades and quiet areas.

For the third element of Action 1, partner Amsterdam has organized a consultation of fifteen European cities about current approaches in the cities with respect to quiet façades and quiet areas. The results of the consultation were reported in the Action 1 report, and provided a starting point for the work in Action 5, such as the definitions of quiet façades and quiet areas. The Action 1 report has been sent by Amsterdam to the fifteen cities involved in the consultation.
In the period May-July 2011 the consultation of fifteen European cities into current approaches of the cities to quiet façades and quiet areas was completed. Fifteen European cities have participated in the consultation.
The cities have been contacted via personal contacts and via the Working Group Noise of the EUROCITIES network (http://workinggroupnoise.web-log.nl). The fifteen cities are: Amsterdam, Bilbao, Bristol, Brussels, Florence, Pisa, Gothenburg, Hamburg, Helsinki, Oslo, Paris, Utrecht, Zagreb, Zaragoza, and Zurich.

The following questions have been answered by authorities of the cities.

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?

The answers provided by the cities are summarized in Annex A of the Action 1 report.

From the answers to question 1 it was found that in seven of the fifteen cities quiet façades do play a role in noise policy and/or urban planning. Also quiet areas are part of noise policy, or will be in the future, in several cities.
From the answers to question 2 it was found that a definition of quiet façades is employed in eight cities. Three cities currently use the rather unrealistic definition given in the Environmental Noise Directive (quiet façade must be at least 20 decibel lower than the noisy façade), so here QSIDE may be useful for improving the definition. Five cities have reported a definition of a quiet area, some of which include non-acoustical criteria.
For more details, see the Action 1 report.

Action 2: engineering model for noise levels at quiet places
Partner UGent was leader of Action 2. Together with partners CUT, VTI, and TNO an engineering model has been developed for calculating noise levels at quiet places in cities.
A preliminary version of the model was described in a version of the Action 2 report that was completed on 28 September 2012. In August 2013 the final version of the report was delivered, and uploaded on the project website of QSIDE.

The structure of the report is as follows. The main text of the report describes the final formulation of the model. The appendices contain the texts of scientific articles that have been submitted to an international journal – Acta Acustica united with Acustica.

Below we present an outline of the model. For details the reader is referred to the Action 2 report.

The Action 2 noise model is an extension of conventional noise-mapping models. This means that a two-stage approach should be followed:

- first a conventional noise-mapping model is used for calculating 'basic' noise levels representing only direct and reflected sound waves,
- next the new QSIDE model is used for calculating noise level contributions (L_{pb}) representing complex effects from multiple canyon reflections, intermediate canyons, rooftop shape, and turbulent scattering (see figure below).

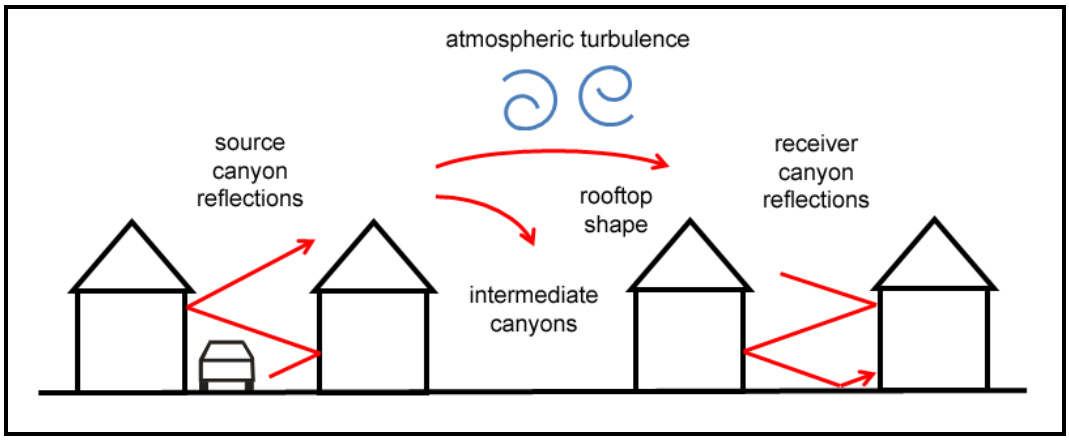


Illustration of the elements of the QSIDE noise model for shielded urban locations.

The mathematical procedure for calculating the noise level contributions (L_{pb}) in the second stage is as follows.

First the noise level at the shielded location – in absence of turbulent scattering – is calculated:

$$L_{pbd} = L_W - A_{free} - A_{bar} - A_{can} - A_{roof} - A_{inter}$$

Next the effect of turbulence is included by logarithmic addition of a scattering term:

$$L_{pb} = L_{pbd} \oplus L_{p,scat}$$

Here we have the following quantities.
L_{pbd} = the "background" sound level excluding the following sound paths: direct, reflected, diffracted around vertical edges.
L_W = sound power level per octave band of a point source representing part of the road, no directivity is taken into account since multiple sources will contribute to the shielded level as well as multiple reflections from various directions.
A_{free} = 3D free field divergence. This term should also include the atmospheric attenuation outside the canyon.
A_{bar} = the attenuation of the barrier, including the effect of the ground.
A_{can} = additional attenuation caused by multiple reflections in the source and receiver canyon (normally negative). Atmospheric attenuation in the canyon, façade absorption, façade scattering, etc. are included implicitly in this term.
A_{roof} = effect of non-flat roof.
A_{inter} = additional attenuation caused by the diffraction into intermediate canyons.
$L_{p,scat}$ = turbulence scattered noise level.

Suitable approximate formulas for the attenuations A have been derived by fitting to an extensive database of detailed sound propagation simulations, performed with the numerical finite-difference FDTD method.

Action 3: effects of quiet façades and quiet areas on traffic noise annoyance and sleep disturbance

Partner TNO was leader of Action 3. Together with partners UGot and UGent analyses have been performed of results of studies and surveys on urban populations in NL, BE, and SE.
A preliminary version of the report describing the results of the analyses was completed on 28 September 2012. In August 2013 the final version of the report was delivered.

Human-response studies that were analyzed in Action 3 included two Swedish studies, two studies in Belgium, and one study in the Netherlands. Thus, this not only allowed comparison between studies in different EU cities and countries, but in addition between studies complementary in design. Study populations were located in five different European cities: Stockholm, Gothenburg, Antwerp, Gent and Amsterdam. In the table below an overview of the different types and size of included studies by country and city is presented. The main focus was on road traffic noise annoyance, but some studies offered the possibility to further investigate effects of least exposed side exposure on sleep disturbance. In addition, a study in Sweden allowed investigation of the impact of the physical environmental quality of the least exposed façade and perceived accessibility of green areas.

Overview of studies and analyses carried out within QSIDE

Country	City	Type	Number of participants
Sweden	Stockholm, Gothenburg	Cross-sectional (Focused study)	956
Sweden	Gothenburg	Intervention	132 (55 before, 77 after)
Belgium	Antwerp	Cross-sectional	675
Belgium	Gent	Cross-sectional (Focused study)	100
Netherlands	Amsterdam	Cross-sectional (Population based)	1967

The influence of noise exposure at the least exposed façade was explored in different ways, including:

1. A cut-off value for exposure at the least exposed side (L_{denmin});
2. A cut-off value for a relatively small versus a relatively large difference between most and least exposed façade (DIF: L_{denmax} - L_{denmin});
3. The least exposed side exposure (L_{denmin} in dB, as a continuous variable).

The different analyses performed correspond to different potential models for the 'quiet side effect'. Two of those, are inspired by the idea that the possibility to 'escape' from the noise reduces noise annoyance. The first one, using an 'absolute' value as cut-off to define a quiet side, explores the hypothesis that this requires a side with a maximal disturbance by road traffic noise of exposure at the least exposed façade (explored in QSIDE: L_{denmin} < 50 dB versus L_{denmin} >= 50 dB). The second one, using a relatively large difference in exposure between most and least exposed façade as indicator of 'relative quietness', assumes that noticeable less disturbance will influence the effects (explored in QSIDE: DIF < 10 versus DIF >= 10 dB). The third evaluation is grounded in a somewhat different model assuming that both most and least exposed façade exposure contribute to noise annoyance.

It was investigated how the different indicators for least exposed side exposure, in addition to exposure at the most exposed façade, affected the mean annoyance score (linear regression models: main analyses). In addition, it was explored if the least exposed façade affects the probability of having an annoyance score above a certain cut-off value for at least annoyed (A) (in addition to the exposure at the most exposed façade) (logistic regression models: exploratory, note that the aim here was not to derive (local) exposure response curves). In one study, this was additionally done separately for LA, A and HA to test whether the effect of least exposed façade exposure, differed for these different outcome variables.

Results of the different studies carried out in Action 3 provided further support for the influence of exposure at the least exposed façade. Significant effects were found for different indicators of road traffic noise exposure at the least exposed façade in most studies, with the exception of the Antwerp study. The effects of L_{denmin} seemed independent of L_{denmax}.
If expressed in terms of L_{denmax} the magnitude of the effect on predicted annoyance score ranged (between studies) from 3 to about 5 B for a 10 dB change in L_{denmin} . This means that a 10 dB change in L_{denmin} corresponded to approximately a 3 to 5 dB change in L_{denmax}. A similar range in effect estimates was found for DIF > 10 dB versus DIF < 10 dB.
Further, Swedish and Belgian results indicated significant effects of a quiet façade, and also of the location of the bedroom on the quiet façade, on sleep disturbance.

The analyses and surveys have been described in various articles in scientific journals and at international conferences, which are listed below. People interested in these results can consult the journals and proceedings of the conferences.

- De Kluizenaar et al. Urban road traffic noise and annoyance: The effect of a quiet façade. Journal of the Acoustical Society of America 2011; 130(4): 1936–1942.
- De Kluizenaar et al. Traffic noise and annoyance: The effect of quiet facades and quiet areas. Euronoise 2012, Prague, 10 – 13 June, 2012.
- De Kluizenaar et al. Road traffic noise and annoyance: A quantification of the effect of quiet side exposure at dwellings. International Journal of Environmental Research and Public Health 2013.
- De Kluizenaar et al. Annoyance and disturbed sleep due to road traffic noise: The importance of the least exposed side –QSIDE. Internoise 2013, Innsbruck, 15 – 18 September 2013.
- Gidlöf-Gunnarsson et al. The effect of creating a quiet side on annoyance and sleep disturbances due to road traffic noise. Internoise 2012, New York, 19 – 22 August 2012.
- Van Renterghem and Botteldooren. Focused Study on the Quiet Side Effect in Dwellings Highly Exposed to Road Traffic Noise. International Journal of Environmental Research and Public Health 2012; 9(12): 4292-4310

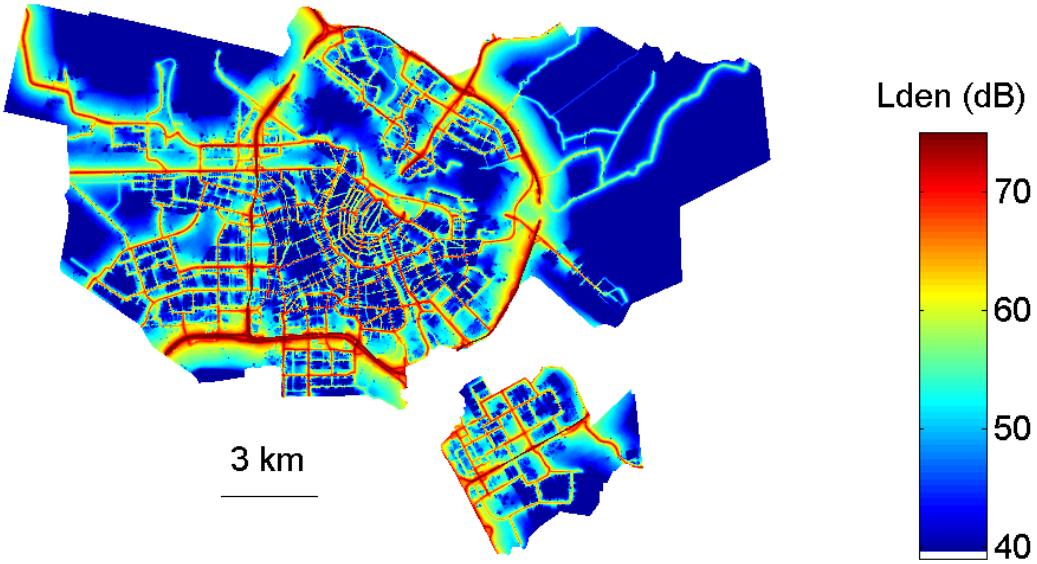
Action 4: noise level calculations, demonstrations and scenarios

Partner UGent was leader of Action 4. The work in Action 4 was strongly linked with the work performed in Actions 2, 3, and 5, and therefore all other partners contributed more or less to Action 4. A study on traffic noise in relation to sustainable urban planning was performed by TNO. The report describing the work performed in Action 4 was completed in August 2013.

The two general objectives of Action 4 were:

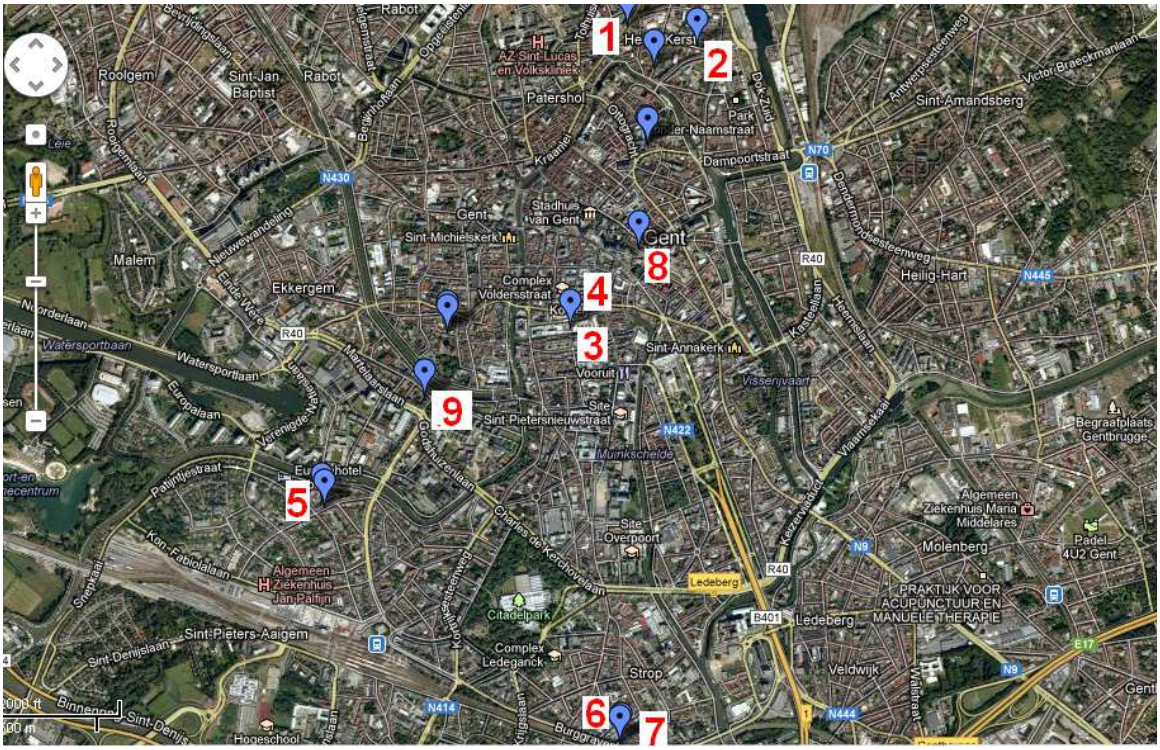
i) To provide calculated noise levels in cities to be used for the analyses performed in Actions 2 and 3.
ii) To provide demonstrations material and to consider future scenarios, serving as input for Action 5.

The first objective has been achieved. This work was performed in close connection with the work performed in Actions 2 and 3. An example of this work is the calculation of noise levels in the city of Amsterdam, at the façades of the dwellings. These noise levels have been used for the analysis performed in Action 3 of the human-response survey in Amsterdam.
The figure below shows the noise levels at a fixed height of 4 m. For the actual Action 3 analysis, the noise levels have been calculated at the actual heights of the respondents of the survey.

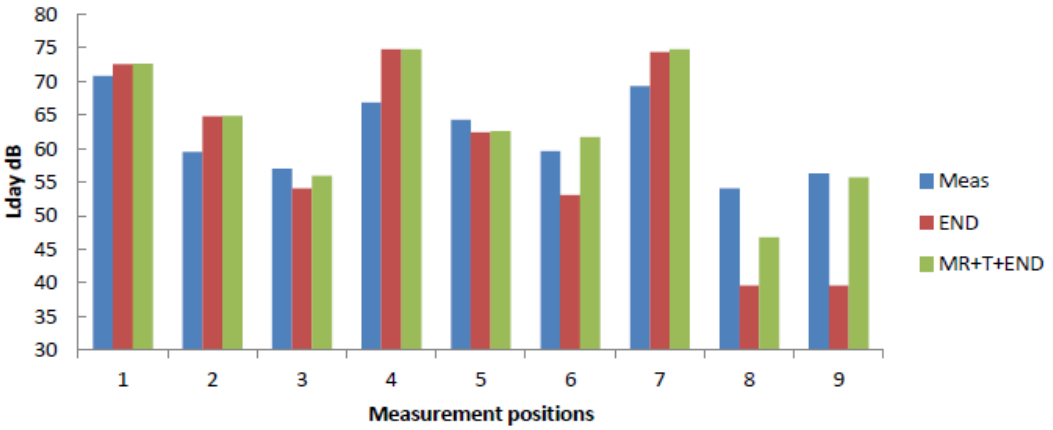


Road traffic noise map of Amsterdam. The color represents the noise level in L_{den} calculated on an area-covering grid at height 4 m.

UGent has performed an analysis of traffic noise levels in the city of Ghent, which clearly demonstrates the improvement obtained with the QSIDE model for noise levels at shielded locations. Measurements of noise levels have been performed at nine locations, which are indicated in the map below. The locations include shielded areas with relatively low traffic noise levels. The graph below the map compares the average measured noise levels with calculated levels. The blue bars represent the measured noise levels, the red bars represent levels calculated with a standard noise model, and the green bars represent noise levels calculated with the improved QSIDE model. The figure clearly shows that the QSIDE model yields a major improvement compared with the standard model.



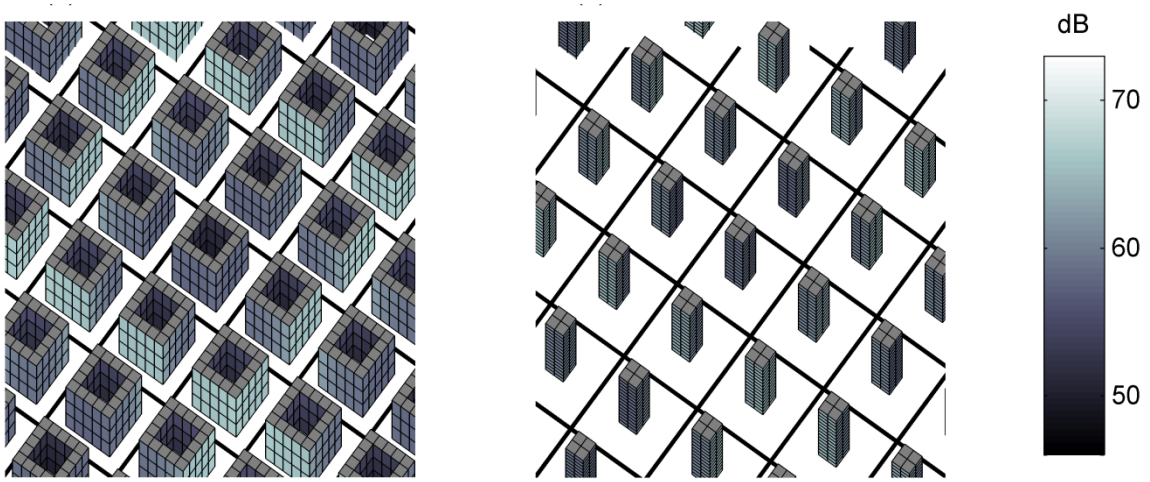
Measurement locations in Ghent, Belgium.



Comparison of predicted and measured noise levels Lday. Blue: measurement. Red: standard calculation performed in the framework of the Environment Noise Directive of Europe (END). Green: prediction of the noise model developed in QSIDE, calculated by summing the 'basic' END level and the background level accounting for multiple reflections (MR) and turbulence scattering (T).

TNO has performed a study in Action 4 into the relation between traffic noise control, including the protection of quiet places, and the broad concept of sustainable urban planning. This study is of interest for EU cities, since cities in general have a broad agenda, so traffic noise control should not be considered as an isolated topic. The study focused on long-term future scenarios of cities, including traffic scenarios. The effects of shapes of building blocks on noise levels at quiet façades were also considered. The figure below illustrates these effects. The left picture shows closed building blocks, with low traffic noise levels at the inner

courtyards shielded from the streets. The right picture shows ‘tower-like’ buildings without inner courtyards. The gray-scale bar represents the noise level at the façades of the buildings. Part of this study has been published in the international journal Landscape and Urban Planning (E.M. Salomons and M.Y. Berghauser Pont, Landscape and Urban Planning **108** (2012) 2-16). People interested in these results can consult the journal.



Two examples of urban fabrics with a rectangular grid of streets between building blocks, and traffic noise façade levels represented by a gray scale. The left picture shows blocks with sides of 5 building units and 3 floors. The right picture shows blocks with sides of 2 building units and 15 floors.

Action 5: recommendations for EU cities on quiet places

Partner AMS was leader of Action 5. Together with partners VTI, GOT, and TNO a website/document has been developed with recommendations and guidelines for EU cities on quiet places in cities. A preliminary version of the website was prepared in March 2013, which served as a basis for the QSIDE workshop on 24 April 2013 in Lyon. In August 2013 the final version of the website / document was delivered.

The screen dump below shows the top of the welcome screen of the website, including a pull down menu with various items.

Illustration: top of the welcome screen of the website www.qside.eu.

As described in the project proposal, the initial idea was to prepare a single document in Action 5. During the project the idea came up to present the document also as a website. This dual presentation has several advantages. First it allows easier access for interested people from EU cities. Second it also allows including videos showing examples of noisy and quiet places in cities. Third, it is an easy way to ensure that the QSIDE results will remain accessible after the project.
The originally planned single document is now a single pdf-version of the complete website. This document can be downloaded from the website, as shown in the screen dump of the welcome screen shown above.

The website has the internet address www.qside.eu and will remain accessible after the end of the project. The text describes various aspects of quiet places, such as:

- indications of benefits of quiet places in terms of reduced annoyance,
- recommendations for (limiting) noise levels at quiet façades and in quiet areas,
- descriptions of other qualities than low noise levels at quiet places, such as vegetation or nice architecture,
- examples of quiet places, with videos and pictures,
- traffic noise control and quiet places in relation to sustainable urban planning,

- brief descriptions of scientific QSIDE work supporting the recommendations.

The intention is that cities will find material on the website that is helpful for the implementation of quiet places in the noise policy of the city. In this way, the website should be considered as a tool that supports the protection and creation of quiet places in cities, which is an important element of European environmental noise policy as formulated in the Environmental Noise Directive 2002/49/EC.

In April 2013 a QSIDE workshop was held in Lyon, where the website was presented to representatives of cities and to researchers of projects that are related to QSIDE. For more information, see Action 6 below.

The recommendations for (limiting) noise levels at quiet façades and in quiet areas are in terms of average (equivalent) noise levels, Lden and Lnight. Setting limiting values for these average levels may not be sufficient to protect people against sleep disturbance by traffic noise. Sleep disturbance may be caused by a few noise peaks caused by a few vehicle passages. Therefore the following additional recommendation has been included on the website.

> In order to minimize chances of sleep disturbance by night-time traffic noise, it is recommended that cases of *direct* traffic-noise exposure at the quiet façade are avoided.

This recommendation is based on a computational study of maximum noise levels at façades of dwellings, which is described in the Action 4 report. The recommendation is illustrated below.

Case 1: direct exposure at quiet side *Case 2: urban background noise at quiet side*

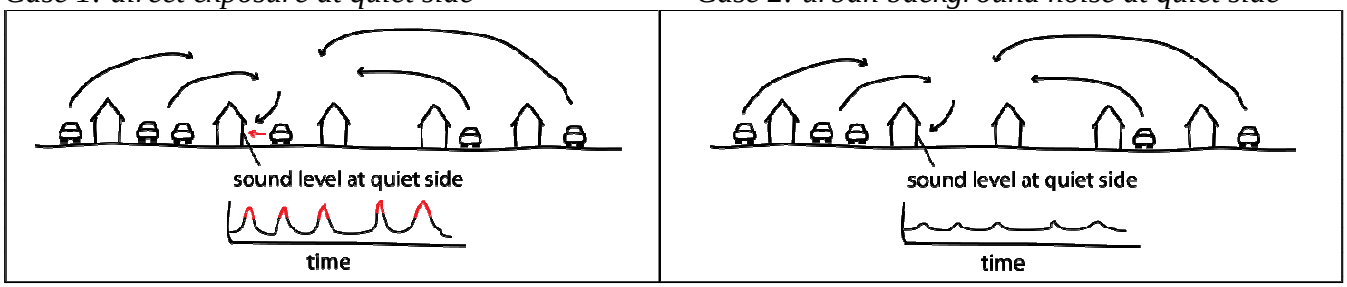


Illustration of two cases of night-time traffic noise exposure at the quiet side. It is recommended that situations of case 1 (left) are avoided, in order to minimize chances of sleep disturbance by night-time traffic noise.

Action 6: dissemination, website, and workshop

VTI was leader of Action 6. All partners have contributed to the dissemination of the results of the project. The project website has been set up at the beginning of the project, and served as a platform for dissemination of project results and for exchange of information between the partners via the internal website. The website for EU cities (see Action 5) was also coordinated by VTI. This website was set up end of 2012, and the final version was completed in August 2013. The website was presented at the QSIDE workshop on 24 April 2013 in Lyon.

The address of the project website is www.qside.eu/proj. The address of the website for EU cities is www.qside.eu. The project website can be reached through a link on the EU website. On the project website, the reports of Actions 1-6 are collected for downloading. In addition, abstracts of QSIDE papers at conferences are collected, including Internoise and Euronoise. The full papers cannot be included because of copyrights. The conference papers can be obtained only through the proceedings of the conferences.

Below we give a list of the articles about QSIDE work, including both articles in peer-reviewed scientific journals and conference papers presented at international conferences. Acknowledgements to the QSIDE project[1] were included.

1. T. Van Renterghem and D. Botteldooren, "Pilot study on the presence of quiet sides in Flanders" Internoise 2011, Osaka, Japan
2. Y. de Kluizenaar, E.M. Salomons, S.A. Janssen, F. J. van Lenthe, H. Vos, H. Zhou, H.M.E. Miedema, J.P. Mackenbach., "Urban road traffic noise and annoyance: the effect of a quiet facade", J. Acoust. Soc. Am. 130 (2011).
3. W. Wei, T. Van Renterghem, D. Botteldooren, M. Hornikx, J. Forssén, E. Salomons, M. Ögren "An efficient model for background noise mapping." Euronoise 2012, Prague
4. Y. de Kluizenaar, E. Salomons, S. Janssen, "Traffic noise and annoyance: the effect of quiet facades and quiet areas" Euronoise 2012, Prague
5. F. van den Berg, C. Schoonebeek, M. Hillebregt, "On the definitions of quiets facades and quiet areas." Euronoise 2012, Prague
6. M. Hornikx, J. Forssén, M. Ögren, D. Botteldooren, T. Van Renterghem, W. Wei, E. Salomons "On the improved point-to-point calculations for noise mapping in shielded urban areas." Internoise 2012, New York
7. A. Gidlöf-Gunnarsson, E. Öhrström, J. Forssén, "The effect of creating a quiet side on annoyance and sleep disturbances due to road traffic noise" Internoise 2012, New York
8. F. van den Berg, "Quiet zones and traffic policy in Amsterdam." Internoise 2012, New York
9. E. Salomons: "Measurements and calculations of noise in the streets of Amsterdam, Rotterdam, and Paris." Internoise 2012, New York
10. E.M. Salomons, M. Berghauser Pont, "Urban traffic noise and the relation to urban density, form, and traffic elasticity." Landscape and Urban Planning 108 (2012) 2-16.
11. Van Renterghem and Botteldooren. "Focused Study on the Quiet Side Effect in Dwellings Highly Exposed to Road Traffic Noise." International Journal of Environmental Research and Public Health 2012; 9(12): 4292-4310

[1] The acknowledgement is: "Part of this work was financially supported by the Life+ program of the European Community (project QSIDE, LIFE09 ENV/NL/000423)."

12. Y. De Kluizenaar, S.A. Janssen, H. Vos, E.M. Salomons, H. Zhou, F. Van den Berg, "Road traffic noise and annoyance: A quantification of the effect of quiet side exposure at dwellings." International Journal of Environmental Research and Public Health 2013.
13. Y. De Kluizenaar, A. Gidlöf-Gunnarsson, D. Botteldooren, A. Bockstael, S.A. Janssen, H. Vos, F. Van den Berg, E.M. Salomons "Annoyance and disturbed sleep due to road traffic noise: The importance of the least exposed side –QSIDE. Internoise 2013, Innsbruck.

In addition, the work performed in Action 2 will be published

14. M. Hornikx, J. Forssén, D. Botteldooren, T. Van Renterghem, W. Wei, M. Ögren, E. Salomons, "Urban background noise mapping: the multiple-reflection correction term", accepted for publication in Acta Acustica.
15. W. Wei, D. Botteldooren, T. Van Renterghem, M. Hornikx, J. Forssén, E. Salomons, M. Ögren, "Urban background noise mapping: the general model", submitted for publication in Acta Acustica
16. J. Forssén, M. Hornikx, D. Botteldooren, W. Wei, T. Van Renterghem, M. Ögren, "Urban background noise mapping: the turbulence scattering model", submitted for publication in Acta Acustica.

The QSIDE workshop for EU cities took place on 24 April 2013 in Lyon. The title of the workshop was:

Quiet façades and quiet urban areas
Benefits for people
Implementation in urban noise policy

The invitation for the QSIDE workshop is shown below. The invitation was sent to a large number of potential attendants, including about 60 partners of the working group Noise of the Eurocities network, and to about 40 other relevant persons. In addition the invitation was sent to representatives of five French cities near Lyon: Grenoble, Saint-Etienne, Nice, Montpellier, and Aix-en-Provence.
The QSIDE workshop preceded a meeting of the working group Noise of Eurocities (25-26 April). The idea was that in this way we would attract more participants. However, the number of participants was a bit disappointing, possibly because of limited financial resources of cities in this period of financial crisis.
The total number of persons attending the workshop was 13. Three cities were represented at the workshop: Berlin, The Hague, and Lyon. In addition the QSIDE partners Amsterdam and Gothenburg were present.
Further, three partners of the related European projects HARMONICA, HUSH, and QUADMAP attended the workshop. This gave us the opportunity to have valuable discussions on the relations between the three projects and QSIDE.
The program of the workshop was as follows.

1. Presentation of QSIDE – by Erik Salomons, Frits van den Berg, Carlo Schoonebeek, Martin Knape, and Mikael Ogren
2. Presentation of HARMONICA – by Vincent Gissinger
3. Presentation of HUSH and QUADMAP – by Francesco Borchi
4. Discussions.

Since the group was small, discussions were held during the presentations rather than at the end of the workshop. The presentation of QSIDE followed the structure of the QSIDE website www.qside.eu. The HARMONICA project was presented by Vincent Gissinger of Acoucité Lyon. The HUSH and HARMONICA projects were presented by Francesco Borchi of the University of Florence. The sheets of the presentations are reproduced in the appendices of the Action 6 report.

QSIDE workshop

Quiet façades and quiet urban areas

benefits for people and implementation in urban noise policy

On Wednesday 24 April 2013, the QSIDE project team will organize a workshop in Lyon preceding the Eurocities WG Noise spring meeting.
The workshop is intended for officials from local authorities who are interested in the benefits of quiet façades and quiet areas.
The workshop will focus on the following questions:

- What are the characteristics of quiet façades and quiet areas? How can they be defined?
- How can cities implement quiet façades and quiet areas in their traffic noise policies?

A summary of results of the QSIDE project will also be presented at the workshop, including:

- the calculation of traffic noise levels in shielded urban locations,
- the reduction of traffic noise annoyance and sleep disturbance due to quiet façades and quiet areas.

The QSIDE team welcomes feedback from cities including experience with urban planning and building policies. The feedback will be used in the final recommendations of QSIDE.

Program 24 April 2013, 13:30-16:30h
1. QSIDE results
2. Related EU projects, QUADMAP, HARMONICA, HUSH
3. Discussion

A preview of QSIDE results is available at www.qside.eu/nweb

24 April 2013, 13:30 – 16:30h, QSIDE workshop
25 and 26 April 2013, Eurocities WG Noise

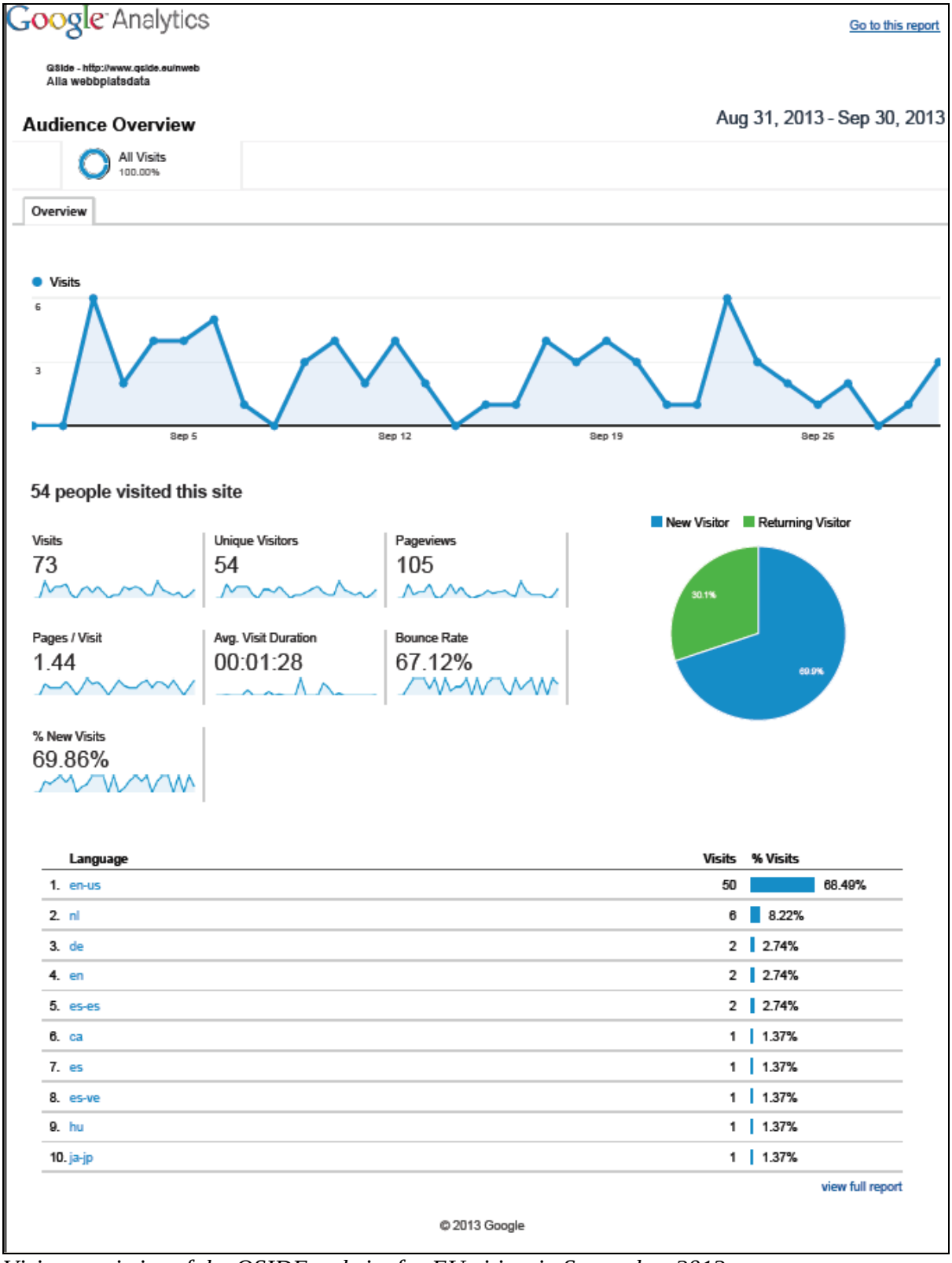
Participants of the QSIDE workshop are also invited to attend the Eurocities WG Noise meeting.
Information on Eurocities WG Noise can be found at http://workinggroupnoise.web-log.nl.

Registration
To attend the QSIDE workshop, please send an email to Erik Salomons (erik.salomons@tno.nl) or Mikael Ögren (mikael.ogren@vti.se).

Location
The QSIDE workshop and the Eurocities WG Noise meeting will be held at the following address:
Grand Lyon, Hôtel de communauté, 20 rue du Lac, Lyon

About QSIDE
The main objective of the project QSIDE is to demonstrate how European cities can effectively reduce harmful effects of traffic noise (annoyance and sleep disturbance) by protecting and creating *quiet façades and quiet areas*. The protection of quiet façades and quiet areas is supported by the European Noise Directive 2002/49/EC. QSIDE will deliver a new method for calculating noise levels at shielded locations, and a new method for assessing the positive effects of quiet façades and quiet areas on people. QSIDE results provide support for taking into account quiet facades and areas in urban environmental policy. The QSIDE project is partially funded by the European Life+ program.

Front and back side of the invitation for the QSIDE workshop in Lyon.



Visitor statistics of the QSIDE website for EU cities, in September 2013.

5.2 Evaluation

In general the objectives of the QSIDE project have been partly achieved. This is summarized below. For more details, see section 5.1.

Action1: objectives have been achieved. Information for other Actions has been collected, as well as information about current approached in EU cities.

Action 2: objectives have been achieved. The new QSIDE model for noise levels at quiet places has been developed.

Action 3: objectives have been partly achieved. Results on benefits of quiet places have been analysed for cities in NL, BE, and SE. This led to different results in different cities. A single common approach for predicting benefits of quiet places has not emerged from the analyses, partly owing to the deviations between the results for different cities.

Action 4: objectives have been partly achieved. Noise levels for analyses in Action 3 have been calculated. Demonstration material for Action 5 has been generated. The relation between traffic noise control and quiet places has been analysed and described. Initially more extensive calculations for future scenarios were foreseen, but these could not be performed because the final Action 2 model was completed later than planned. Lesson learnt: apply deadlines in the project more strictly.

Action 5: objectives have been achieved. The document with recommendations and guidelines for EU cities has been prepared, and moreover has also been prepared as a website.

Action 6: objectives been partly achieved. QSIDE work has been presented extensively in journals and at conferences. The project website worked well. The website for EU cities has been prepared. The workshop for EU cities took place in Lyon. The number of attendants was lower than foreseen, possibly because of limited funding in cities for this type of events.

5.3 Analysis of long-term benefits

The work performed in QSIDE should be taken into account in future updates of the Environmental Noise Directive 2002/49/EC. The project has produced new results and insights about quiet façades and quiet urban areas, which are important elements of the Environmental Noise Directive. The current version of the Environmental Noise Directive does not provide sufficient guidance concerning the methods how these elements should be addressed by the cities. Advantage should be taken here of the QSIDE results.

Further, the QSIDE results should be taken into account in the harmonised European noise model Cnossos, which is currently being developed by the EU.

Partners of QSIDE are well-known researchers in the field of environmental noise control in Europe, and as such the partners will continue to promote the QSIDE results, also in relation to the Environmental Noise Directive and the calculation model Cnossos.

5.4 Dissemination issues

In Section 5.1 (under Action 6), we have given a list of the articles about QSIDE work, including both articles in peer-reviewed scientific journals and conference papers presented at international conferences.

The QSIDE website for EU cities is an important platform for future dissemination of QSIDE results. The QSIDE workshop in Lyon was successful, although the number of attendants was lower than foreseen, possibly because of limited funding in cities for this type of events. We have tried to compensate for this by developing the Action 5 document for EU cities as a website, so that relevant persons in cities can learn about the QSIDE results from behind their

desks. The Life logo is included on the website, and has also been included in sheets of presentations of QSIDE work. Funding by Life was also acknowledged in published scientific articles and in conference papers about QSIDE work.

5.4.1 Dissemination: overview per activity

See Section 5.1.

5.4.2 Layman's report

See next pages.

The project QSIDE: positive effects of quiet façades and quiet urban areas on traffic noise annoyance and sleep disturbance.
General description for a non-expert audience ('layman's report').

*Traffic noise in European cities is a major source of annoyance and sleep disturbance. A good approach to reduce the harmful effects of traffic noise is to create **quiet façades and quiet urban areas**. The project QSIDE provides strategies and tools to put this approach in practice.*

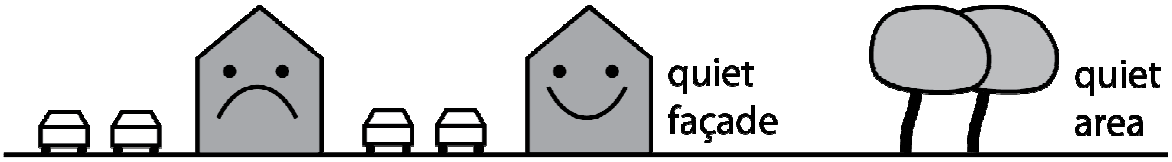
1. Outline of the project

The main objective of the project QSIDE is to demonstrate how European cities can effectively reduce harmful effects of traffic noise - annoyance and sleep disturbance - by offering two types of *refuges* to the inhabitants:

- *quiet façades of dwellings,*
- *quiet urban areas such as parks and quiet residential areas.*

For example, a quiet façade offers the possibility to choose a bedroom on the quiet side of a house, thereby reducing the chances on sleep disturbance by traffic noise. The refuges can be created in new urban areas, but they can also be created by modifying existing urban areas, for example by modifying traffic flows or by choosing specific orientations of houses with respect to roads.

In the project the general term *quiet places* was introduced, which includes both quiet façades and quiet urban areas. The figure below illustrates the beneficial effects of quiet places.



Quiet façades and quiet areas are good for inhabitants.
The general term 'quiet places' is used for quiet façades and quiet areas.

2. Project partners and funding

The project was performed in the period 2010-2013 by seven partners:

- TNO Delft, coordinator of the project
- Ghent University
- Chalmers University
- University of Gothenburg
- VTI Gothenburg
- city of Amsterdam
- city of Gothenburg.

The four involved cities are indicated on the geographical map shown below. The project was financially supported by the Life+ program of the European Community (project QSIDE, LIFE09 ENV/NL/000423).

3. Results of the project

Main results of the project are the following.

1. A website / document with recommendations and guidelines for EU cities on practical aspects of quiet places in cities.
2. A new calculation method for traffic noise levels at quiet places in cities.
3. Results of analyses of the effects of quiet places on inhabitants of cities in NL, BE, and SE, and considerations of possible calculation schemes to predict the effects.

The three results are briefly described in the following sections.

3.1 Result 1: document for EU cities

A document has been prepared with recommendations and guidelines for EU cities on practical aspects of quiet places. The document was primarily prepared as a website consisting of several webpages, but a single pdf-version of the complete website has also been prepared.

The website has the internet address www.qside.eu and will remain accessible after the end of the project. The website describes various aspects of quiet places, such as:

- indications of benefits of quiet places in terms of reduced annoyance,
- recommendations for (limiting) noise levels at quiet façades and in quiet areas,
- descriptions of other qualities than low noise levels at quiet places, such as vegetation or nice architecture,
- examples of quiet places, with videos and pictures,
- traffic noise control and quiet places in relation to sustainable urban planning,

- brief descriptions of scientific QSIDE work supporting the recommendations.

The intention is that cities will find material on the website that is helpful for the implementation of quiet places in the noise policy of the city. In this way, the website should be considered as a tool that supports the protection and creation of quiet places in cities, which is an important element of European environmental noise policy (see next section).

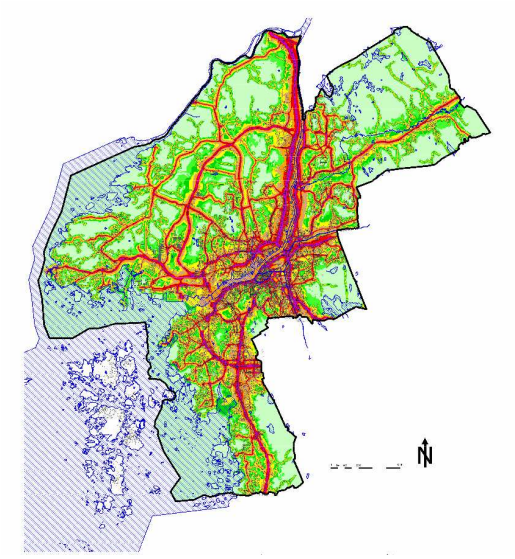
In April 2013 a QSIDE workshop was held in Lyon, where the website was presented to representatives of cities and to researchers of projects that are related to QSIDE.

The screen dump below shows the top of the welcome screen of the website, including a pull down menu with various items.

Illustration: top of the welcome screen of the website www.qside.eu.

3.2 Result 2: method for calculating traffic noise levels at quiet places

Before explaining the new QSIDE calculation method, we first mention that EU cities regularly produce maps of traffic noise. An example is the noise map of Gothenburg in 2007 shown below. The colour represents the noise level in decibels. Noise levels are high (red) near busy roads and lower (green) in quiet areas. The noise maps must be calculated with methods indicated in a European document that is commonly called *Environmental Noise Directive* (2002/49/EC).

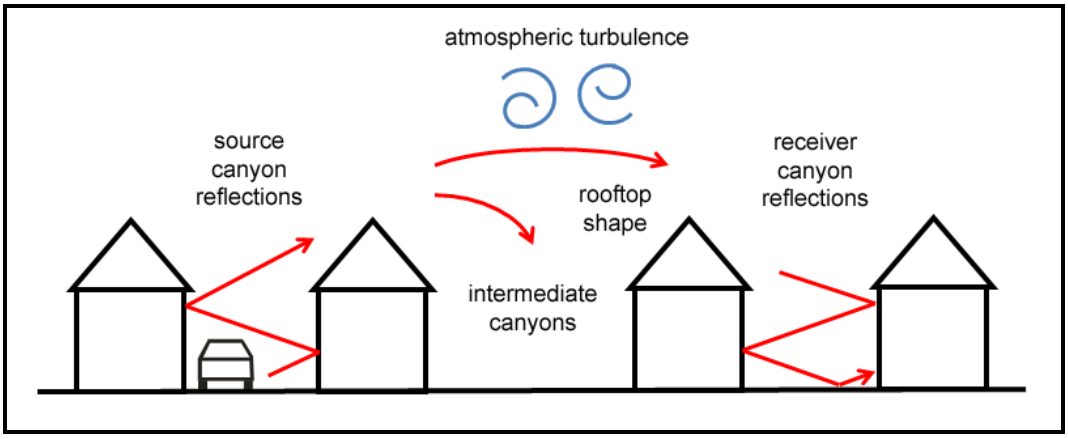


The Environmental Noise Directive also indicates that cities should provide information on *quiet places*, but quantitative methods for obtaining this information are not specified. This is a problem, since it is known that noise levels at quiet places are in general underestimated by standard calculation models – including the new EU calculation model Cnossos which is intended for the next EU noise mapping round in 2017.

As a first step to solve this problem, QSIDE partners have developed an engineering model for calculating noise levels at quiet places. The model takes into account:

- effects of multiple reflections between buildings in a street
- scattering of sound waves by turbulence in the atmosphere.

This is illustrated schematically in the figure below.



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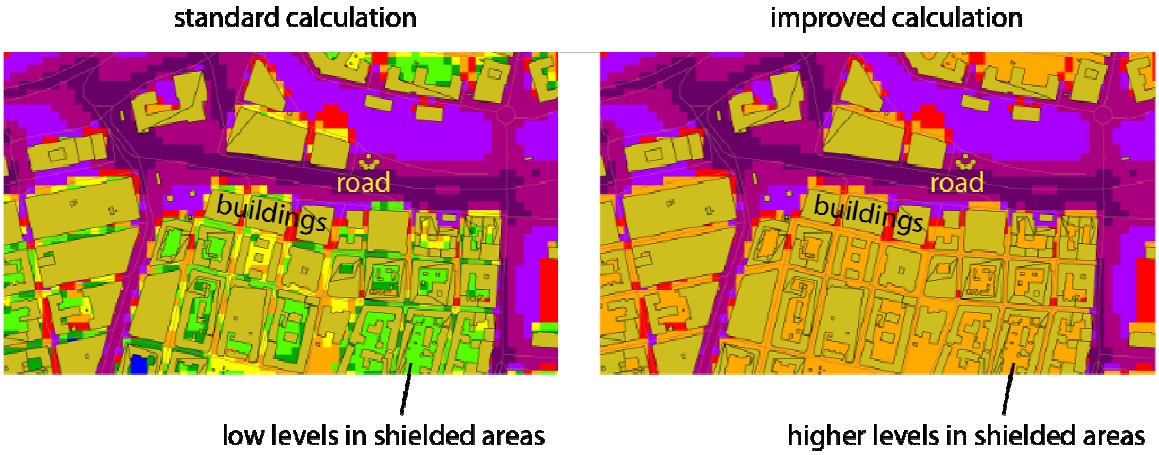
The QSIDE calculation model is an *extension* of standard calculation models such as Cnossos. This means that one should first calculate a noise maps with a standard method and next add an improvement calculated with the QSIDE model. Thus:

standard noise map + QSIDE correction = improved noise map

This approach is illustrated in the figure below, showing standard and improved noise maps of a small area of the city of Gothenburg. The noise map on the left was calculated with a standard model and the noise map on the right shows the improvement obtained the QSIDE model. On the roads and in areas near the roads, the noise levels are high (purple). In areas that are shielded by buildings (yellow), the standard noise map shows low levels (green) while the improved noise map shows higher levels (orange).



3.3 Result 3: method for estimating the beneficial effects of quiet places.

Annoyance and sleep disturbance by traffic noise in a city are conventionally estimated by means of exposure-response relations. For example, typically 25% of all people living in dwellings with a traffic noise level of 60 dB at the (noisiest) façade of the dwelling consider themselves as *annoyed* by the traffic noise. In QSIDE various possible methods have been explored for refining this approach, taking into account the beneficial effects of quiet façades and quiet areas.

The figure below illustrates the methods explored in QSIDE. The house on the left does *not* have a quiet façade, since there is traffic on both sides (front and back) of the house. The house on the right *does* have a quiet façade, since there is only traffic on one side of the house. Consequently, the people living in the left house are expected to be a bit more annoyed by the traffic noise, *on the average*, than the people living in the house on the right. This is illustrated by the smiling and non-smiling faces.

The explorations in QSIDE of the various possible methods are based on extensive studies of annoyance and sleep disturbance in five cities: Amsterdam, Antwerp, Ghent, Gothenburg, and Stockholm. Results of surveys in the cities have been related to noise levels at the most and least exposed façades, and also to quiet or green areas near the dwelling. Some of these analyses showed clear effects of quiet façades along the lines illustrated above, while other analyses showed no significant effects. Swedish and Dutch results indicated a significant effect of a quiet façade on traffic noise annoyance. Further, Swedish and Belgian results indicated that sleep disturbance is significantly affected by a quiet façade, and also by the location of the bedroom on the quiet façade.

Consequently, a single method for estimating the effect of a quiet façade on annoyance and sleep disturbance has not been formulated in QSIDE. However, the analyses and surveys have been described in various articles in scientific journals and at international conferences. People interested in these results can consult the journals and proceedings of the conferences.

4. Environmental impact of the project

The work performed in QSIDE should be taken into account in future updates of the Environmental Noise Directive. The project has produced new results and insights about quiet façades and quiet urban areas, which are important elements of the Environmental Noise Directive. The current version of the Environmental Noise Directive does not provide sufficient guidance concerning the methods how these elements should be addressed by the cities. Advantage should be taken here of the QSIDE results.

Partners of QSIDE are well-known researchers in the field of environmental noise control in Europe, and as such the partners will continue to promote the QSIDE results, also in relation to the Environmental Noise Directive and the new European calculation model Cnossos.

5.4.3 After-LIFE Communication plan

The after-Life communication plan for the QSIDE project was completed in August 2013. The plan is described in a short report, which was completed in August 2013. Below the main text of the report is reproduced.

Early in the project it was realized that it is important that the QSIDE results will remain available after the project. This applies in particular to the results of QSIDE Action 5, in which recommendations to cities were formulated concerning the protection and creation of quiet façades and quiet urban areas. Cities may take into account quiet façades and quiet urban areas in urban noise policy. To this end, recommendations were given in Action 5 for values of traffic noise levels at quiet façades and in quiet urban areas.

To achieve continuing availability of the QSIDE results, it was decided during the project that the main deliverable of Action 5 – a document with recommendations and guidelines for EU cities – would be prepared in the form of a website. This website is referred to as the 'QSIDE website' here.

In general, a website is a good medium for presenting scientific and practical results. A website is often considered more attractive than a paper document or electronic document. The QSIDE website will remain accessible after the end of the project.

On the QSIDE website the visitor finds various examples of quiet urban areas, some which are illustrated in a lively way by videos. The main content of the website is formed by the Action 5 results. A link to the QSIDE project website is included.

The QSIDE website offers the opportunity to download the complete website as a pdf document (without the videos). The internet address of the website is www.qside.eu. The figure below shows a screen dump of the top of the welcome screen of the website.

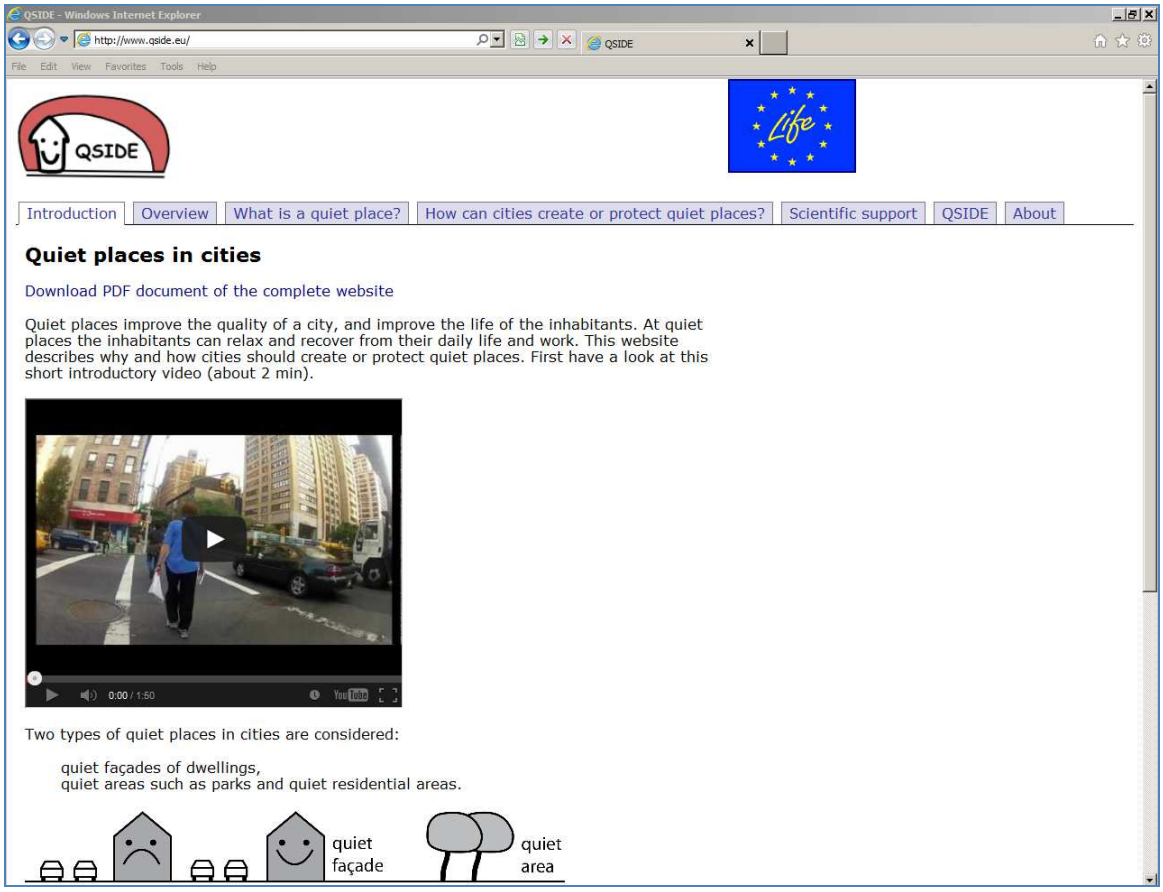
The QSIDE website will be the main future 'link' between QSIDE and EU cities. Cities that are interested in the results of QSIDE and want more information will find on the website two contacts that will help them. Help may be provided in two ways: i) direct answers to questions, or ii) referring to the appropriate expert in the QSIDE consortium.

During the project, a considerable number of scientific articles on QSIDE work have been prepared, both for conferences and for journals. Some of these articles have already been published, such as the articles on work in QSIDE Action 3. Other articles are still in the review process (for the scientific Journal "Acta Acustica united with Acustica"), so these will be published after the end of the project. This illustrates that QSIDE partners will continue their scientific work in this field.

Future presentations about QSIDE are already planned. At a conference in the Netherlands in November ("Geluid, Trillingen en Luchtkwaliteit", see http://www.geluidentrillingen.nl/) there will be two presentations about QSIDE. At another meeting in November in Ghent (SONORUS, see http://www.fp7sonorus.eu./) there will also be a presentation of QSIDE.

The partners of QSIDE are well known experts in the field of environmental noise control in Europe. In these roles they will recommend that use will be made of QSIDE results in the

context of various European developments that may occur in the future, for example a possible update of the Environmental Noise Directive or a revision of the European calculation model for environmental noise (Cnossos).



Screen dump of the QSIDE website, showing the top of the welcome screen.

6. Comments on the financial report

Included in full version of final report.

7. Annex

Signed Participant Cost Statements of all partners

Included in full version of final report.