QSIDE

DOCUMENT

Quiet places in cities

Quiet façades and quiet areas in urban noise policy. Recommendations and examples.

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PROJECT

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This document is a pdf-version of the QSIDE website www.qside.eu.

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The website presents descriptions and examples of quiet façades and quiet urban areas. Recommendations to cities for the definition and protection of quiet façades and quiet urban areas are also presented.

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Quiet places in cities

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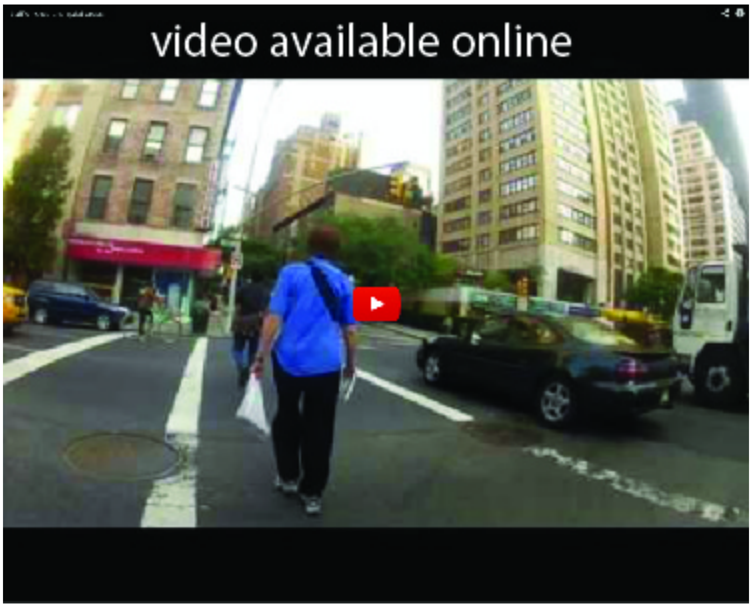
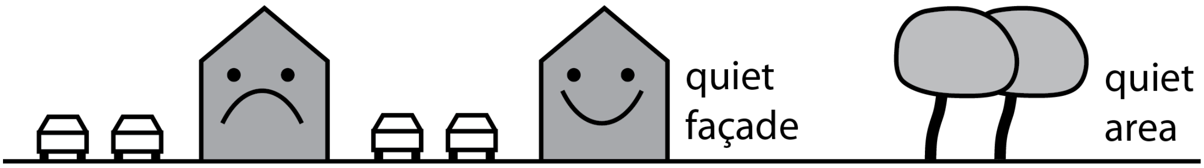
Quiet places improve the quality of a city, and improve the life of the inhabitants. At quiet places the inhabitants can relax and recover from their daily life and work. This website describes why and how cities should create or protect quiet places. First have a look at this short introductory video (about 2 min).



Two types of quiet places in cities are considered:

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



Quiet façades are attractive locations for gardens and balconies. Inside the house, bedrooms may be chosen preferably at the quiet façade. Quiet areas are locations where people can walk and relax, or can perform activities such as running.

Quiet places should be protected against excessive noise, in particular traffic noise. Traffic noise levels at quiet places should preferably be 45 dB or lower, but levels up to 50 or 55 dB may still be acceptable. This is explained in detail on this website.

Quiet places should also have other qualities than low traffic noise levels.

For example: nice architecture in a quiet residential area, nice vegetation in a park, or attractive sounds such as bird song. These qualities are also considered on this website, but the main focus is on the protection against traffic noise.

The website consists of the following sections.

- Introduction - this page.
- Overview - an overview of the website.
- What is a quiet place? - Definition of "quiet area" and "quiet façade" in relation to existing policies and research findings.
- How can cities create or protect quiet places? - Examples on quiet areas with figures and videos, and a discussion on urban planning and quiet areas and façades.
- Scientific support - Information on human response in terms of annoyance and sleep disturbance, and on how to calculate correct sound levels at shielded sides.
- QSIDE project - this website was prepared by partners of the EU Life+ project QSIDE, which is summarized in this section.
- About - About this website.

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DOCUMENT	**Quiet places in cities** **Quiet façades and quiet areas in urban noise policy. Recommendations and examples.**
SECTION	Overview **Noise and quietness in cities**

Noise and quietness in cities

By Erik Salomons

> *Quiet places in cities are very important for the inhabitants.*
> *They may reduce harmful effects of traffic noise.*
> *Protection of quiet places is supported by the European Environmental Noise Directive.Two types of quiet places are distinguished here: quiet façades and quiet areas.*
> *Quiet areas include not only parks but also quiet residential areas.*
> *It is recommended to keep traffic noise levels in quiet areas below 45-55 dB, and traffic noise levels at quiet façades below 45-50 dB.*

Noise is an inevitable element of modern cities. Sources of noise are cars, trucks, airplanes, construction equipment, for example.

Figure 1. Busy city center (Times Square in New York).

Noise cause annoyance and sleep disturbance of people living in cities. Therefore cities should restrict excessive noise, in particular at locations where people live and spend most of their time. Cities should also have quiet places, where people can relax and recover from the noisy city life.

Figure 2. Park in Amsterdam (Vondelpark).

The obvious and most important location for a quiet place is: home!

But: many people in cities live in dwellings near busy roads, so there is also traffic noise at home. For these people it may be good if the dwelling has at least one quiet side (quiet façade), where they can sit in the garden or on a balcony. Sleep disturbance is lower if the bedroom is on the quiet side. Another possibility is to have a quiet area such as a park in the neighborhood of the dwelling, although a quiet dwelling is more important than a quiet area near the dwelling.

When is a place a quiet place? The simple answer is: if there is not too much noise. But: an attractive quiet place should also have other qualities, for example nice vegetation or beautiful buildings. Also positive sounds may help, for example sounds of birds in a park.

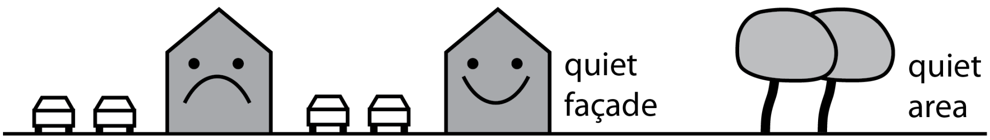

Figure 3. Quiet façades and quiet areas are good for inhabitants.

The aim of this website is to help cities with the creation and protection of quiet places. The focus is on road traffic noise, which is the most important outdoor source of noise. For example, a city may protect a quiet place by restricting traffic in the area. Other types of noise, such as noise from neighbors or noise from bars and restaurants, are not considered here.

Effects of road traffic noise

Road traffic noise has serious effects on people. The most important effects are annoyance and disturbance of daily activities such as communication, relaxation, and sleep. Sleep disturbance is particularly serious since undisturbed sleep is important for our physical and mental health. Research has shown that road traffic noise exposure enhances risks of hypertension and heart disease. Typically 10% of a city population is annoyed by road traffic noise. Typically 3% is highly sleep disturbed by road traffic noise. These numbers are estimated from statistical surveys and calculated noise levels at the façades of the dwellings.

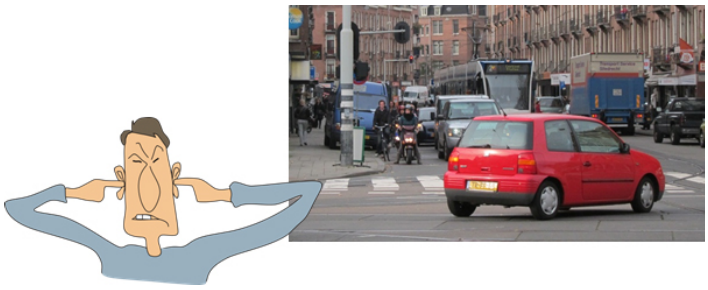

Figure 4. Traffic noise causes annoyance.

Traffic noise control in Europe

The European Union has laid down a strategy for reducing environmental noise exposure and its effects. The strategy includes that major EU cities calculate traffic noise maps and façade noise levels every five years. The EU document 'Environmental Noise Directive' describes how the noise maps should be calculated. The calculations take into account the numbers of cars on the roads and the locations of buildings in the city.

As an example, a traffic noise map of Amsterdam is shown in figure 5. High noise levels occur near busy roads. Low noise levels occur in the regions between the roads.

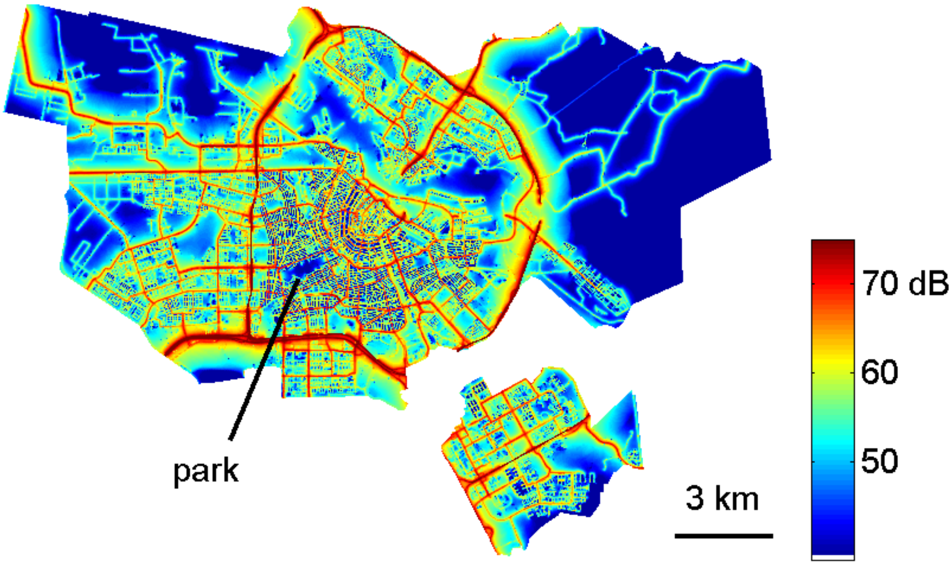

Figure 5. Traffic noise map of Amsterdam. The park of figure 2 is indicated. The color represents the 24h traffic noise level (day-evening-night level). Noise levels in the park are lower than in the area around the park. Note: traffic in quiet streets is often ignored for noise mapping, but here a minimum of 20 cars per hour was assumed.

Based on the noise maps, the cities have to make 'action plans'. This means that noise levels should be reduced at locations where the levels are high, for example by taking measures that reduce local traffic.

The Environmental Noise Directive also indicates that the cities have to

- estimate the number of inhabitants with a quiet façade at their home,
- protect quiet areas against an increase in noise.

The aim of this website is to help the cities to tackle local noise problems by taking advantage of the positive effects of quiet façades and quiet areas.

Quiet façades and quiet areas

Let us take a closer look at quiet façades and quiet areas in cities. Figure 6 shows a part of the traffic noise map of Amsterdam. The map shows high noise levels of 70 dB at the busy streets (orange, red). The map also shows many less noisy streets, with noise levels of 60 dB (yellow). The small grey areas along the streets are dwellings. We see that the dwellings are built here in closed blocks around courtyards. The noise levels in the courtyards are below 50 dB (blue), so much lower than in the streets outside the courtyards. The upper photograph in figure 6 shows a view through the window of a house on a courtyard. At the front of this house there is noise from traffic in the street, while at the back there is quietness. Actually we have both a quiet façade and a quiet area here! Most of the courtyards here are not accessible to the public, but there are a few public courtyards.

Figure 6. Part of the traffic noise map of Amsterdam from figure 5. There are busy streets (orange), less busy streets (yellow), quiet courtyards (blue) enclosed by houses (grey). The less busy streets, illustrated by the lower photograph, are typical of this lively urban area (Jordaan area). The upper photograph shows a view from a quiet façade on a quiet courtyard.

Types of quiet areas

Figure 7 shows a schematic picture of noisy areas and quiet areas in a city. Traffic noise is loud near busy streets and in noisy quarters. Three types of quiet areas are shown:

- parks
- quiet courtyards
- quiet (residential) quarters.

Large city parks free from motorized traffic are attractive quiet areas. An example is the Amsterdam city park shown in figure 2. Figure 5 shows that the traffic noise level in this park is lower than levels outside the park. In a quiet city park, people may enjoy the peace and quiet, the plants and trees, and other people in the park. A quiet urban quarter may be a historic city center, a lively area such as the Amsterdam area shown in figure 6, or a shopping area free from excessive traffic noise. Quiet quarters have more traffic noise than parks do, but still may be attractive for many people.

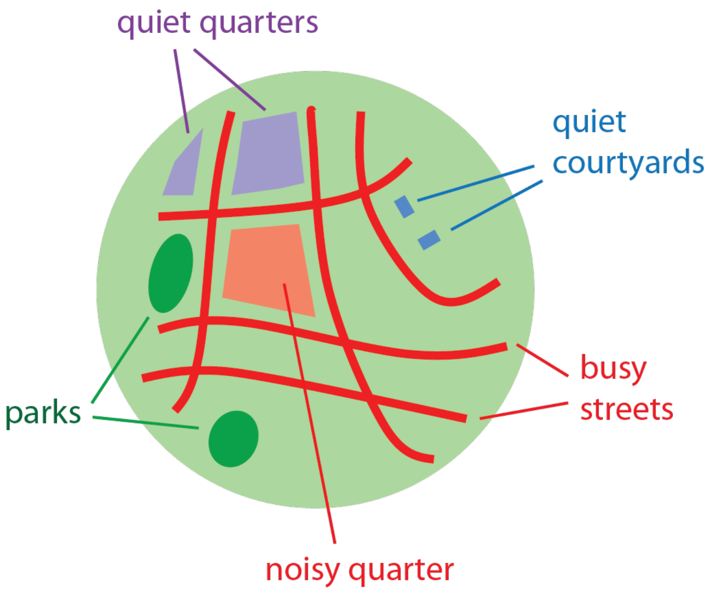

Figure 7. Schematic picture of noisy areas and quiet areas in a city.

Some people like walking in a quiet park.
Some people like reading a book in a quiet courtyard.
Some people like visiting a quiet urban quarter.

In general, an attractive quiet area has two characteristics: (i) low traffic noise levels, (ii) other qualities such as vegetation or nice buildings.

Traffic noise levels in quiet areas

What is a reasonable traffic noise level in a quiet area? To answer this question, one may use results of scientific studies into the response of people in quiet areas to traffic noise and other sounds.

First we note that the response of people to traffic noise in a quiet area depends on the type of quiet area. The "acceptance" of traffic noise is lower in a quiet green area outside the city than in a city park, while in a quiet residential area the acceptance may be higher.

In general, annoyance by traffic noise in a quiet area increases with increasing traffic noise level. On the other hand, there are also positive sounds in quiet areas, for example rustling leaves or bird song. Therefore it makes sense to consider the overall appreciation of the acoustic environment (soundscape) in a quiet area. The table below shows typical results that have been found for park visitors. With increasing noise level, the overall appreciation of the acoustic environment decreases.

Noise level	Percentage of park visitors that consider the acoustic environment "good"
50 dB	70 %
55 dB	50 %
60 dB	40 %

from the CityHush project, www.cityhush.org

One should be careful about the definition of the noise level here. The levels in the table are total noise levels, including noise from all relevant sources: traffic, people, birds, etc. Traffic noise levels are typically a few decibels lower than total noise levels.

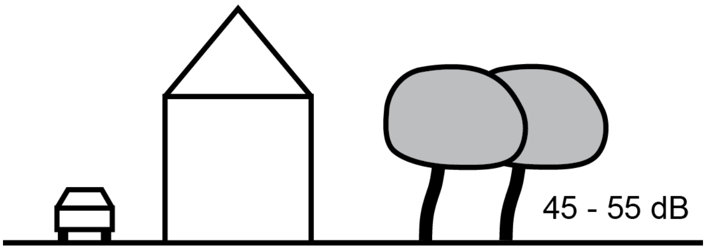

Figure 8. A quiet urban area may be defined as an area where the noise level (day level) is below 45 dB (preferred limit) or below 55 dB (upper limit). Other qualities such as vegetation or nice buildings enhance the attractiveness of the area.

To minimize negative effects from traffic noise in quiet areas, one might adopt an upper traffic noise limit level of 50 dB, or even 45 dB. However, many city parks and 'quiet' urban quarters have traffic noise levels between 50 dB and 60 dB. Therefore one may take a more practical viewpoint and use a range of traffic noise limit levels in quiet areas, for example ranging from a preferred value of 45 dB to an upper value of 55 dB. Above the upper value, it is a good idea to consider traffic noise reduction measures, to enhance the attractiveness of the area for recreational and leisure activities.

In scientific studies one also finds that the average annoyance of people at home is reduced if there is a quiet area near the dwelling, with traffic noise levels below 50 dB (day level). This effect is similar to the positive effect of a quiet façade on annoyance at home.

Traffic noise levels at quiet façades

What is a reasonable traffic noise level at a quiet façade? To answer this question, one may again follow a scientific approach into the response of people to traffic noise, in dwellings with or without a quiet façade.

One finds for example that the average annoyance of people at home is reduced (i.e. lower than average) if the dwelling has a quiet façade with traffic noise levels below 45 dB or 50 dB (day-evening-night level). Further, sleep disturbance is reduced if the bedroom is located on a quiet façade with a noise level below 40 dB (night level).

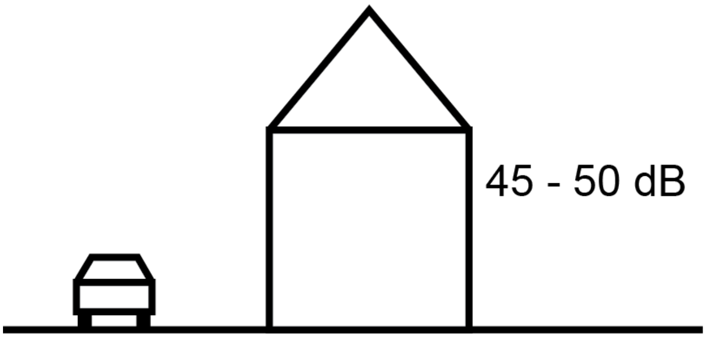

Figure 9. A quiet façade may be defined as a façade where the day-evening-night noise level is below 45 dB (preferred limit) or below 50 dB (upper limit).

There are indications that 'having a quiet façade' is roughly equivalent to a decrease by 2 dB of the traffic noise level at the noisy façade (Note: 2 dB is just an indicative figure; for detailed information see Section Human Response). Similarly, 'not having a quiet façade' is roughly equivalent to an increase by 2 dB of the traffic noise level at the noisy façade. This implies that average annoyance is lower in dwellings with a quiet façade than in dwellings without a quiet façade, as indicated in the table below.

Noise level on "noisy" façade	Annoyed at home ***with*** quiet façade	Annoyed at home ***without*** quiet façade
50 dB	9 %	13 %
55 dB	15 %	21 %
60 dB	22 %	29 %

note: these are just indicative figures.

One might adopt a traffic noise limit level of 50 dB, or even 45 dB, for a quiet façade (day-evening-night level). One might also adopt a range of traffic noise limit levels for quiet façades, for example ranging from a preferred value of 45 dB to an upper value of 50 dB. Above 50 dB, the risk increases that traffic noise disturbs daily activities and sleep.

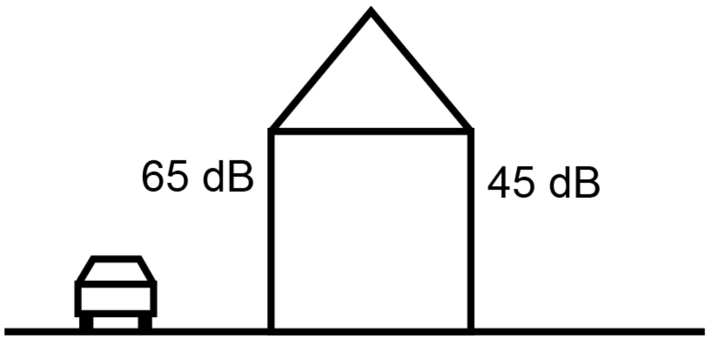

Figure 10. The Environmental Noise Directive defines a quiet façade as a façade where the day-evening-night noise level is 20 dB lower than the level on the 'noisy' façade.

The EU document 'Environmental Noise Directive' defines a quiet façade as a façade where the traffic noise level is 20 dB lower than the level on the 'noisy' façade of the dwelling. In other words, the difference between the highest façade level and the lowest façade level of a dwelling is used to define a quiet façade. Recent investigations indicate that it is better to define a quiet façade by the level on the quiet façade only. There may be beneficial quiet-façade effects also for level differences smaller than 20 dB, for example for a highest façade level of 60 dB and a lowest façade level of 45 dB.

In addition to limiting the equivalent night level L_{night}, we also recommend that cities reduce chances of high peak levels during the night at the quiet façade. This can be done by avoiding situations with roads located directly on quiet façades. Quiet façades should preferably be located adjacent to 'urban areas without direct traffic-noise exposure', such as (semi-)closed courtyards. This is illustrated below. In this context it is interesting to note that the WHO Guidelines for community noise recommends that, "for a good night's sleep", individual noise events with maximum levels exceeding 45 dB should be avoided.

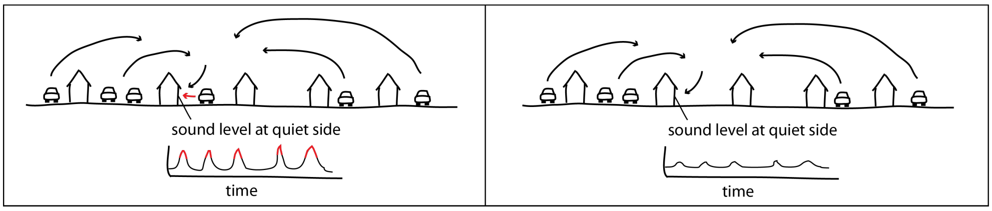

Figure 11. Situations with direct traffic-noise exposure of quiet façades (left) should preferably be avoided, since passing cars cause maximum indoor levels that may cause sleep disturbance. In situations with only indirect traffic noise exposure (right), there are less high peaks on the quiet façade, so inhabitants have the possibility to sleep on this side without traffic-noise disturbance.

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SECTION	**What is a quiet place?**

What is a quiet place?

By Frits van den Berg

> *A quiet façade enables residents to sleep with their window open without being disturbed by noise. In daytime it allows them to leave a window open or enjoy the outdoor garden or balcony at that façade without undue disturbance from noise. Though the experience of quietness or tranquillity does not depend on noise levels only, most people would prefer a traffic noise level below 45 dB L_{den} at the quiet side of the house and would accept a level of 50 dB L_{den} only when the rest of the neighbourhood is very noisy.*
>
> *A quiet outdoor area implies a pleasant soundscape where people enjoy staying for a while. Traffic noise should not dominate the area/soundscape and one can hear pleasant natural or man-made sounds. A quiet area is never entirely characterized by just sound levels as other qualities are important too. Even though people seek tranquillity, they also want a safe and clean place and a pleasant view, preferably with green or water. Most people prefer a traffic noise level below 45 dB L_{day} and would not accept a level over 55 dB L_{day}.*

City noise

Road traffic sound is the dominant and most constant source of noise in the urban environment. Sounds from rail and air traffic and industry may be important too, but these are less ubiquitous as they are important only in the vicinity of railway lines and yards, air routes and airports, and noisy enterprises.

There are other sound sources in the urban environment, but they are not part of the European Noise Directive (END) that considers only transportation and industrial sources and their impact on residents being at home. Surveys in the four most populated cities in the Netherlands show that the most annoying noise sources for residents are scooters/mopeds and neighbours, followed by city road traffic and construction and demolition sites. As scooters/mopeds are usually not part of the assessment of road traffic noise levels, three out of the four most annoying noise sources in these cities are not addressed in the END. Even this conclusion is incomplete because the surveys do not address all noisy sources. E.g. noise from pubs or leisure activities is often not mentioned in surveys. From the Amsterdam quiet areas project we know that people in the street are an important nuisance, probably belonging to the top 5 in noise annoyance.

But sounds are not just a nuisance. At home in a city also rustling trees, chirping birds, the chatter of passersby and playing children, music, and even the background of cars, trams, pedestrians, cyclists, and perhaps trains or arcraft may be heard: sounds that we usually like, though probably not at all times. Sometimes people enjoy the bustle of the city, special events in town or something ‘happening’ in the neighbourhood.

It is not well known how noise is evaluated when being outdoors. It is evident from most studies that visual and acoustical properties are important with respect to tranquillity or quietness. Generally natural sounds are preferred and mechanical sounds are least appreciated. In cities traffic noise is apparently tolerated to some degree when being outdoors. Pleasant sounds in an urban environment are predominantly natural sounds (wind, water, animals and other nature) and music (most of this voices and ‘unplugged’ music), followed by people; least pleasant sounds are traffic and other mechanical sounds (machines, building, drills, lawn mowers, sirens).

The acoustic environment is a major factor influencing the overall comfort in an urban open public space. Acoustic comfort is closely linked to the visual impression of the space. For a comfortable acoustic environment it is important to reduce the background noise level. For pleasant sounds (music, water) the relationship between acoustic comfort and sound level is weaker than for noise from traffic or demolition. In Amsterdam several factors were investigated that could influence the need for quietness for Amsterdam residents. It was found that sounds with negative associations (noise) were related to an increase in this need, whereas sounds with a positive connotation (liveliness) were related to a decrease in the need for quietness.

What is a quiet façade?

A quiet façade serves two aims. One is that it enables residents to sleep with their window open without being disturbed by noise. Second is that it enables residents to leave a window open or enjoy the outdoor garden or balcony at that façade without undue disturbance from noise. Therefore, a dwelling has a quiet façade when there is no noise on that side of the house. Although it is that simple, this raises the point what it means ‘there is no noise’. In relation to a quiet façade we often mean this in relation to a specific noise. Most probably this is road traffic noise, but it could also be noise from trains, aircraft or industry. Of course people in the street, a shop or pub, or neighbours can also cause noise, but this is usually not taken into account when considering a quiet façade because it is not mechanical noise. These latter sounds are not constantly present and are not always perceived as noise, but also they are often not easy to control.

The END addresses transportation and industrial noise. It defines a quiet façade as having a relatively low noise exposure: at least 20 dB below the most exposed façade. This implies a high level at the most exposed side, as in many urban areas daytime sound levels almost everywhere will usually be above 40 dB(A). So a quiet façade according to the END is perhaps not absolutely free from noise, but the noise level is much lower than on the other side. Other guideline or limit values for a quiet façade are based on absolute values on the noise level, such as 50 dB(A). In this case too a quiet façade may not be absolutely free from noise, but most people will not be annoyed because the noise level is sufficiently low. In the QSIDE project several cities have been interviewed about their current approach with respect to quiet façade, and it was found that all cities but one that we have consulted used a definition based on an absolute level (see Table below).

Adverse effects of road traffic noise may occur above levels of or equivalent to 42 (no severe annoyance) to 48 dB ('residential area good and healthy') L_{den}. Where limits for (quiet) façades in urban residential areas have been established, the limit value varies between 48 (Gothenburg) to 58 dB (Hamburg) L_{den}. Other cities (Amsterdam, Utrecht, Helsinki) have limits or a stricter applied limit (Gothenburg) in between at values of 50 to 57 dB L_{den}. The WHO guideline values for the most exposed façade are equivalent to 52 to 57 dB L_{den} and set to a value below which a majority of the population will not be (moderately or seriously, respectively) annoyed. The WHO gives a limit for the night-time noise level of 40 dB L_{night}, but in countries where 40 dB cannot be achieved in the short term an interim value of 55 dB L_{night} is recommended as part of a stepwise approach.

City	Status of quiet façade	Definition of quiet façade
Amsterdam	existing policy	< standard limits, i.e. < 48 dB Lden road < 55 dB rail, < 50 dB industrial
Gothenburg	existing policy for city center	preferably < 45 dB $L_{AEq,24h}$, < 50 dB obligatory
Brussels	not enforced, assessment only	quiet side < noisy side - 20 dB

City	Status of quiet façade	Definition of quiet façade
Hamburg	existing policy	< 49 dB L_{night} in residential, < 54 in mixed areas, in new buildings living rooms and bedrooms must be situated at quiet (noise averted) side
Helsinki	recommendation	< standard limit, i.e. 55 dBA L_{eq7-22}; 50 dBA L_{eq22-7} on façade and garden/balcony
Utrecht	existing policy	see Amsterdam
Zurich	existing policy	< standard limits

Based on the results of a literature search and the results of the Qside project, we recommend that the least exposed façade of a dwelling is a quiet façade (with respect to road traffic noise) if:

- the noise level is preferably limited to 45 dB L_{den};
- the noise level is not higher than 50 dB L_{den};

To enjoy the outdoor space at the quiet façade it must have sufficient quality; e.g. a garden or park is better than a parking lot. A higher quality of the outdoor living area at the quiet side can increase the effect of the quiet façade.

A quiet night time façade should preferably comply with the WHO night noise guideline value of 40 dB and not exceed 45 dB Lnight. These L_{night} values will often correspond to noise classes 46-50 and 51-55 dB L_{den}, respectively, so the recommendations for L_{den} usually imply sufficiently low night time levels. The WHO interim value of 55 dB L_{night} is too high to warrant a quiet façade.

In addition to limiting the equivalent night level L_{night}, we also recommend that cities reduce chances of high peak levels during the night at the quiet façade. This can be done by avoiding situations with roads located directly on quiet façades. Quiet façades should preferably be located adjacent to ‘urban areas without direct traffic-noise exposure’, such as (semi-)closed courtyards. This is illustrated below.

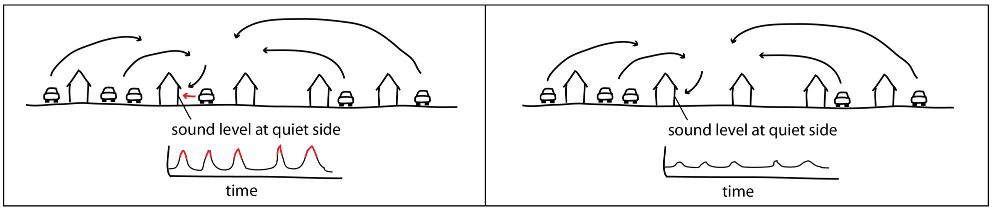

Figure 1. Situations with direct traffic-noise exposure of quiet façades (left) should preferably be avoided, since passing cars cause maximum indoor levels that may cause sleep disturbance. In situations with only indirect traffic noise exposure (right), there are less high peaks on the quiet façade, so inhabitants have the possibility to sleep on this side without traffic-noise disturbance.

The noise levels should be established at a height of 4 m in front of the façade to comply with the END. Only incident sound (excluding façade reflection) must be measured or calculated. For other noise sources there is less information available. Considering the different abilities of different noise sources to increase the risk of annoyance, the limits for industrial noise can probably be similar to the proposed values, though for rail traffic they could be somewhat higher, for aircraft noise they should be lower.

What is a quiet area?

What we mean by quiet area here is an outdoor space, including a pleasant soundscape, where people enjoy staying for a while. Levels of traffic (or other) noise should be low enough to not dominate the space/soundscape, and there are bound to be pleasant natural or man-made sounds. The level and type of sounds depend on the need to be fulfilled in that space: is it for play or exercise without too much traffic noise or a tranquil place to rest and relax? For example: a restaurant square can be lively and pleasant and can be thought of as quiet because of the absence of dominant mechanical sounds, but it is not a place to sit alone and enjoy nature. Those that really want to enjoy peace and quiet probably prefer a greener place and not so many people around. A quiet area is never entirely characterized by just sound levels as other qualities are important too. Even though people seek the quietness, they also want a safe and clean place and a pleasant view, preferably with green or water.

Apart from those other qualities, there are two ways to characterize an urban place acoustically as quiet. One is that noisy sounds should be either so soft that they are not intrusive or last only for a short time so there is quietness in between the noises. This description best matches the ability of most people to allow for some noise. A problem in this approach is that usually we have no information on the time that noises that stand out from the background are (clearly) audible. The other way is a more conventional acoustic criterion: an area is (sufficiently) quiet if the noise level is below a limit. This level can be L_{day}, as we usually enjoy the outdoors at daytime, but it could (also) be $L_{evening}$ if the place is important for leisure after work.

The first approach has been proposed in the Netherlands and Sweden. The Swedish proposal included tolerable levels of noise in urban areas of 45 to 50 dB L_{day} (or 10 to 20 dB below the level of surrounding streets). The second approach has been recommended or applied in a number of countries: in nearly all cases the limit was (equivalent to) 45 tot 55 dB L_{day}, but a value of 40 to 45 dB was also mentioned (mentioning 40 dB as a 'gold standard'). In two of the twelve cities we consulted, quiet areas are defined using acoustic criteria, though as yet these are only recommendations. In Brussels this is based on L_{den} (≤ 55 dB), in Helsinki on $L_{eq,7\text{-}22h}$ (≤50 dBA) and $L_{eq,22\text{-}7h}$ (= L_{night}, ≤45 dBA). In the Amsterdam quiet areas study L_{day} or L_{den} (≤ 55 dB) has been proposed. In Brussels and Amsterdam also non-acoustic criteria are mentioned, in Oslo only non-acoustic criteria.

Adverse effects have been shown to occur above 57 dB(A): people then became annoyed when making a city walk, severely annoyed above 62 dB(A). For comparison: when dwellings are exposed to 60 dB L_{den}, 10% of the inhabitants report a high degree of annoyance when being indoors. In the Amsterdam quiet areas project respondents mentioned a number of small and large quiet places, none of them with a traffic noise level at their centre above 60 dB L_{day}. There could be a preference for a low noise level (36-40 dB), but this depended very much on the popularity of two areas and probably less because of the low noise level. Apart from that, areas with a (central) traffic noise level between 45 and 55 dB L_{day} were most prevalent in the survey results.

Based on all these results, our recommendation for a quiet area (with respect to road traffic noise) is:

- the level in that area is not higher than the level in the surrounding area;
- the noise level in (the central part) of the area is preferably limited to 45 dB L_{day};
- the noise level in (the central part) of the area is not higher than 55 dB L_{day};

If an area is meant for rest and relaxation or the experience of quietness the level must be as low as possible, but certainly below 45 dB. In busy urban areas this is often not achievable, but one should aim for 50 dB. The high limit of 55 dB could be appropriate for an area of active urban recreation without a specific demand for tranquillity.

To enjoy the area it must have sufficient quality with respect to use, view, cleanliness and safety. A higher quality of the area can increase the effect of the peace and quiet.

The noise levels should be established at a height of 1.5 m (approximately ear height) which is the minimum measurement height according to the END.

What is outdoor quality?

The recommendations for quiet façades and areas included the ‘quality’ of the outdoor area. But what is that quality? In general the quality of a public city space is about the appreciation of that space because of physical and social characteristics. This can be divided in, e.g., architectural and natural qualities, and a perception of pleasant socializing and safety. But it is hard to pin down what exactly determines urban quality. According to one writer

> *"the quality of urban design is the product of the conscious and unconscious design decisions of many different interests and individuals. Urban designers have difficulty defining urban design and agreeing what constitutes good urban design amongst themselves; consider, then, the problem of defining and discussing quality of urban design with unselfconscious urban designers!"*

Quality includes people's perceptions and experiences of a development or area, the image and 'feel' of areas, the legibility of localities, the opportunities to discover and learn in an environment and the degree of freedom of access and action. Complexity, surprise, diversity of activities and users, vitality, a sense of time and historical continuity are important factors, but this yet leaves to be decided how to determine this objectively or how to implement this in practice. Based on images of commercial streets five properties could explain most of the perceived quality: imageability, enclosure, human scale, transparency and complexity. These properties consist mostly of objective quantities; imageability for example is defined by the number of people, the proportion of historic buildings, the number of courtyards/plazas/parks, the presence of outdoor dining possibilities, the number of buildings with non-rectangular silhouettes, noise level, number of major landscape features and number of special buildings (‘with identifiers’). These quantities are not readily available; they can be counted or measured but they are not absolute data as they depend on perception from a certain position.

It has already been mentioned that people usually view natural sounds as pleasant and proper to a quiet place. In Amsterdam over 75% of respondents thought the presence of green or water, quiet/tranquil, and well-kept/clean were important characteristics, and over 50% thought nice colours, no noise, spacious, nice sounds and nice odours were also important. In countryside areas in the UK *hearing* birdsong, peace and quiet, natural sounds, wildlife, running water and *seeing* a natural landscape or streams contributed to a feeling of tranquillity and *hearing* constant noise from cars, lorries, motorbikes, lots of people, and seeing lots of people, urban development, power lines or roads detracted from it. This again demonstrates that natural acoustical and visual elements contribute to tranquillity whereas artificial elements are more liable to disrupt it.

Relation between sound level indicators

In several countries or cities guideline values or limits have been proposed that are based upon different indicators such as L_{den}, L_{day} or $L_{Aeq,T}$ (with T = 1 hour, day + evening or night). To be able to compare values it will be assumed that the night-time equivalent sound level is 6 to 10 dB lower than the daytime level, and the level at evening halfway between both. In the Netherlands L_{night} is usually approximately 10 dB below L_{day} for city traffic and up to 6 dB below L_{day} for traffic on motorways (where the proportion of heavy traffic is higher at night). Given these assumptions, we can estimate:

- $L_{Aeq,24h} = L_{den} - 3\ (\pm\ 1)$ dB
- $L_{Aeq,7\text{-}22h} = L_{den} - 1.5\ (\pm\ 1)$ dB
- $L_{Aeq,22\text{-}7h} = L_{night} = L_{den} - 9\ (\pm\ 1)$ dB
- $L_{day} = L_{den} - 1\ (\pm\ 1)$ dB

References

Information on proposed and actual noise limits in this text are taken from the Euronoise2012 paper (see below) when no other reference is mentioned.

1. The END: European Commission: European Noise Directive 2002/49/EC of the European Parliament and of the Council, of 25 June 2002, relating to the assessment and management of environmental noise (2002)
2. About the quiet areas project in Amsterdam: Hester Booi and Frits van den Berg: Quiet Areas and the Need for Quietness in Amsterdam, International Journal of Environmental Research and Public Health 9, 1030-1050, (2012)
3. The WHO noise guidelines: B. Berglund, T. Lindvall, D.H. Schwela (ed.): Guidelines for Community Noise. World Health Organization (1999)
4. An overview of proposed and actual limit values for quiet façades/areas: Frits van den Berg, Carlo Schoonebeek, Menno

Hillebregt: On the definitions of quiet façades and quiet urban areas, proceedings of Eurnoise2012, Prague (2012)
5. Qside report with overview of quiet façades/areas policy of selected cities: Qside Action 1 report (2011); see www.qside.eu

QSIDE	
DOCUMENT	**Quiet places in cities** **Quiet façades and quiet areas in urban noise policy. Recommendations and examples.**
SECTION	**How can cities create or protect quiet places?** Examples

Examples

This section presents some examples of quiet façades and quiet areas (and non-quiet areas).

- Example 1, Quiet side of a building in the Netherlands (with interviews!)
- Example 2, Example of quiet façades in Gothenburg
- Example 3, Amsterdam bike & walk tour
- Example 4, Paris bike & walk tour
- Example 5, New York bike & walk tour
- Example 6, Amsterdam noise policy and examples of quiet sides and quiet areas
- Example 7, Gothenburg noise policy and quiet façades
- Example 8, Birds in the urban soundscape

From the examples 3-5, a general "picture" of noise in a city emerges (see Fig. 1):

- noise levels are high near busy streets and in noisy quarters,
- noise levels are lower in quiet urban areas: parks, quiet residential quarters, and quiet courtyards.

Parks and quiet courtyards are well-known quiet areas in cities. However, quiet residential quarters should not be ignored as important quiet areas in cities. Figure 2 shows an example of a quiet residential quarter in Amsterdam.

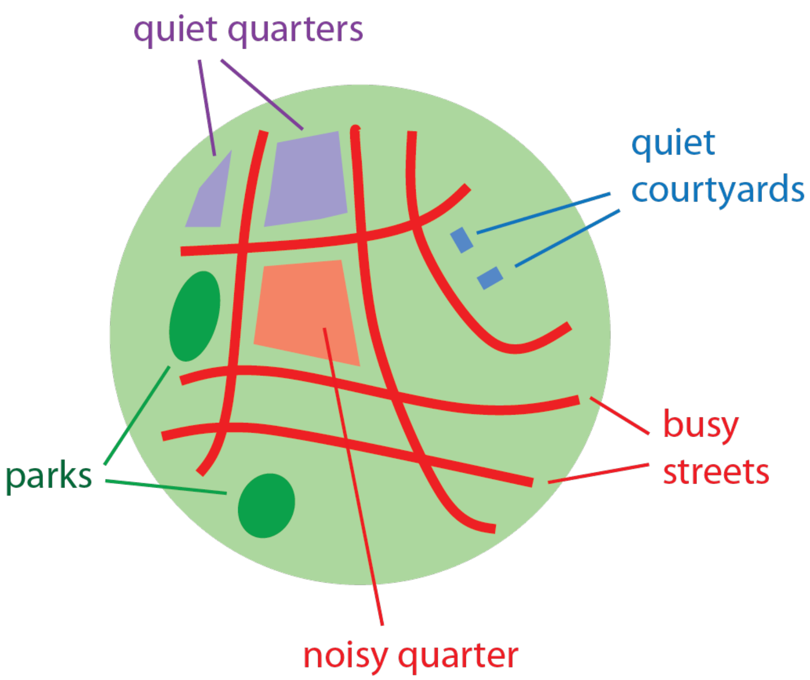

Figure 1. General "picture" of noise in a city, with noisy areas (red) and quiet areas.

Figure 2. Example of a quiet residential area in Amsterdam (Jordaan).

Example 1, quiet side of a building

By Erik Salomons

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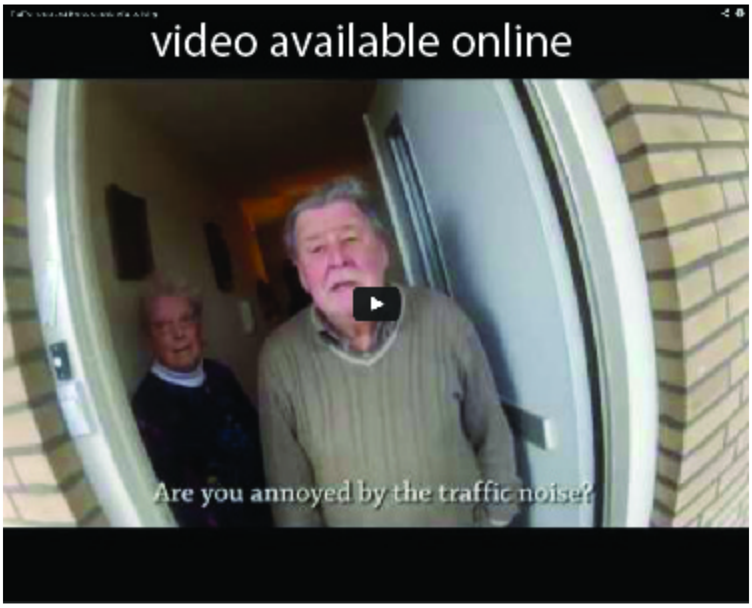
Video 1



This video shows interviews with inhabitants of a building with a high traffic noise exposure (70-75 dB), in a city in the Netherlands.

Figure 1 below shows a part of the traffic noise map (see www.zoetermeer.nl).

The building is indicated on the map. The curved shape of the building is a smart way to create a quiet side.

The quiet back side seems to give some relief, although the apartments are not very well suited for sleeping at the back side (see video).

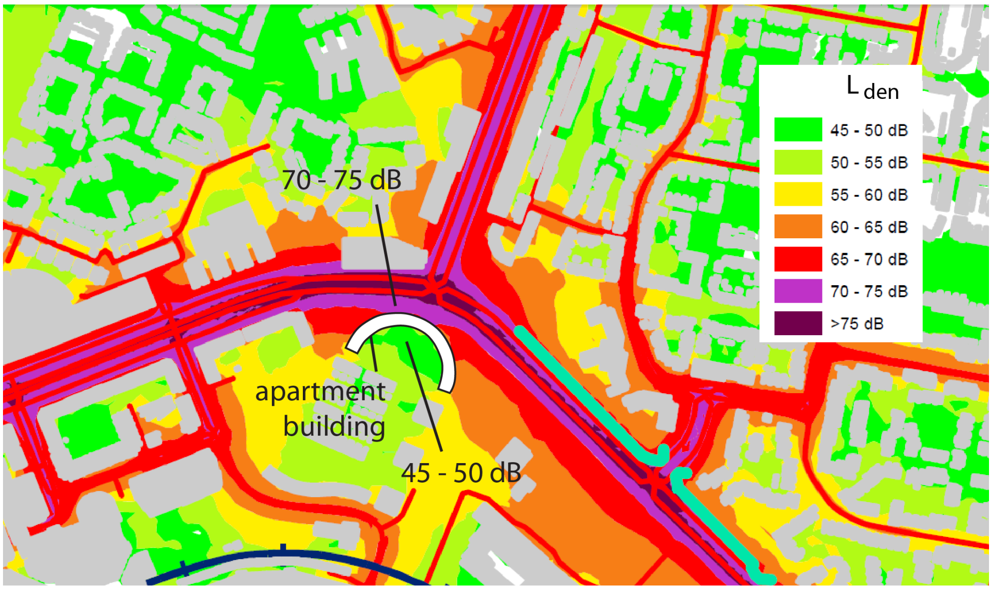


Figure 1. Traffic noise map of a part of Zoetermeer, the Netherlands.

Example 2, quiet sides in Gothenburg

By Mikael Ögren

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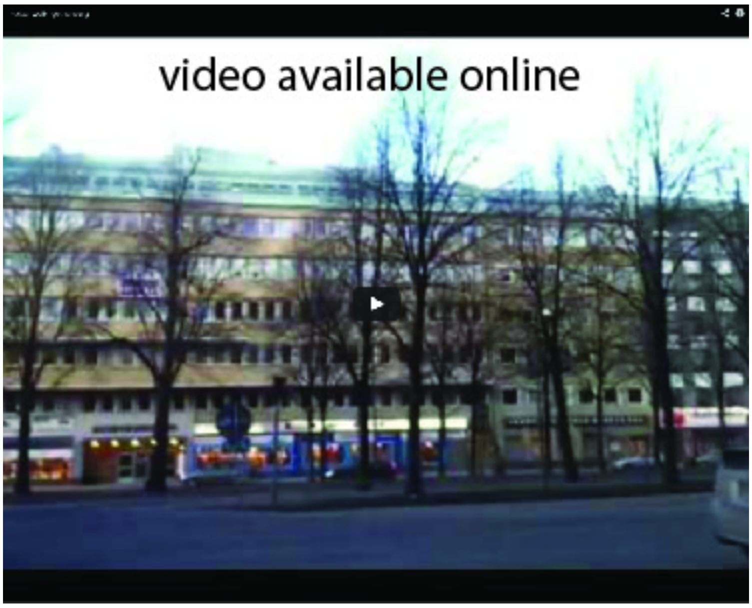
The video below illustrates a short walk around a block in Haga, Gothenburg. Press on the subtext button to show the sound level measured during the walk (rectagular button with two lines).

Video 1



The noise map of the area is shown in figure 1 below, and as noted in the video the level is around 10 - 15 dB noisier on the exposed side of the block. The walking path is indicated with a black line inside the building block.

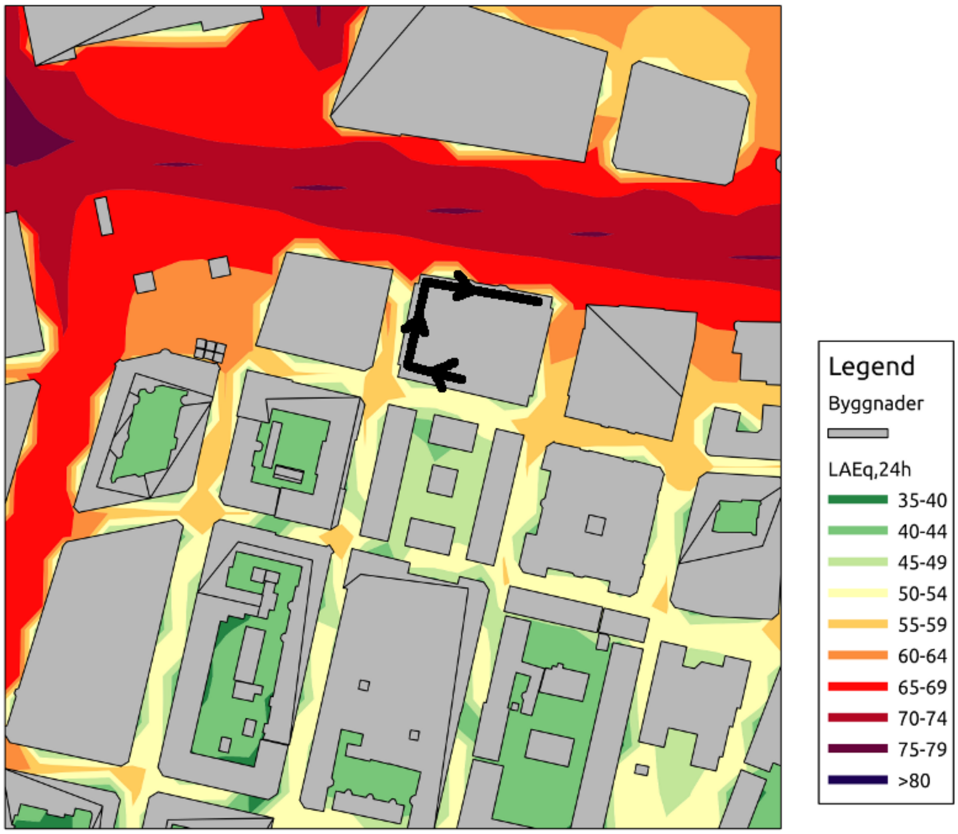


Figure 1. Traffic noise map of a part of Haga, Gothenburg.

Example 3, Amsterdam

By Erik Salomons

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Figure 1 shows calculated traffic noise levels in Amsterdam. Indicated is a park in the city center, which is called Vondelpark. Calculated noise levels are about 50 dB at the boundary of the park, and lower than 50 dB well inside the park.

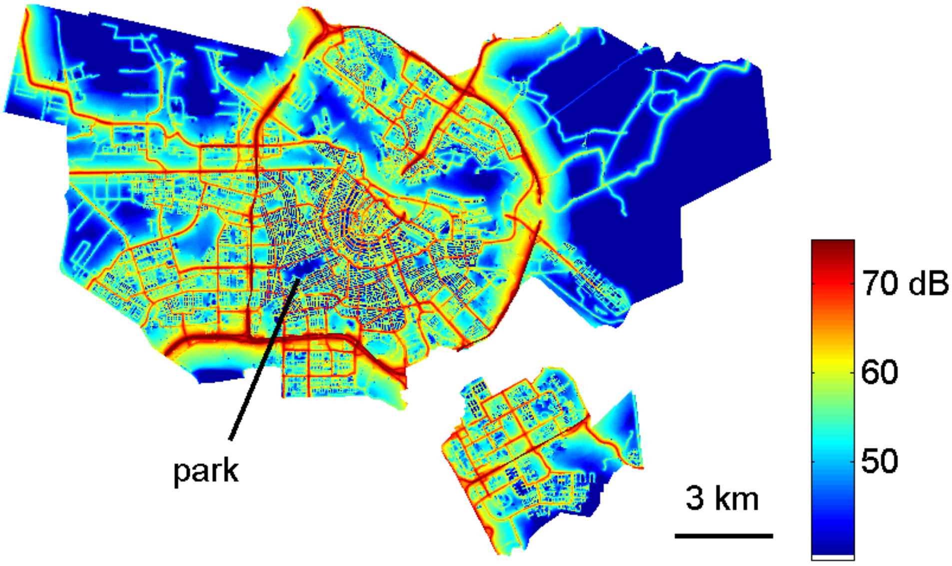


Figure 1. Calculated traffic noise map of Amsterdam. The color represents the 24h traffic noise level (day-evening-night level). Noise levels in the park are lower than in the area around the park. Note: for traffic in quiet streets with unspecified traffic volume, a volume of 20 cars per hour was assumed.

Figure 2 shows measured and calculated sound levels in streets in Amsterdam. The measurements were performed during bicycle tours on two days. Calculated levels are based on average traffic volumes for the day period. Measured levels in the Vondelpark are 50-60 dB, with contributions from nearby traffic and people in the park.

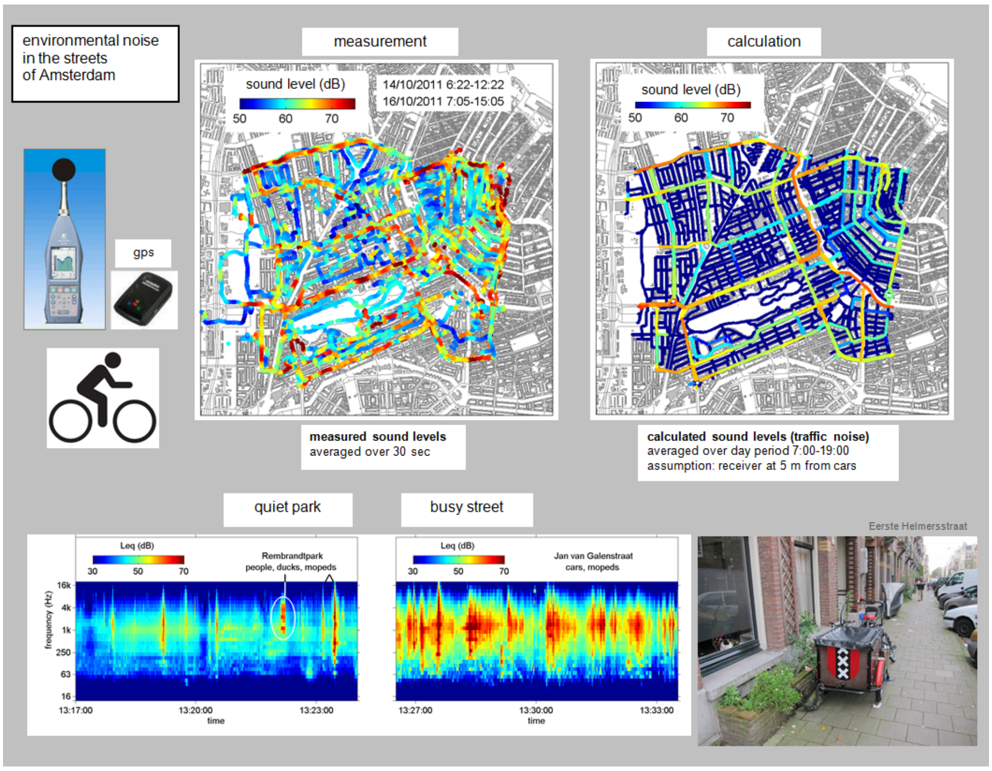
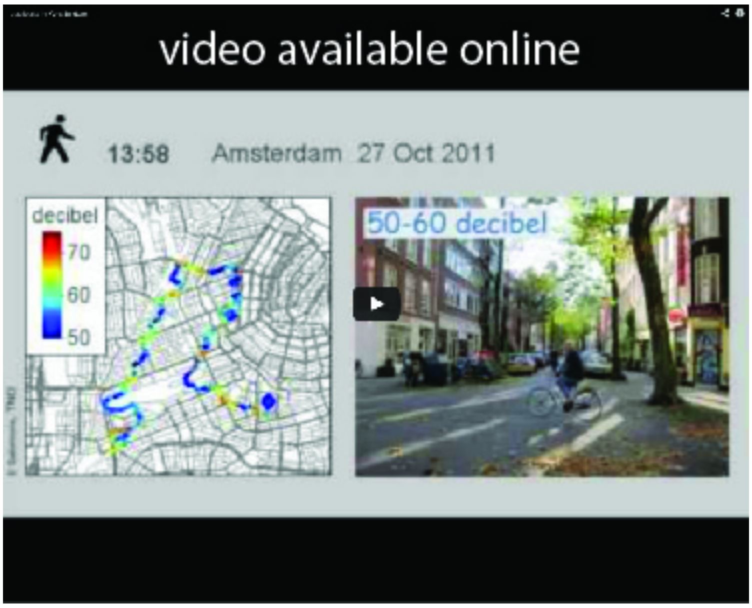


Figure 2. Measured and calculated sound levels in streets in Amsterdam. The measurements were performed during bicycle tours on two days. For the calculations, average traffic volumes for the day period were used. For quiet streets with unspecified traffic volume, a fixed level of 50 dB was assumed. Spectrograms in a park and a busy street are shown.

The results in Figs. 1 and 2 confirm the general picture: high traffic noise levels are found primarily near busy streets. The measurements confirm that sound levels are low in quiet residential areas between busy streets.

Video 1



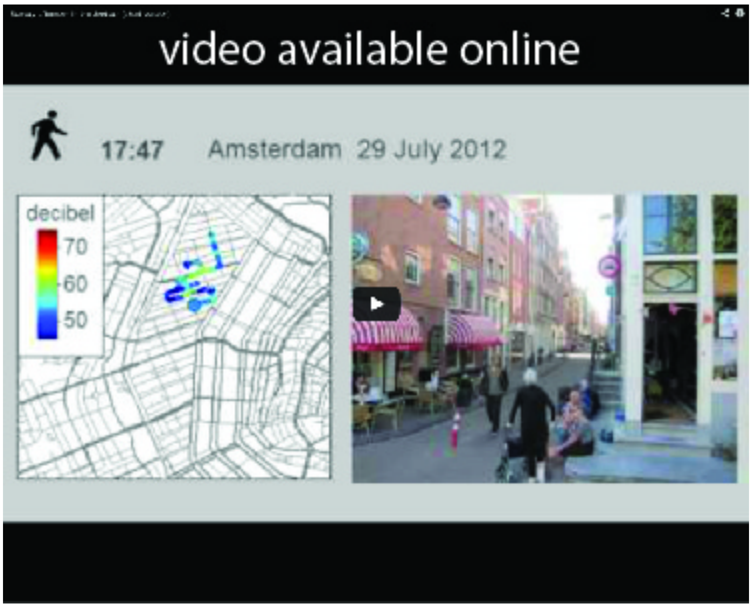
Video 1 gives an impression of sound levels in Amsterdam, with

- 70 - 80 dB in busy streets
- 50 - 60 dB in quiet areas (park, quiet residential area).

Video 2

Video 2 gives an impression of sound levels in the Jordaan, a residential area in Amsterdam. Public courtyards in the area are very quiet, with sound levels below 50 decibel. Sound levels are a bit higher in the lively streets, where people have a drink outside at the bars. Video 3 is a short version.

Video 3


video available online
17:47
Amsterdam 29 July 2012
decibel
70
60
50

Example 4, Paris

By Erik Salomons

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Figure 1 shows measured and calculated sound levels in streets in Paris. The measurements were performed mainly in busy streets, but some quiet residential areas were also included. Measured levels in the quiet areas are in the range 50-60 dB. Calculated levels are based on average traffic volumes for the day period. The results in Fig. 1 again confirm the general picture: high traffic noise levels occur primarily near busy streets, and levels are lower in quiet areas between busy streets.

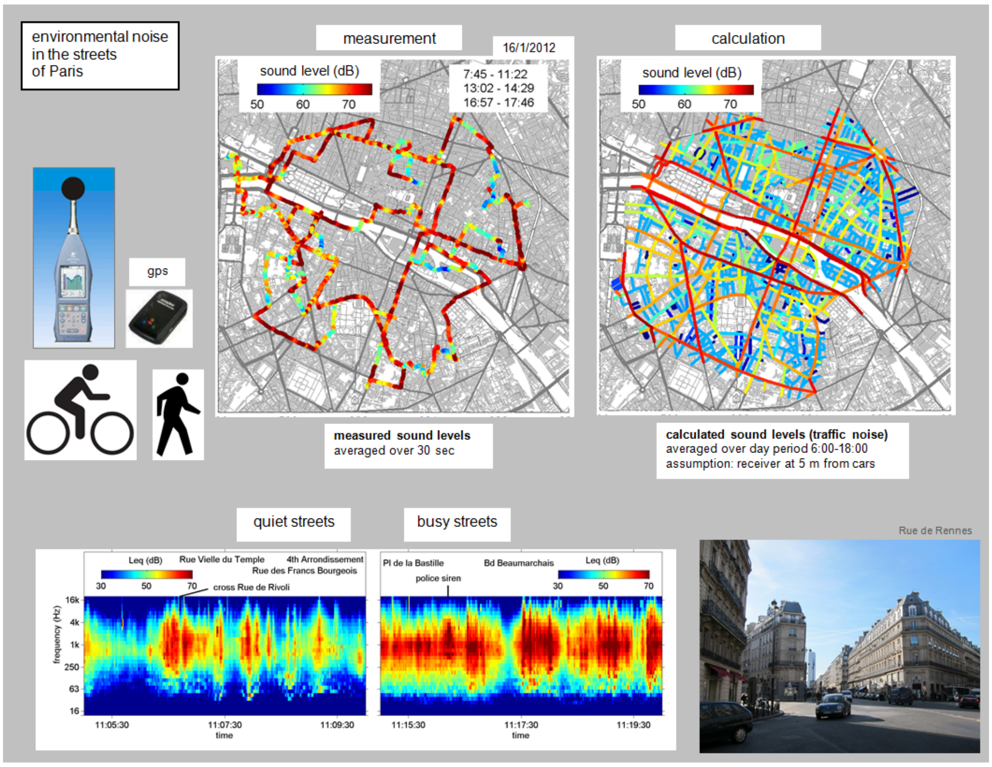

Figure 1. Measured and calculated noise levels in streets in Paris. The measurements were performed by bicycle and by foot. For the calculations, average traffic volumes for the day period were used. Spectrograms in quiet streets and busy streets are shown.

Example 5, New York

By Erik Salomons

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Figure 1 shows sound levels recorded during tours through New York by bike and by foot, in the period 14-19 August 2012. High sound levels occur in particular in the Broadway area. Lower sound levels occur in Greenwich Village, Central Park, and the High Line Park.

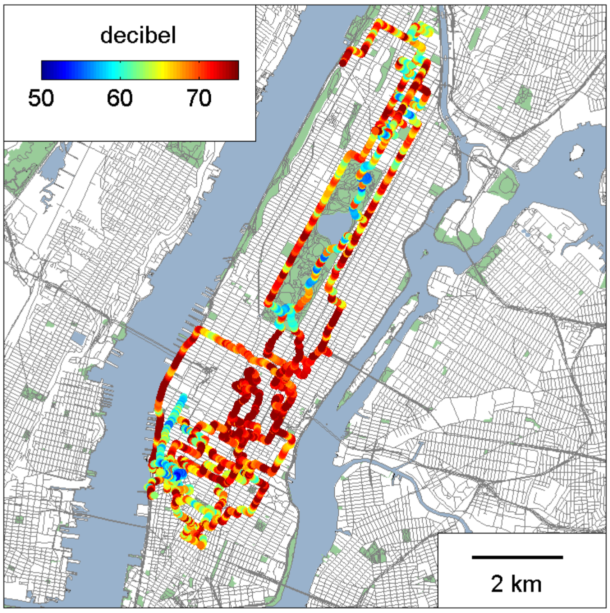


Figure 1. Sound levels recorded during tours through New York by bike and by foot. The color represents the sound level averaged over 30 seconds.

Central Park is used by many people for relaxing or for physical activities such as running. The High Line Park is an interesting park, as it was built on an abandoned elevated railway line (see Fig. 2). Although the High Line Park is not really quiet, it is appreciated by many people for walking and for running. Greenwich Village is an attractive quiet residential quarter. Also north of Central Park, in Harlem, one finds attractive quiet streets.

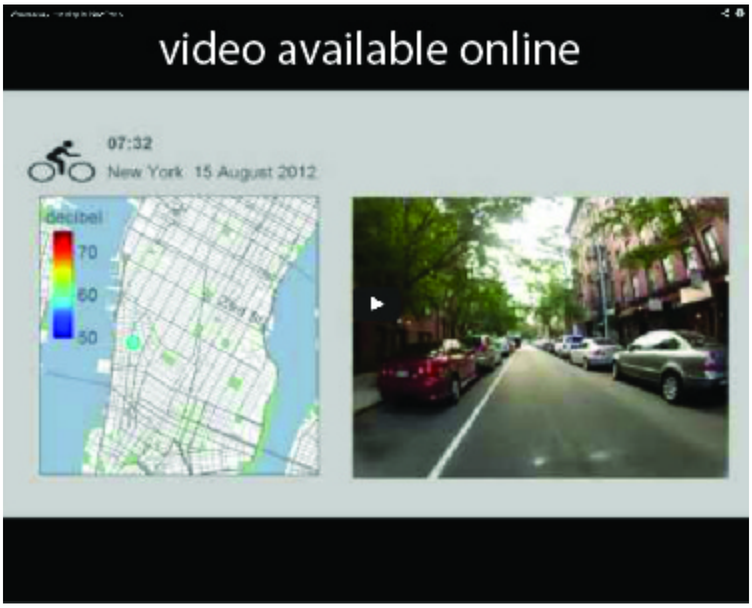
Figure 2. High Line Park.

Video 1

Video 1 shows an impression of sound levels during a tour, with 70 – 80 dB in busy streets and 55 – 60 dB in quiet areas.

The following three videos show longer impressions of the tours.

Video 2

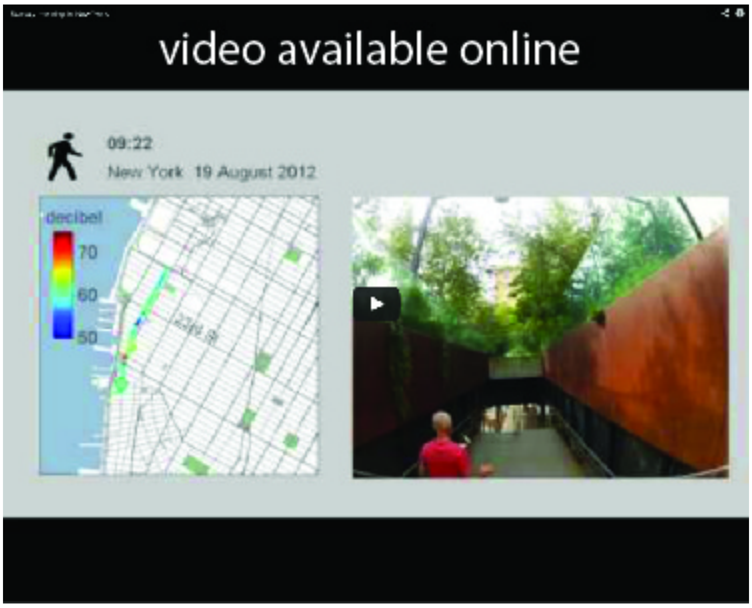


Video 2. A bike tour from Greenwich Village to the busy Broadway area and back to Greenwich Village. Noise levels are higher on the busy avenues than on the streets perpendicular to the avenues.

Video 3

Video 3. A bike tour from Greenwich Village via Central Park to Harlem.

Video 4



Video 4. A walk in the High Line Park, from 12th Street to 30th Street and back to 12th Street, and next in Greenwich Village. In the park there were many runners, and major noise sources are: traffic from nearby busy roads, airplanes, and fans at the back sides of houses.

Example 6, Amsterdam noise policy and examples

By Carlo Schoonebeek, Menno Hillebregt, and Frits van den Berg

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Introduction

Amsterdam has a great need for new houses [1]. Therefore even places exposed to high noise levels need to be considered. To ensure a minimum quality of life Amsterdam has a noise prevention policy (see appendix 1). In this noise policy the use of a quiet side is obligatory if the Dutch legal [2] upper noise limits are exceeded and required if the Dutch legal preferred limits are exceeded [3]. There are several levels for influencing the noise level at buildings:

- the building plan: building orientation and shape, noise shields;
- at an architectural level: double facade or deaf facade;
- by facilities at the dwelling: loggia's, closed balcony's, noise screens fitted to the building (coulisse screens), absorbing walls;
- Urban planning and traffic measures including the use of noise reducing pavement.

Only the first three levels are discussed in this section. Urban planning and traffic measures are discussed further in the noise action plans of the cities.

In the Netherlands the noise legislation forbids the building of new houses at noise levels above the mentioned Dutch upper limit (see also endnote 2). The legislation allows some exceptions of which the following two are the most important:

- the use of a "deaf facade"
- the use of a curtain wall.

These (typical Dutch) exceptions are discussed in the next section.

In the Amsterdam noise action plan 2008-2013 (European Noise Directive) the importance of quiet areas at a walking distance is also mentioned. This also compensates for the loudness in a city.

Examples in Amsterdam of building in noise congested areas

Science park in Amsterdam (east district).

The project in Science park was realised in 2008. The location is next to the railway line Amsterdam Almere-Amersfoort. Some of the interesting (noise) aspects of this project are the use of double facades and noise screens to provide protection against railway noise. See figure 1.

Figure 1. Science Park in Amsterdam. a. Lay out showing the use of noise shields and double facades. b and c. The noise screens against railway noise. d and e: double facades. The high building is called "The castle".

Laan van Spartaan in Amsterdam-West

This project is located between a central railway line on the eastside, the A10 motor highway on the west side and a city road (Jan van Galenstraat) on the south side. This project has been developed recently (partly). See figure 2.

Some of the interesting (noise) aspects of this project are:

- shielding buildings parallel to the A10 highway that frees the inner part of the plan from noise. At this side the quiet sides are situated.
- partly a court yard structure:
- curtain wall for the dwellings near the A10 highway;
- a (partly) deaf facade for the dwellings closest to the A10 highway.

Figure 2. Laan van Spartaan: a. overview b. double facade with baffle c. entrance that shields the inner part of the project against the highway noise. d. courtyard with a football field in the front. e. The other (quiet) side of the building shown in fig. b. f: coulisse screen against car noise.

Leeuw van Vlaanderen

This is a building from the sixties that was renovated in 2005. It is situated parallel to the A10 highway in Amsterdam-West, 10 feet behind the guardrail. The use of a shielding gallery and a quiet side are some of the aspects of this project. See Figure 3.

Figure 3. Leeuw van Vlaanderen, a. situation alongside the highway A10 in Amsterdam. The building on the left is the "Leeuw van Vlaanderen" building. b. the quiet backside c. the front side with a (new) double facade.

Miscellaneous

Figures 4 and 5 show two more examples of shielding of houses from road traffic noise. A quiet back side is probably very important for the inhabitants of the houses in these example

Figure 4. Examples of a noise barrier. These are situated mostly outside the cities (this one in Eindhoven near a provincial road).

Figure 5. Combination of a noise shield and (open) curtain walls in Amsterdam at Haarlemmer Houttuinen. The shield only protects the lower dwellings.

Examples of Quiet Areas (QA)

In 2008-2009 the 'Amsterdam quiet areas project' was performed. Respondents were asked for their favourite quiet site in the city. This resulted in 1.280 responses. In the picture below the most mentioned places are presented. In the background the calculated noise levels are shown, due to rail and road traffic.

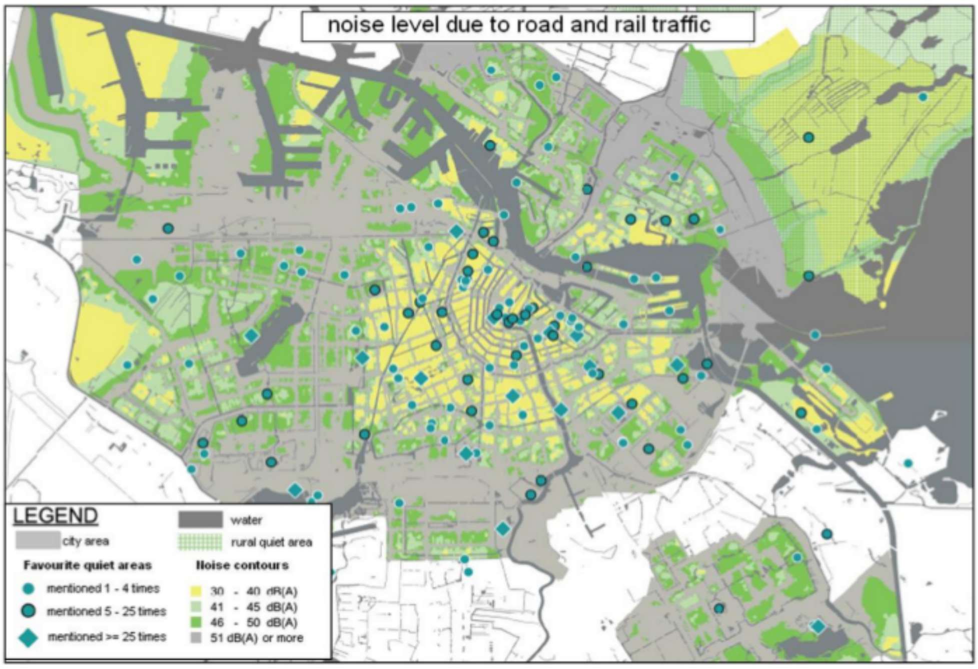

Figure 6. Quiet places in Amsterdam

It is important to preserve these quiet areas. In Amsterdam there is no policy for the preservation of quiet places yet, but there is a policy for the preservation of green areas. For more information see the publications by Frits van den Berg (literature section). Figures 7-9 show some examples of quiet areas in Amsterdam.

Figure 7. Parks and recreational green

Figure 8. City oases and closed courtyards

Figure 9. Quiet areas mentioned by Amsterdam inhabitants include quiet residential areas, such as the Palmgracht in the Jordaan area, illustrated by these two pictures.

Appendix 1: Amsterdam noise policy and Dutch noise limits

Since 1990 Amsterdam had a noise policy for quiet sides, where the above mentioned principles are addressed. The main focus of this policy is:

- For new houses (i.e. planned houses) with a facade noise level that exceeds the legally preferred limit (48 dB), a quiet side (Lden <48 dB) is required
- This is done by urban planning or by facilities 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 facade with a noise level above the mandatory upper noise limit), a quiet side is always obligatory.

Table 1. Dutch noise limits for L_{den}.

Source	Prefered	Mandatory	Inside
Road traffic	48	53 (63)	33

Source	Prefered	Mandatory	Inside
Rail traffic	55	68	33
Industrial	50	55	35

Endnotes

1. In the "Structure vision Amsterdam 2040" the task for the period till 2040 is 70 000 new houses.
2. The Dutch legal upper noise limit is 55 dB(A) for industry, 53 dB for high ways, 63 dB for city roads and 68 dB for railways.
3. The Dutch legal lower noise limit (the so called "preferred limit") is 50 dB(A) for industry, 48 dB for non urban roads and urban roads and 55 dB for railways.

Literature

1. Action plan of Amsterdam (only in Dutch). Amsterdam, 2008. Link: http://www.amsterdam.nl/gemeente/organisatie-diensten/dmb/publicaties/milieu/milieubeleid/actieplan_geluid/
2. Brands, A.E. en G.P. van den Berg, gemeente Amsterdam, 2009 (only in Dutch), Link: http://www.rijksoverheid.nl/documenten-en-publicaties/brochures/2009/07/01/stille-gebieden-in-de-stad.html
3. Frits van den Berg, Carlo Schoonebeek and Menno Hillebregt, On the definitions of quiet façades and quiet urban areas, paper for EURONOISE 2012 10–13 June, Prague.

Example 7, Gothenburg noise policy and quiet façades

By Martin Knape

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The noise policy of Gothenburg was decided in 2006. Quiet façades and courtyards are an important part of the policy, at least regarding new dwellings in central areas. The policy only applies within 4 km of the city centre and close to public transport.

Our noise policy aims at new dwellings in areas with high noise levels and when and how the national guideline limits (55 dBA ($L_{AEq,24h}$), 70 dBA (L_{AFmax})) can be surpassed. The basic idea of the policy is that high noise levels on one side can be compensated with lower noise levels on the other side and in courtyards and on balconies or patios.

What does the policy say?

If noise levels at the exposed façade are somewhere between 55 dBA ($L_{AEq,24h}$) and 65 dBA ($L_{AEq,24h}$) 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 is illustrated in figure 1 below. Courtyards are usually regarded as part of the quiet side where 45 or at least 50 dB ($L_{AEq,24h}$) is the level to achieve.

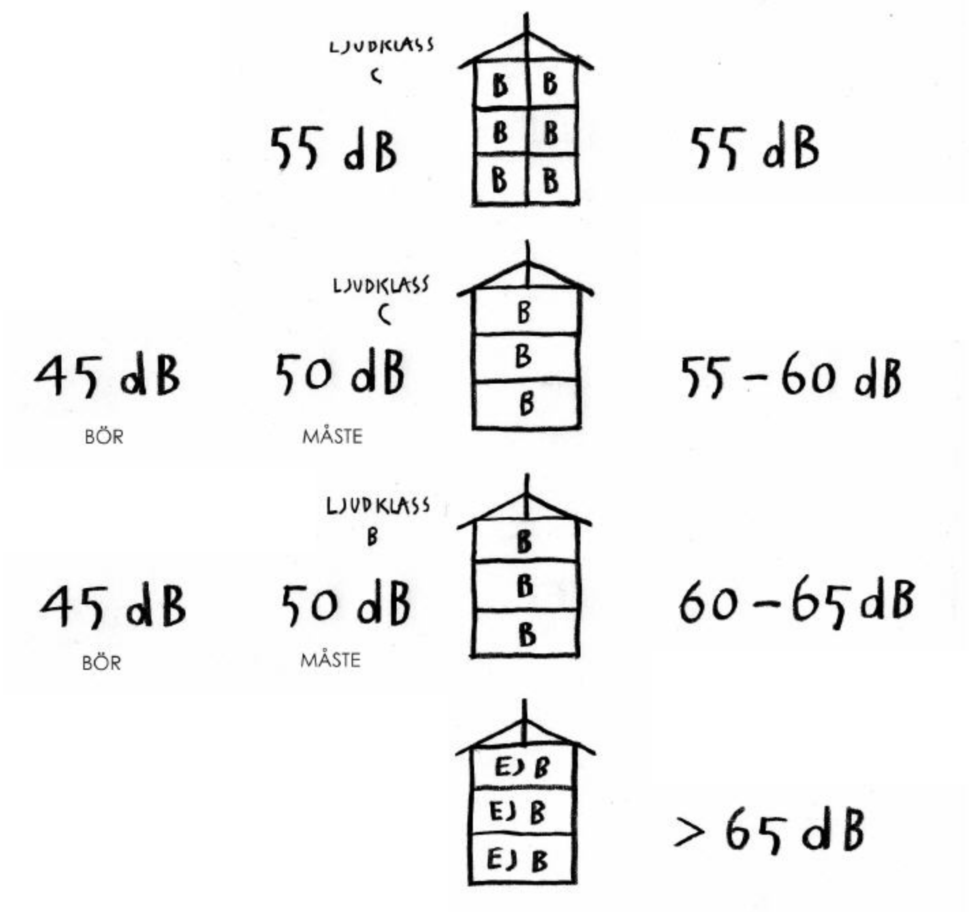

Figure 1. Illustration of the Gothenburg noise policy.

The demands regarding indoor noise levels are higher if traffic noise levels are above 60 dBA ($L_{AEq,24h}$). Then 26 dBA ($L_{AEq,24h}$) and 41 dBA (L_{AFmax}) should be reached, as opposed to 30 and 45 when below 60. If traffic noise levels are above 65 dBA ($L_{AEq,24h}$) no dwellings should be built, but other buildings such as offices may be built (for example as a barrier).

A new policy on the way!

Quiet areas, such as parks, are not yet a part of the city's formal policy. However, the city is working on creating a new noise policy which should address noise from a wider perspective and take what we call the "sound environment" of the area into account. This means that, for example, parks and kindergardens should also be part of the assessment. The top level of 65 dBA will probably be abolished, in central parts of the city, in accordance with the new Swedish national regulations.

Example 8, birds in the urban soundscape

By Erik Salomons

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Birds are an important element of the urban soundscape. Birds can be heard in particular in quiet areas.
The video below presents bird sounds recorded during an 8 hour bike tour in Amsterdam on a Sunday. You hear a selection of the 117 bird sounds detected during the tour.

Birds seem to like the two parks in the area (Rembrandtpark and Vondelpark) and also the residential area between the two parks. There were less birds in the busy canal area on this Sunday.

Video 1

It is interesting to note that Great tits (Parus major) sing at higher pitch in response to urban noise, so they are better able to hear each other. This has been shown in a scientific study, in which urban Great tits were compared with rural Great tits. See the BBC news item about this research.

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SECTION	**How can cities create or protect quiet places?** Urban planning

Urban planning

The protection and creation of quiet places is closely related to urban planning, as described by the following texts.

- Urban planning and quiet places in Amsterdam
- Traffic noise control and sustainable urban planning

Urban planning and quiet places in Amsterdam

By Carlo Schoonebeek, Menno Hillebregt, and Frits van den Berg

<<< Back to Urban planning

Introduction

In this section we discuss some basic principles for building in sound congested places. There are several levels for influencing the noise level at buildings:

- the building plan: building orientation and shape, noise shields;
- at an architectural level: double facade or deaf facade;
- by facilities at the dwelling: loggia’s, closed balcony’s, noise screens fitted to the building (coulisse screens), absorbing walls;
- Urban planning and traffic measures including the use of noise reducing pavement.

Only the first three levels are discussed in this section. Urban planning and traffic measures are discussed further in the noise action plans of the cities.

Basic principles for building in noise congested areas (including QF)

Building orientation and shape & noise shields

In the design of a housing plan it is important to create quiet façades and quiet areas. In the examples below the effect of the building orientation with respect to the noise sours is shown. Quiet sides can be created, even in high noise level areas (see Figures 1 and 2).

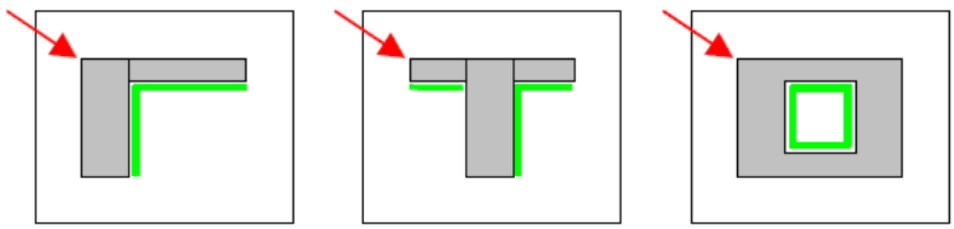

Figure 1. Examples for the effects of building orientation (Source: factbook Programma Stiller Stadsverkeer). Red arrow: incident noise. Green arrow: quiet facades.

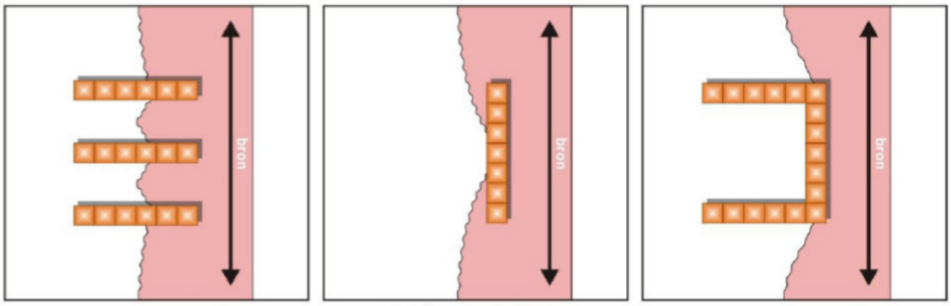

Figure 2. Examples of effects of orientation of the dwellings. (Source: van Riet HW-beleid Bussum.)

In Amsterdam many housing projects are realised by building parallel to the noise source (rail or road traffic), hereby creating a noise barrier. In the noisiest parts offices can be situated or houses with a "deaf" facade or a double facade (explained below).

It is also possible to make use of a noise barrier (screen). Outside the cities noise barriers are often used in the Netherlands, mostly alongside roads and railways. Noise shields are costly and there are only a few examples in the city of Amsterdam.

Closed housing blocks

In many European cities it was common to build with closed housing blocks (courtyards). From a noise point of view closed housing blocks guarantee that there is a quiet side for all dwellings. In Amsterdam this was also the case until approximately the eighties as is shown in figure 3.

Figure 3. Closed housing blocks (courtyards) in Amsterdam and Rotterdam.

Measures at architectural level

At an architectural level the following measures are common to create quiet sides:

- Terrace wall structure
- Shielding gallery
- Double facade and deaf facade
- Sound absorbing walls

In figures 4 and 5 some of this solution are shown:

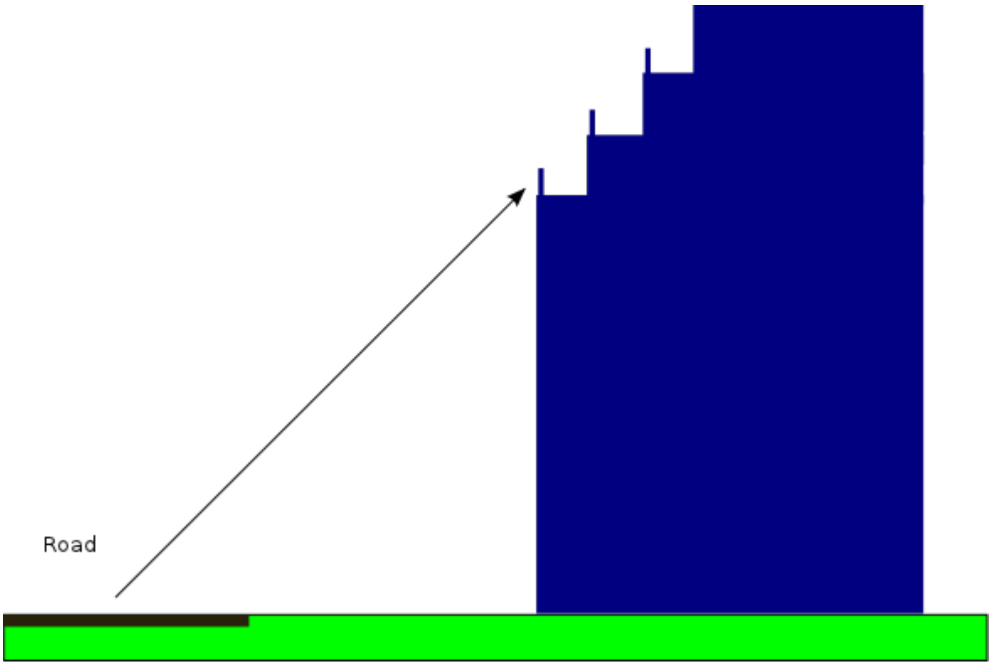

Figure 4. Example: terrace wall (side view).

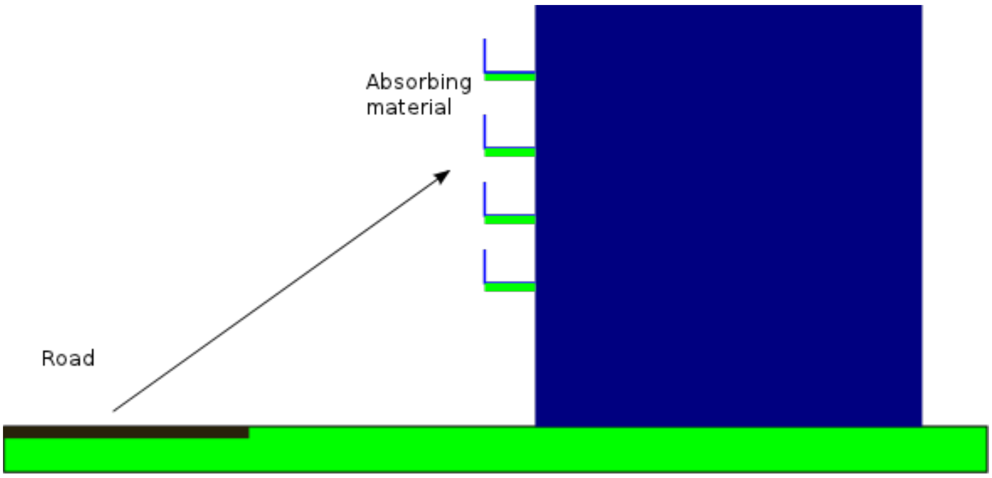

Figure 5. Shielding gallery.

Deaf facade and curtain wall

The Dutch noise legislation forbids the building of new houses in areas where the Dutch legal noise (upper) limit is exceeded. The noise limit doesn’t apply when a "deaf facade" is used. Another possibility for this situation is the use of a curtain walls.

Deaf facade
If a wall of a dwelling has no opening parts (windows, door) then in the Dutch noise legislation the facade is not regarded as a facade. In these cases the noise limit doesn’t apply. This is called a 'deaf facade”. Because a deaf facade is of course not an ideal situation every dwelling with a deaf facade must have a quiet side, where the lower noise limit is met (mostly 48 dB).

Curtain wall
As shown in figure 6 this is a facade with a soundproofing screen attached to it. This is not a ‘deaf facade’. In the ideal case the sound level at the facade opposite the screen meets the Dutch lower noise limit, thereby creating a “soundproof” wall.

For these curtain walls there are certain demands: between the screen and the facade outdoor conditions should prevail, minimum ventilation openings are required, and the distance between the screen and the soundproof wall must be at least 0.5 meters.

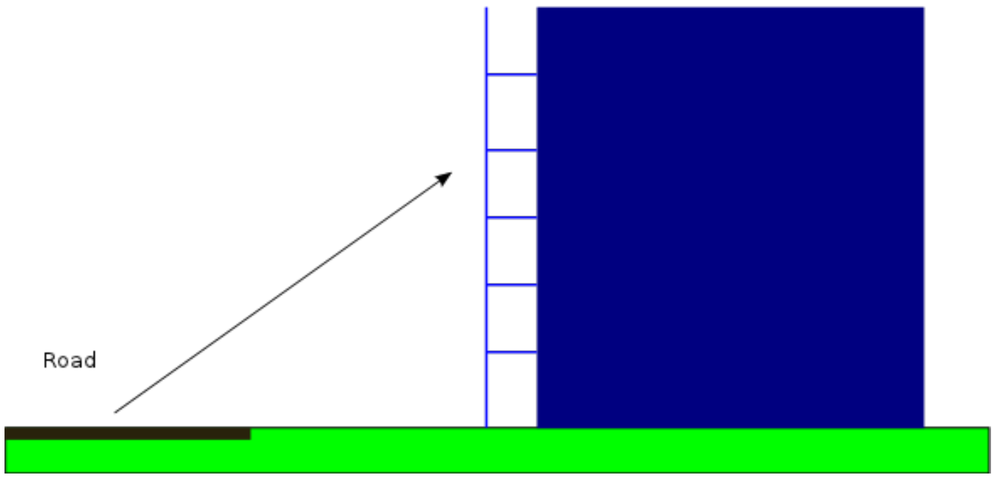

Figure 6. Curtain walls in front of dwellings (double facade).

For both double facades as facades designed as deaf facades the sound insulation must be so that in the bedrooms and living areas 33 dB prevails (according to the Dutch Building Act).

Facilities at the houses

In situations where there is no quiet facade (e.g. an apartment building perpendicular to the road) a quiet facade can be created by facilities at the houses, e.g. loggia's or glazed conservatories (see Figure 7). Loggias are recessions in the facade, creating a quiet side. A glazed conservatory (greenhouse) is a screened balcony on the facade.

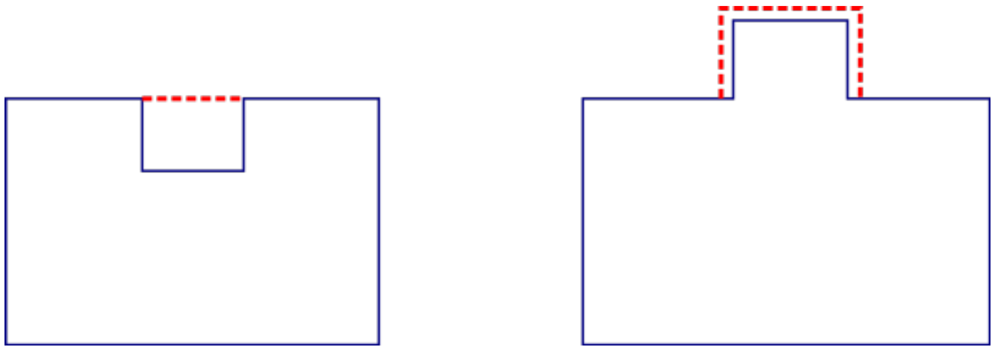

Figure 7. Loggia's

In Amsterdam the following rules apply for these loggia's and closed balconies:

- the outside area must be cold;
- there are prescribed openings for outdoor air;
- there are minimum dimensions;
- and (at least) the bedrooms need to be ventilated onto the loggia.

Traffic noise control and sustainable urban planning

By Erik Salomons

<<< Back to Urban planning

Sustainable urban planning aims for an optimization of the quality of life of the inhabitants of a city, both present and future inhabitants. The quality of life depends on a broad range of factors, including economic, social, and environmental factors. Traffic noise is one of the environmental factors. Traffic noise control should be considered as an important element of sustainable urban planning.
In this section, we consider a few elements of the relation between sustainable urban planning and traffic noise control. The implications of urban densification strategies, leading to higher population densities and traffic volumes, are addressed. Illustrations for specific cities are presented, in particular for Amsterdam, which is representative of many European cities with a historic center and suburbs developed in the 20th century.

1. Traffic noise in cities

Road traffic noise levels in cities show large spatial variations. The noise levels are high near busy roads and low in shielded areas or areas far from busy roads. Thus, the traffic noise levels are related to the local traffic volumes. The traffic volumes are in turn closely related to the infrastructure of the city, in particular to the road network and the buildings (dwellings, offices, shops, …). Thus, we have a two-stage relation from infrastructure to traffic noise:

1. Buildings and road network influence traffic volumes.
2. Traffic volumes determine traffic noise levels, in particular traffic noise levels at the houses of the inhabitants.

This is illustrated schematically in Figure 1.

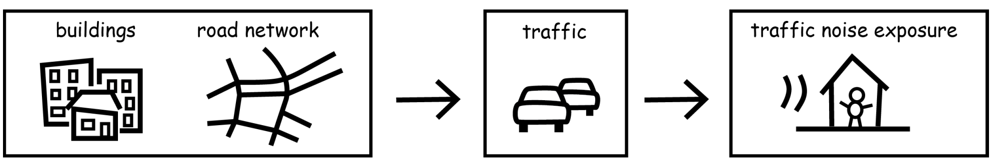

Figure 1. Schematic illustration of the causal chain of traffic noise exposure of inhabitants of a city (at home). Traffic volumes in the city depend on the locations of buildings and on the road network.

The first relation, from infrastructure to traffic volumes, is complex. Traffic volumes in the city depend on the locations of buildings and on the layout of the road network, but there are also other factors of influence. The buildings are usually starting points and/or end points of trips by car on the road network, except for trips of cars that only use the road network for passing through the city. The spatial and temporal distributions of trips on the road network depend on the complex system of travel behavior of people, with many interrelated factors of influence, such as labor market demand, travel times, quality of public transport, bicycle paths, and footpaths.

The second relation, from traffic volumes to traffic noise exposure, is also rather complex. Noise levels at the façade of a dwelling depend on the distances to the roads and on the traffic volumes. Intermediate buildings also play a role: a building may screen or reflect sound waves generated by traffic. Further, the design of building blocks is of interest. In general, closed building blocks lead to lower noise levels at façades that are not exposed directly to traffic noise (quiet façades).

The above considerations imply that there is also a close relation between traffic noise control and the planning of the city, in particular the planning of new developments of buildings and roads. In other words, traffic noise control is closely related to urban planning.
A further implication is that cities should consider noise reduction plans as a part of broader urban development plans. A city is concerned not only with traffic noise control, but with a wide range of aspects of urban life and sustainability. Sustainable urban planning needs to address more than one issue; win-win situations where many interests are addressed by the same overall plan must be the goal.

2. Sustainable urban development

Sustainable development may be defined as development that optimizes the quality of life of people, including future generations, considering both economic and environmental aspects. This definition is in line with the definition given in 1987 by the Brundtland commission [1].

Sustainable *urban* development can be seen as sustainable development applied to a city [1].

Elements of a sustainable city are:

- sustainable economy
- good housing of the inhabitants
- clean environment, low noise and air pollution
- good health of the inhabitants
- sustainable transport system, less automobile use, more non-motorized transport
- efficient land use (compact city).

Most elements are related to each other. For example, public health is affected by noise and air pollution caused by road traffic. Sustainable urban development requires a careful balance between the elements. For example, there may be an optimum situation with a moderate amount of motorized traffic in a city, considering both positive (economic) effects and negative (environmental) effects of motorized traffic.

An important question is: which spatial urban planning strategies are best for urban sustainability? There is an ongoing debate on the answer to this question [1]. Presently, many urban planners believe that urban *densification* strategies are preferable, and they consider a *compact* city as a sustainable city. However, there is no consensus about this. To understand the evolution of ideas about sustainable urban planning, it is useful to take a brief look at urban development in Europe in the past century.

3. Development of European cities in the 20th century

The structure of many European cities has been influenced by the ideas of Le Corbusier and coworkers, formulated in the first half of the 20th century. In view of problems in industrial cities at the beginning of the 20th century, Le Corbusier wanted to create better living conditions and a better society. A central idea was that one should separate the four basic functions of a city: housing, work, transport, and leisure. For example, houses should be concentrated in residential quarters and (major) roads should preferably be located far from houses. Le Corbusier was influenced by the book "Garden cities of tomorrow", published by Ebenezer Howard around 1900. The designs of Le Corbusier have been called ‘vertical garden cities’.

An example of the influence of Le Corbusier’s functionalism is the Amsterdam urban plan of 1935 ("Algemeen Uitbreidingsplan van Amsterdam"), with its characteristic garden cities (suburbs) on the west side of the city (see Figure 2). The plan was executed after the Second World War and has resulted in open urban areas in the outer parts of Amsterdam, which differ from the more compact areas in the central part of the city developed in the 15th to 19th century.

In the sixties the new quarter Bijlmermeer was developed, with high-rise apartment buildings separated by green areas (see Figure 3). The green areas were intended for leisure, but unfortunately it turned out that they were considered as unsafe areas by the inhabitants. To counteract a population decrease in the seventies, and to increase the liveliness of the city and the quality of life of the inhabitants, urban development ideas in Amsterdam shifted to the concept of the compact city, i.e. a densely populated city that mixes housing, work, and leisure.

The tendency towards the compact city still exists today. It can be seen as a response to urban sprawl and the creation of suburbs far from the city center. Cities have grown in size considerably over the last century. This has its positive effects (more living space per inhabitant) but it may also have negative effects. People living in suburbs are likely to use motorized transport more often than people in the center do. A compact city may have better environmental qualities than a sprawling city (see section 5), and furthermore may improve economic and social aspects of urban life.

The above considerations focus on the density of a city - for example, building density or population density. The road network is another important element of the structure of a city. This can be seen in Paris, with its long boulevards developed by Haussman in the 19th century. At that time one could not foresee that road traffic would grow as much as it has done over the past decades. The wide boulevards and streets in Paris are still able to contain current large traffic volumes (see Figure 4), but smaller streets in Paris, and many other cities, are less suitable for today’s traffic.

Figure 2. The Amsterdam urban plan of 1935, with its characteristic garden cities (suburbs) shown in orange on the left.

Source: http://commons.wikimedia.org /wiki/File:Algemeen_uitbreidingsplan_amsterdam1935.jpg

Figure 3. View of the Amsterdam quarter Bijlmermeer built in the 1970s (picture 2008).
Source: http://commons.wikimedia.org /wiki/File:Gooiord,_Bijlmer.jpg

Figure 4. A crossing of wide streets in Paris (rue de Rennes and rue du Four).

4. Urban plans for the next decades

Important questions for cities for the next decades are the following questions.

1. Should traffic be reorganized?

- Should motorized traffic in the city center be restricted?
- How?
- How do we achieve a modal shift to sustainable transport modes?

2. What type of spatial urban planning is preferred?

- Sprawl or infill?
- Separation of functions?
- Compact city?

For example, the cities of Amsterdam and Rotterdam address these questions in plans for the next decades [2-6]. Both cities foresee a significant population increase.

The answers to the above questions depend on the local situation. There are no universal answers. In the following sections we present a few general considerations, which may help in the process of finding local answers to the questions, and thereby developing local sustainable urban plans. We first consider spatial urban planning (Section 5) and next traffic planning (Section 6).

5. Spatial urban planning: sprawl or infill?

As described in a previous section, the ideas of urban functionalism were abandoned in the 1970s or 1980s. The reason is that 'the human side' of the city had been forgotten by the functionalist movement. This is described by Halbertsma and Ulzen in their book about the cultural history of the European city [7]. After the Second World War, cities became less lively: people worked in the daytime, while at night the cities became 'ghost cities'. This caused problems in cities that previously flourished, such as Liverpool, Manchester, cities in the Ruhr area, and Bilbao.

In the 1980s there was an increase of creative activities in cities, such as IT, advertising, marketing, and art. 'Bad' urban areas were revitalized by the inflow of creative inhabitants. This process is called *gentrification*. An example is the city of Glasgow, which even became cultural capital of Europe in 1990. Another example is the urban quarter Jordaan in Amsterdam (see figure 5).

Figure 5. The Amsterdam quarter Jordaan is an example of an urban area that was revitalized by gentrification in the 1980s.

What are the implications of urban sprawl or infill for traffic noise and traffic-related air pollution? Two counteracting effects play a role here:

1. effect of automobile use
2. effect of the distance between automobiles and people.

In a sprawling city, with suburbs located far from the city center, automobile use is higher than in a compact city (see Figure 6). Automobile use depends on many factors, and travel distance is clearly an important one. This is addressed in more detail in the next section.
In a sprawling city, or in a city developed along the ideas of functionalism, with major roads located far from houses, average distances between cars and inhabitants (or dwellings) are generally larger than in a compact city. On the other hand, screening of traffic noise by buildings is less effective in a sprawling city than in a compact city.

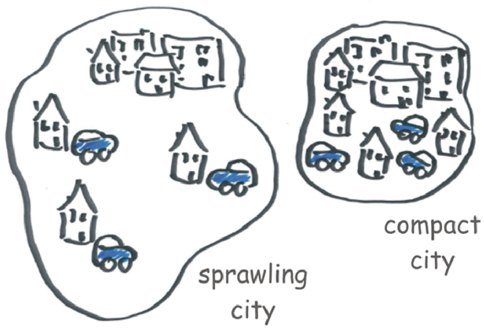

Figure 6. Comparison of a sprawling city and a compact city. Inhabitants of suburbs in a sprawling city use automobiles more often than inhabitants of a compact city do.

Consequently, an increase of urban density may lead to an increase or a decrease of average noise levels and air pollution concentrations. Details of the urban layout, i.e. buildings and road network, play a role. One way to get a better grip on the details is the use of a three-dimensional urban density (Spacematrix), as introduced by Berghauser Pont and Haupt [8]. The three elements of the Spacematrix are

- ground space index (GSI)
- floor space index (FSI)
- road network density (N)

which are defined by the illustrations in Figure 7. In general, a compact city or a compact urban area corresponds to a high value of the floor space index FSI.

In Ref. [9], the relation between the three-dimensional urban density and urban traffic noise is analyzed for the cities of Amsterdam and Rotterdam. It is found that average traffic noise levels (at the most exposed façades of dwellings) decrease slightly with increasing floor space index. This trend is derived by comparing different areas in the cities. The same trend was also found for artificial urban fabrics, taking into account the fact that automobile use per person decreases with increasing floor space index (see Section 6).

The trends for air pollution are in general not identical to the trends for traffic noise. For air pollution the above mentioned counteracting effects also play a role, but dispersion of air pollution and noise propagation are two different physical phenomena. For more information, see for example Ref. [10].

Urban density can also be related to traffic noise levels at the backsides of houses. In general, a compact city is characterized by a high concentration of high buildings (high values of FSI). Figure 8, reproduced from Ref. [9], shows two examples of urban fabrics with FSI of the order of 0.75. Example (a) has closed building blocks, with low traffic noise levels at the inner courtyards shielded from the streets. Example (b) has 'tower-like' buildings without inner courtyards.

These observations can be related to the structure of Amsterdam. The central part of the city has many closed building blocks, while the suburbs developed in the 20th century have a more open structure. Consequently, in the city center low traffic noise levels occur in closed courtyards, while high levels occur along busy streets. In the suburbs there are less busy streets close to the houses, so levels on the most-exposed façades are lower here than in the city center. On the other hand, there are less closed courtyards with quiet façades in the suburbs.

This illustrates that urban infill scenarios have the danger of high noise (and air) pollution, in particular if the scenarios do not include a reduction of automobile use per person. Traffic reduction measures (see next section) will help to reduce the high noise levels in a compact city. Furthermore, screening by buildings in a compact city may be exploited to create quiet backsides and quiet areas.

As indicated before, traffic noise control should be considered in the context of sustainable urban development, taking into account a broad range of urban factors. This applies also to the question whether urban planners should go for dense cities with shielded areas and closed courtyards or rather for a city with a more open structure. Traffic noise is only one aspect of shielded areas and closed courtyards. Other aspects are for example public security and social interaction of inhabitants, which may be higher in cities without closed courtyards. The detailed balance of all relevant factors depends on the local situation in a city.

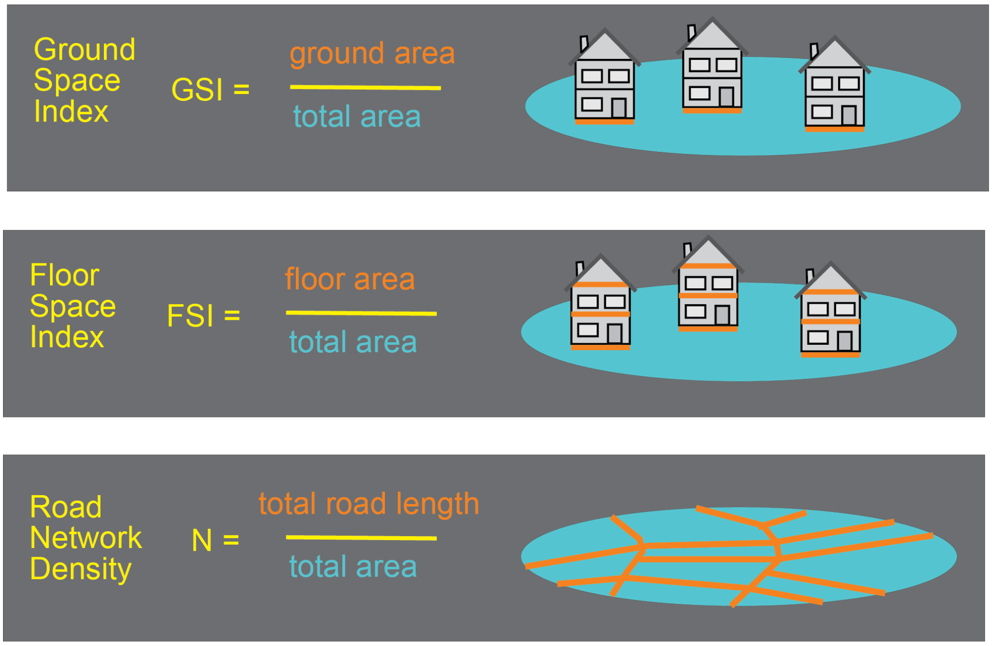

Figure 7. Illustrations of the definitions of GSI, FSI, and N, which are the elements of the three dimensional urban density called Spacematrix.

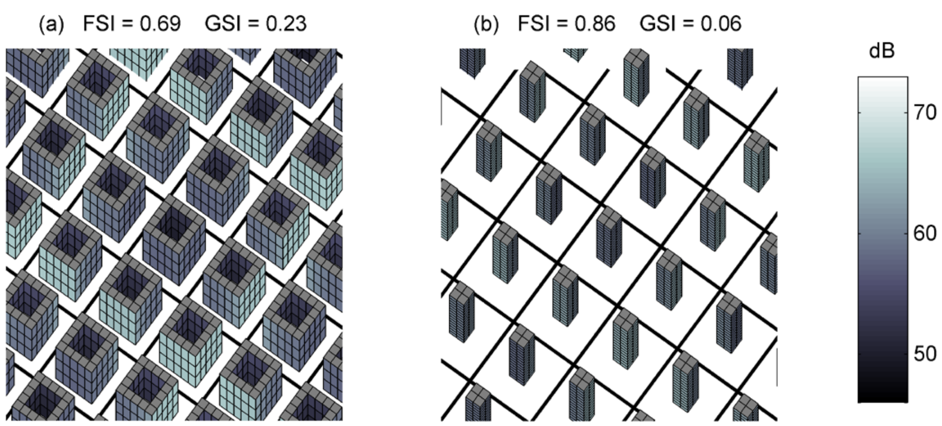

Figure 8. Two examples of urban fabrics with a rectangular grid of streets between building blocks, and traffic noise façade levels represented by a gray scale. Example (a) has blocks with sides of 5 building units and 3 floors. Example (b) has blocks with sides of 2 building units and 15 floors.

6. Traffic planning: think global, act local

6.1 Global analyses

Traffic noise in a city is directly related to the traffic volumes on the road network. The traffic volumes depend on various characteristics of the city, such as

- road network and buildings (dwellings, offices, shops,…), as described in Section 1,
- public transport,
- infrastructure for cyclists and pedestrians.

Travel behavior of the inhabitants (and visitors) also plays a role, which is related to personal parameters such as lifestyle, wealth, or car ownership [11]. Other parameters are also important such as labor market demand and accessibility to city functions such as schools, hospitals, grocery stores and so on.

On a different ‘level’, traffic volumes are related to urban density or population density. For example, automobile use may be low in a compact city or a city center, and higher in a sprawling city or low-density suburbs. Kenworthy and coworkers [12,13] have presented extensive studies of automobile use in a large number of international cities. They concluded that automobile use is more strongly related to urban density than to wealth (represented by gross regional product). Automobile use decreases with increasing urban density, and public transport increases with urban density.

Figure 9 shows results of Newman and Kenworthy [13], illustrating that automobile use decreases with increasing urban density. Automobile use is high in North-American sprawling cities and low in more compact Asian cities like Hong Kong. It should be noted that there have been critical comments on the statistical methods underlying the graph in Figure 9. More recently, Marshall [14] performed a similar study of automobile use in US cities. This study yielded a graph comparable to the graph of Newman and Kenworthy, showing that automobile use decreases with increasing urban density.

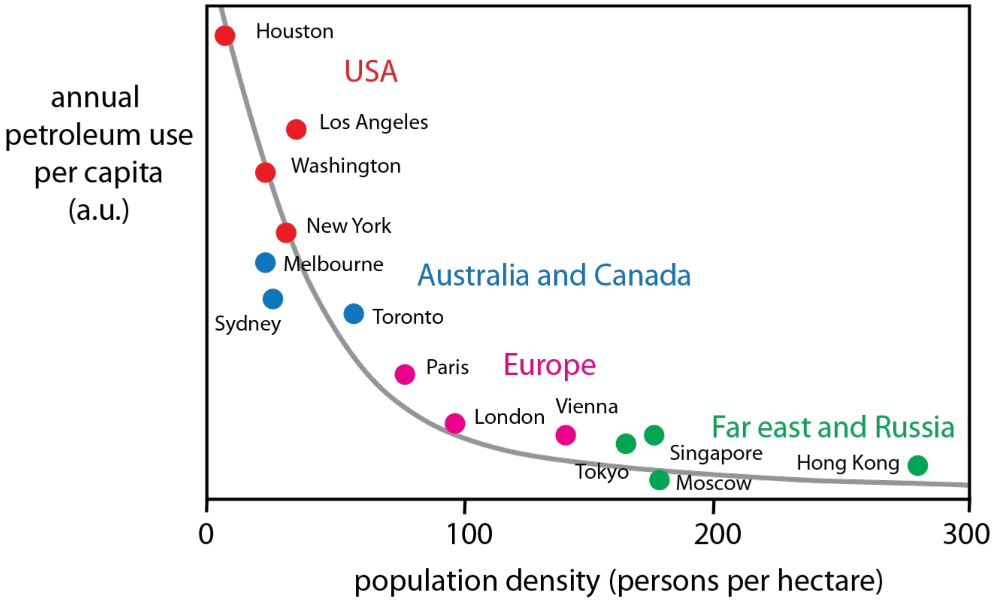

Figure 9. Graph showing the relationship between urban density and automobile use (expressed as petroleum use), after Newman and Kenworthy [13].
Source: http://en.wikipedia.org /wiki/File:Petrol_use_urban_density.svg

Rather than comparing car use in different cities, one may also compare traffic volumes in different areas within a city, and relate this to local traffic noise levels. This approach was followed in Ref. [9]. The results are relevant for intra-urban analyses of traffic noise distributions within a city. Efficient traffic noise control in a city requires that traffic - or more precisely traffic noise emission - is restricted in the areas where urban density is highest.

6.2 Local action

The above mentioned studies focus on comparisons between different cities, or different areas within a city. The observation that car use is lower in compact cities in Asia than in sprawling cities in the US, for example, does not imply that car use is reduced 'automatically' if a European city enhances urban density by an infill scenario. Local action is required to achieve a modal shift from cars to other transport modes.

One way to stimulate people to use bicycles in cities is *road sharing* on urban roads. This means that the roads are designed in such a way that they can be shared by motorized vehicles, cyclists, and pedestrians. Road sharing requires that the speeds of motorized vehicles be low, say 30 km/h. In other words, road sharing requires *traffic calming*. This can be achieved by a proper design of the roads, for example, with obstacles on the road.

Actually, the idea of road sharing was introduced in the Netherlands already in the 1970s. The shared roads in the Netherlands still exist, and are called 'woonerf' – a word that is also used sometimes in English. Figure 10 shows the traffic sign used to indicate a 'woonerf'.

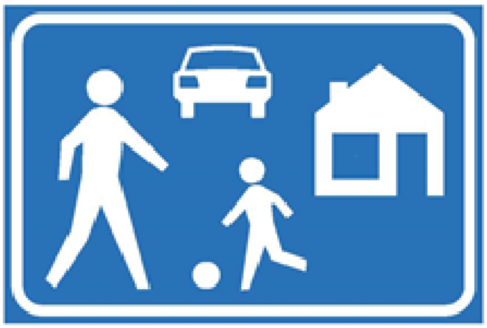

Figure 10. Traffic sign used to indicate a "woonerf" in the Netherlands.

Danish architect Jan Gehl is an internationally known promoter of road sharing and protection of pedestrians and cyclists in cities. Videos of his observations on the streets of cities can be found on the internet [15,16]. Many cities in the world have consulted Jan Gehl for advice on urban development plans.

Figure 11 shows an artist impression of a transformation of a busy and noisy street into a street that is more attractive for cyclists and pedestrians. This example was taken from material presented at a meeting on road sharing in Amsterdam in November 2011 [3]. Figure 12 shows an actual example of road sharing, in the third arrondissement in Paris.

Figure 11. Artist impression of a transformation of a busy and noisy street (top) into a street that is more attractive for cyclists and pedestrians (bottom). Used with permission of the artists [3].

Figure 12. Example of road sharing, in the third arrondissement in Paris. Picture taken by the author, June 2013.

7. Case study: an infill scenario for the center of Rotterdam in 2030

In Reference [6] an analysis is presented of an infill scenario for the center of Rotterdam in the year 2030, corresponding to a population increase from about 30,000 to 60,000 inhabitants. Here we summarize the results of the analysis, since it nicely illustrates the message of this section that traffic noise control should be considered as an important element of urban sustainability plans. The analysis focuses on traffic, environmental pollution, and public health.

Starting point of the analysis was the Rotterdam infill scenario for the year 2030, as described in Refs. [4,5], with 20,000 new dwellings and 30,000 new inhabitants in the central urban quarter ‘Stadscentrum’ of Rotterdam. The buildings with the new dwellings have been designed by urban architects, and are indicated as yellow blocks in the three-dimensional view shown in Figure 13.

Figure 13. Three-dimensional view of the central area of Rotterdam, with yellow blocks representing new buildings for the infill scenario for the year 2030.

The city of Rotterdam has also developed plans for traffic in the year 2030 [5]. A general objective is that the city center should become (more) attractive and accessible, both for the inhabitants and for visitors. Therefore the following traffic measures have been formulated.

1. Modification of major roads – narrower roads, lower speeds.
2. Improved infrastructure for bicycles and pedestrians.
3. Modifications of parking fees.
4. Improved Park and Ride facilities.

The aim of the measures is to achieve a *modal shift*, i.e. a reduction of automobile use in the city center and an increase of non-motorized transport modes.

In principle, the traffic plans should have been taken into account in the analysis of the infill scenario for Rotterdam in 2030. However, the approach to follow here is not straightforward, since at least three competing effects play a role: i) effects of modal-shift measures, ii) autonomous growth of traffic, and iii) effects of the population increase by 30,000 inhabitants. As a crude approximation, it has been assumed that each new inhabitant generates one additional car trip per day.

The results of the analysis are represented schematically in Figure 14. For details about the results we refer to Ref. [6]. The figure shows that, as a result of the population increase:

- Traffic volumes on the roads increase,
- Urban density increases; in fact this was an objective of the infill scenario, since the ambition of Rotterdam is to achieve a more compact city center,
- Traffic noise and air pollution increase.

The increase of traffic noise levels is relatively small. As a consequence, the increase of the estimated *percentage* of inhabitants that is highly annoyed by traffic noise (at home) is also relatively small: 7.0% in 2012 and 7.5% in 2030. However, since the number of inhabitants doubles, the increase of the *absolute* number of highly-annoyed inhabitants is large: about 2300 inhabitants in 2012 and 4600 inhabitants in 2030. The latter number of 4600 highly-annoyed inhabitants has been converted into a health effect expressed in (healthy) life years lost, using a calculation scheme recommended by the World Health Organization. The scheme gives 0.02 life years lost per highly annoyed person (per year), so we find that 4600 highly-annoyed inhabitants correspond to about 100 healthy life years lost (per year).

This negative health effect may be used as an argument for (further) reducing motorized traffic in the city center. In fact the traffic reduction measures described before are in line with this argument. A modal shift from car to non-motorized transport modes will have positive effects on congestion, traffic safety, traffic noise, and air pollution.

A modal shift from car to bicycle will have another positive effect on public health: enhanced physical activity improves the health of the inhabitants. Cyclists are physically more active than car drivers. Using a mathematical technique called Life Table analysis, based on age-specific mortality rates of a population, it was estimated that the modal shift from car to bicycle in Rotterdam in 2030 corresponds to a health gain of 200 life years gained (per year). Here it has been assumed that 10% of the 60,000 inhabitants of the Rotterdam city center in 2030 make the shift from car to bicycle, for short trips (15 km at most) on a daily basis, for example for commuting or shopping.

Finally we mention another positive effect on public health. The Rotterdam infill scenario not only includes measures for promoting cycling in the city center, but also measures aiming for a city center that is more attractive for pedestrians. Improved public space in the city center will have positive health effects through enhanced physical activity of pedestrians. However, these effects have not been quantified in this analysis.

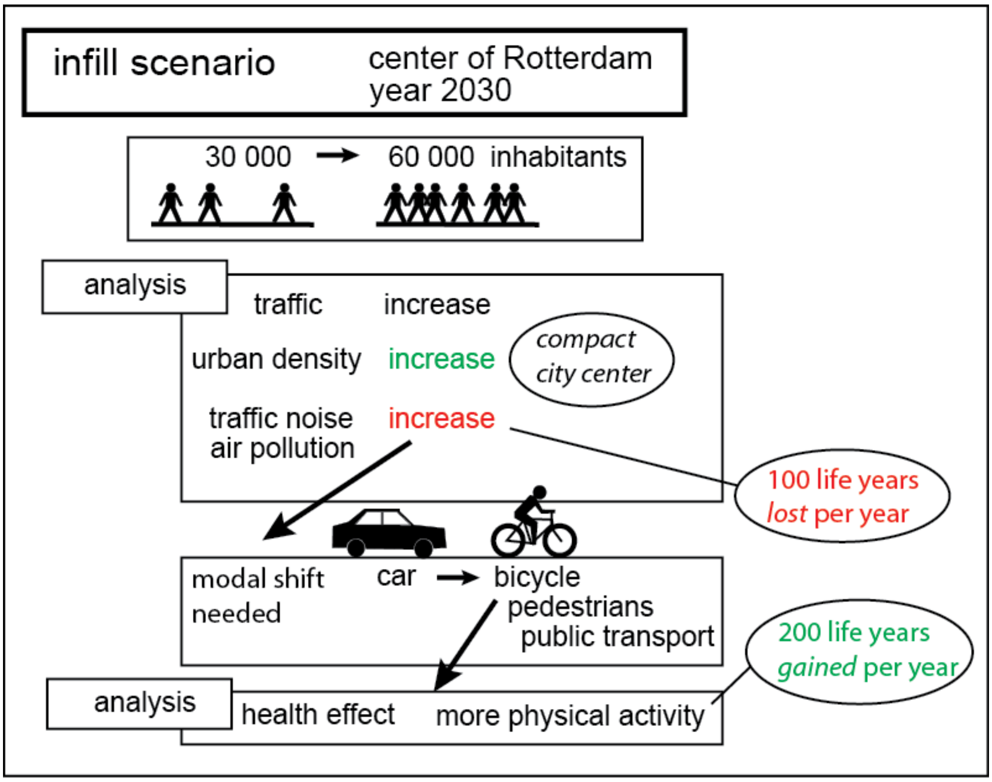

Figure 14. Schematic illustration of the results of an analysis of various elements of an infill scenario for the city center of Rotterdam in 2030, based on an urban sustainability plan aiming at an attractive and accessible city center [4,5]. Increased traffic noise annoyance in 2030 is expressed as a health effect of 100 life years lost per year. This effect can be reduced by modal-shift traffic measures, which in addition has a positive health effect of 200 life years gained per year due to enhanced physical activity of cyclists compared to car drivers.

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New York City streets from pre-automobile times to the present. See: http://www.contestedstreets.org/

QSIDE	
DOCUMENT	**Quiet places in cities** **Quiet façades and quiet areas in urban noise policy. Recommendations and examples.**
SECTION	**Scientific support** Human response Noise levels

Human Response

By Martin Knape and Anita Gidlöf-Gunnarsson

Sounds affect us, either in a positive or a negative way. How we are affected depends on several factors such as the sound level, when the sound occurs, how predictable it is, which information it contains and what we are doing when it occurs. It is also dependent on factors connected to ourselves as human beings, such as our relationship with the source of the sound, how sensitive we are and if other stress factors are present. When sounds are undesirable and unwanted – when they are perceived as intruding, tiring, irritating, and disturbing – they are defined as noise.

General effects of traffic noise

Noise can lead to feelings of discomfort when exposed but it also affects the possibilities of rest, psycological restoration and good, undisturbed sleep. This can after prolonged exposure lead to stress related symptoms, concentration loss, feelings of frustration and depression. These effects are likely to cause secondary health effects such as hypertension, stroke and other cardiovascular diseases. In their report "Burden of disease from environmental noise" the World Health Organization (WHO) estimates that about a million healthy life years are lost annually in Europe due to the negative health effects of traffic noise.

Benefits of quiet sides and quiet areas

In urban areas, traffic noise levels show large variations, which can be used and optimized for reducing the harmful effects of traffic noise. Quiet sides provide opportunities for undisturbed sleep and to enjoy (e.g. relax, socialize) in a quiet backyard or courtyard, or at a quiet balcony. Inhabitant’s with a quiet side report less noise annoyance and disturbances in comparison to inhabitants without a quiet side. Quiet urban areas such as parks may satisfy various human needs, for example, by providing opportunities for psychological restoration, recreation, play, and exercise. Attractive quiet sides and quiet areas have positive benefits that are of importance for urban inhabitants quality of life.

Calculation scheme for the effect of a quiet side on traffic-noise annoyance

In QSIDE it has been suggested that the effect of a quiet side on annoyance by traffic noise at home may be estimated by a simple calculation scheme. The scheme is a refinement of conventional prediction methods for traffic noise annoyance. The conventional methods yield annoyance as a function of a noise level at the most exposed façade of the dwelling. The QSIDE calculation scheme yields a refinement of the annoyance prediction based on a noise level at the least exposed façade. The calculation scheme is based on annoyance studies in Swedish, Belgian, and Dutch cities. A description of the calculation scheme can be found elsewhere in the QSIDE documentation.

Noise levels

By Mikael Ögren

Noise prediction

Prediction methods for noise levels from road and railway traffic have been used for a long time, and typically the methods in use today do a good job of predicting noise levels where they are high, i.e. at positions directly exposed to noise from busy streets. At positions shielded from direct exposure such as quiet courtyards or streets with no or very little traffic flow, the methods tend to underestimate the noise level. This is in principle due to

- More distant sources become important since no strong sources are nearby.
- Multiple reflections become more important; close to the source reflected sound paths become substantially longer than the direct path, but far from the source the direct and reflected path may be almost equal in length.
- Scattering by turbulence becomes important, the naturally occurring turbulence in the air scatters sound power down into the city landscape, which is important where the levels are low.

Many prediction methods can in principle take a high number of reflections into account, but this is computationally very time consuming since all possible ray paths must be identified. In order to make a more efficient method the QSide project made a large number of reference calculations using advanced numerical methods and used these results to create a simplified method that includes many reflections in only one calculation step.

The simplified method for shielded areas was designed to yield a contribution added on top of a calculation with a traditional method. It could be added to a "normal" noise map at all locations since the levels will be relatively low, and will not affect the level at exposed positions. At shielded positions the levels from the "normal" noise map will be too low, but adding the QSide contribution will correct that. The method is illustrated in the image below.

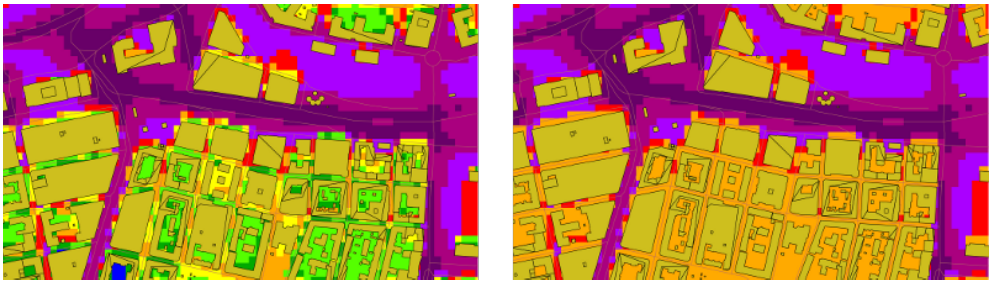

Figure 1. Example of adding calculations on quiet sides to an existing noise map.

There is a short slide show (10 images) that presents an overview of the model which you can access by clicking the image below

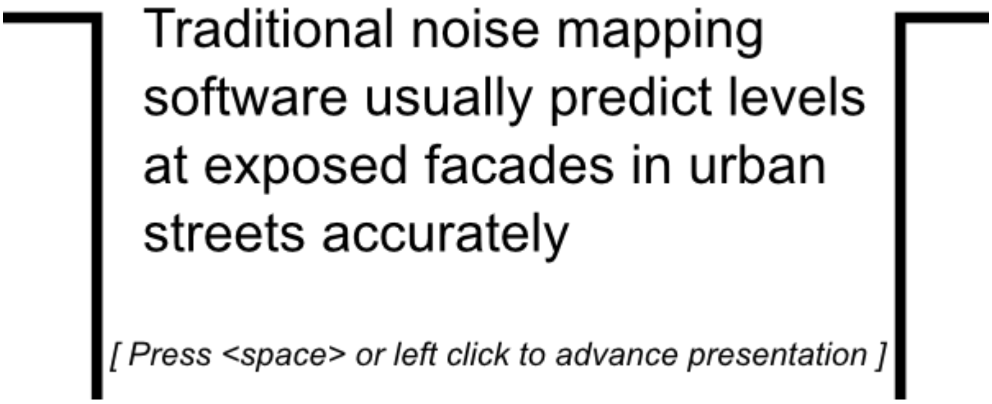

Figure 2. Slideshow of noise prediction in shielded areas, click to access.

References

1. Technical report of QSide calculation model

About this webpage

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