Soundscape, privacy, communication, and orientation.

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Abstract
The auditive element is often neglected, in descriptions of environments. If sound is addressed at all, only the aspect of noisiness is considered. "Soundscapes" can offer a different view. This notion is used in several ways, many of them too limited in scope. Also because a large amount of information is available on the "behaviour" of sound and speech communication, these acoustical aspects make a good starting point for an objective description of residential environments. They could be included in the notion of soundscapes.
Making a philosophy work requires tools, which means: tools are necessary to put ideas for a better environment into practice.
A first step towards a more objective description of soundscapes is the notion of "signal to noise ratio", which can indicate whether a specific sound can be heard in a certain ambient noise. This is the base for understanding communication, privacy and masking. Further it is noted that human speech is a very important sound source, sometimes appreciated (social communication), sometimes not (intruding noise).

A holistic approach of soundscapes should be developed including annoyance, auditive privacy and communication as well. Many of the elements required for this approach exist, but have not yet been taken into this new field. For example, it is necessary to determine in each case what is foreground sound ("signal", speech) and what is background noise, and to treat them separately; the combination of both determines the rate of communication, ranging from perfect privacy to perfect communication. Calculation models from acoustic science are available for speech privacy and speech communication. Similar models can be developed, to compare different urban plans and create a base of guide lines for soundscapes in urban and architectural design.

Keywords: soundscapes, noise annoyance, speech communication, speech privacy, orientation, urbanism

1 Introduction

Mental aspects of the environment are for a large part based on visual impressions. The visual element is clear to most designers, and is generally the main topic of scientific and professional literature. It is easy to describe, to record by means of pictures and to communicate. The auditive element however is often neglected, in particular in exterior spaces. If sound is addressed at all, only the aspect of noisiness is considered. "Soundscapes" already offer a different view. Here sound is taken as an element describing part of the environment, positive and negative. Also because a large amount of information is available on the "behaviour" of sound (emission, transmission, immission) and of speech communication, these acoustical aspects make a good starting point for an objective description of residential environments. They could be included in the comprehensive notion of soundscapes.
In the judgment of specific noises the ambient sound always plays a role. The sound perceived in a certain position at a certain moment consists of a variety of partial sounds, produced by several sources. When assessing a specific, distinguishable sound (music from a bar, for example) this sound makes up the

"foreground", while all other sounds are the background. The soundscape can be defined as the total mix of sounds, including or excluding the foreground sound.
This paper addresses some aspects of soundscapes in relation to the perception and mapping of home. In particular attention will be given to orientation, speech communication and speech privacy. From the large amount of knowledge on hearing, and the propagation of sound it is possible to extract a few rather simple tools for implementation of these matters into urban design. The tools as presented are not adapted yet to specific wishes from the field of urbanists, so any comment in that respect is welcome. More tools will have to be developed, to be able to give a more accurate description of the appreciation of sounds in the residential environment.

2 Soundscapes

Originally the term "soundscapes" was used as a description of the natural sonic environment. Quoting the Canadian composer R.M. Schafer in the 1968 World Soundscape Project: *"The soundscape of the world is changing. Modern man is beginning to inhabit a world with an acoustic environment radically different from any he has hitherto known…"*. In principle soundscapes describe the perception of natural environmental sound/noise as such in parks and cities, as Meijdam (1989, 2000) did. Sound sources can act as sonic land marks ("soundmarks"); they help inhabitants and visitors in their sense of direction, wittingly or unwittingly. The character of neighbourhoods consists not only of the visible elements; the characteristic sounds are just as important, being less prominent, more subconscious. Think of church bells, factory whistles, railroad crossings, ships and many other sounds. In practical cases a mix of sounds will be present, with different characteristics: spectrum, levels, time history, pleasantness, etc. The soundscapes or the sound sources can be categorized in several ways:

- Continuous (traffic)
- Variable:
    - Periodic (church clock)
    - fixed times (school bells)
    - dependant on weather (wind)
    - incidental (street organ)

or, by type of source:

- nature (waterfall, animals, wind)
- mechanical (traffic, industry, carillon, Harley Davidson)
- human (talking, singing, laughing)
    - children (school area, play ground)

Last, a functional, albeit very subjective description can be given, which could be different for different groups of people (residents, visitors, workers, tourists):

- pleasant
- neutral
- annoying
- frightening

In the mix of sounds in the soundscape, many different characteristics may occur. Each of the distinguishable sounds can be taken as "foreground" (in focus); the others then act as "background". Neutral sounds, hardly recognizable, can be very useful to mask other, more intruding sounds, such as the neighbour's conversation. Annoying and frightening sounds should be minimized, of course. In section 3 the (positive) use of neutral or pleasant sounds is illustrated.

As an extension to merely describing a sonic environment, soundscapes can be manipulated, and even composed as a form of art. Generalizing even more, the notion of "scapes" is introduced: there can be as many scapes as there are senses. Next to the well-known landscape, soundscape and smellscape are used; here the subjective element is dominant.

Resuming, roughly three types of soundscape can be distinguished:

- Natural soundscape (animals, traffic, human activity, fountains, bells etc.)
- Enhanced soundscape: addition of soundmarks, reinforcement of natural soundscape

- Artificial soundscape as an art form

In this paper the focus is on natural soundscape and its enhancement. Because description and communication of acoustical aspects of neighbourhoods is not easy, tools are required to make this subject manageable in urban planning. A number of tentative tools are presented; they are by no means completely finished, but act as examples for possible further development. The making of comparable tools in a somewhat different context is treated in the author's dissertation (Ruiter, 2004). Further research could be directed at the analysis of soundscapes, their perception and the relationship between characteristics of soundscapes and perception. Schulte (2001) indicates the need for a clear definition of soundscapes, in particular in relation to annoyance; as stated before, soundscapes should better be interpreted in a much wider sense than annoyance alone.

3 Tools

3.1 Orientation

Sound sources like carillons can be audible in large areas of a city. They contribute to a feeling of "home" for the people used to its sound, and to the character of the city for others, and to orientation for all. Carillons and church bells are often placed in towers, sometimes of considerable height. The first advantage is clear: the sound can easily spread over the city. Secondly, very high sound levels at short distance of the source are avoided: even at horizontal distance nil, the slanting distance remains. In Figure 1 this is illustrated for a rather loud source (100 dB(A) at 1 m distance). The reception positions are assumed in free field, with unobstructed view upon the source. If the source is placed at street level (2 m), sound levels are unacceptably high at short distances. For an elevation of 50 m the sound level at 5 m distance is 20 dB lower and is almost constant over the first 50 m horizontal distance.
This kind of calculations has surely not been the motivation for the building of church towers, but it demonstrates the correctness of the choice for high objects. Creating sound marks should take this into account: elevated sound sources are preferred.

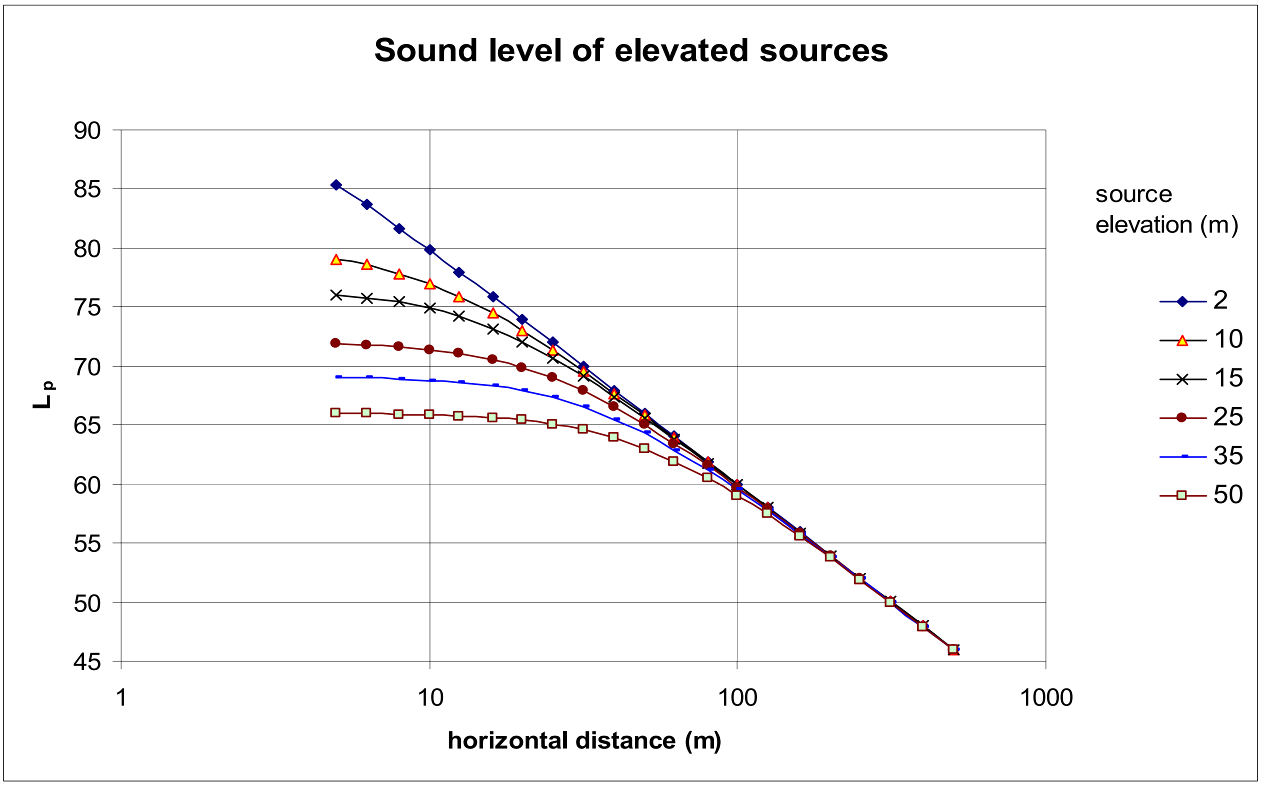

Figure 1 Sound level as a function of horizontal distance to an elevated source.

To act as a sound mark, the sound should be audible continuously or at least frequently. Undoubtedly the spectrum of the source is important as well; specific research results lacking, one would expect a mix of low frequencies (diffracting easily around buildings, important when direct view is obstructed) and high frequencies (for easy determination of direction) would be optimal. Many church bells fulfill this condition.

3.2 Speech communication

Sojourn in a park sometimes is an individual activity, often however communication between the members of a (small) group is desired, and privacy (see 3.3) from others at the same time. If ambient noise hampers communication, for instance neighbours chatting "over the hedge" or at the front doors, a negative effect on the social structure of a neighbourhood results. Walkways or bicycle paths along a busy road can suffer from the traffic noise, impeding communication of pedestrians and bicyclists. These elements of speech communication are well understood, and can be described objectively, even predicted.
Speech communication between people has always been regarded very important. The intelligibility of speech has been the subject of extensive acoustical research. In distinct cases in practice, intelligibility of speech depends on many factors:

- The loudness, rate and articulation of speech
- The visibility of the speaker
- The clarity of the message
- The familiarity of the receiver with the message
- Ambient noise
- Sound transmission from speaker to receiver
- Reverberation and echoes
- Hearing capacity of the receiver

In general the specific factors of the message and the speaker are replaced by average or normal values; a normally hearing receiver is supposed. In the most frequent and (fortunately) most simple case, only the influence of ambient noise is regarded. In ISO 9921-1 (1996) the Speech Interference Level *SIL* is introduced to characterise the ambient noise. It is the algebraic mean of the sound levels in the octave bands of 500, 1000, 2000 and 4000 Hz. In Figure 2 the limits for speech communication are given: for a given combination of ambient noise in *SIL*, and a certain vocal effort of the speaker, the maximum distance between the interlocutors can be read.

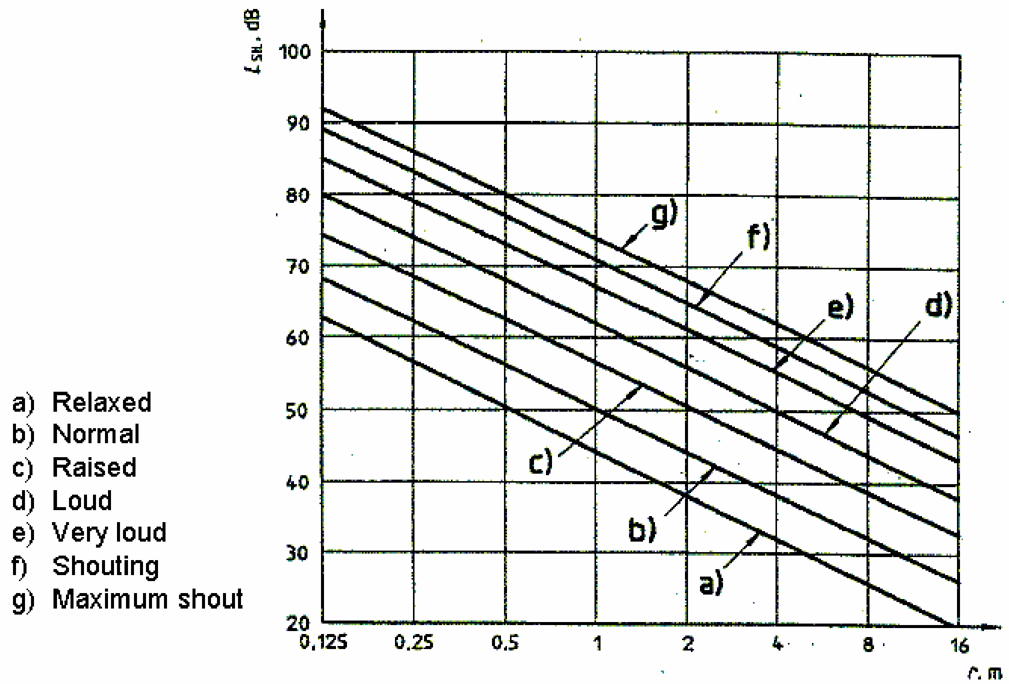

Figure 2. Speech communication limits; conversation is possible with given vocal effort (a-g) at distance *r* in ambient noise level L_{SIL}.

If we take as a starting point, that communication between speakers at 1 m distance should be possible at normal speech volume, a value of *SIL*= 50 dB should not be exceeded. This criterion could be applied to walking and sitting areas in parks, front doors of dwellings, and many other places.
For paths (pedestrians, cyclists) along roads this condition is often violated. To prevent this, the distance between those paths and any urban road should be large enough. For a standardised situation a fixed value can be calculated, dependant on the traffic flow; roughly this distance should be:

$$D = F/200 \quad [1]$$

where
D= distance to axis of road in meters
F= traffic flow in motor vehicles per 24 hours

If screens or shields are inserted shorter distances are acceptable, of course. The calculation of the effect of screens will not be addressed here.

3.3 Speech privacy

In some countries it is compulsory that dwellings have exterior spaces (gardens, balconies, or loggias); in most cases it is desirable to have the opportunity for inhabitants to expose themselves to the open air on their own premises. Other aspects of exterior spaces embrace solar orientation (sun or shadow), dimensions, view, privacy (visual, auditive). One important element of this is the possibility to choose, for example between sun and shadow, communication with the neighbours or not.
In common practice, most of these factors, especially the visual ones, can be taken into account by existing design and drawing tools. The well-known architectural encyclopaedia by Neufert (2000) dedicates one page to balconies, and several remarks to (visual) privacy:
"Corner balconies offer privacy and good shelter and are therefore preferable to open balconies." [The German original edition by the way has *Sichtschutz* instead of *privacy*.]
"Balconies which are offset in their elevation can make façades less severe but it is difficult to provide privacy and protection from the weather and sun".
"Balconies which are offset in their plan layout on the other hand offer excellent privacy and shelter." [Here *privacy* is the translation of *Schutz gegen Einsicht*.]
Privacy is mentioned by Menzel (1989) as one of the leading principles in the design of the much-discussed high-rise district Bijlmermeer of Amsterdam-South-East; the context shows that attention focuses on the visual and social elements. "*In medium high-rise not everyone has his own garden. (…) For compensation a maximum degree of privacy must be pursued. Maximising the distance between the blocks is tried to achieve this.*" [Du Laing, cited by Menzel]. The aspect of auditive (or speech) privacy has received little attention until now, which can partly be explained by the absence of appropriate tools to assess the degree of speech privacy.
Noise annoyance surveys show high numbers of people annoyed by neighbour noise. Dongen et al. (1998) give (Dutch) noise response functions for neighbour noise. Generally no distinction is made between noise annoyance experienced in the home and in the exterior spaces, and the last element is usually neglected. Consequently only conclusions are drawn regarding the sound reduction between dwellings. There is however reason to assume that noise annoyance in exterior spaces, caused by conversation of neighbours plays a part as well. The intelligibility of this conversation is perceived as a violation of privacy, and therefore annoying. But privacy has a second, passive component: it concerns *hearing*, but also *being heard*; *seeing* and *being seen*, maybe even *smelling* and *being smelt*. Regarding the acoustical aspect an indicator is proposed, called the *Required Masking Noise Level*, L_{mn}, based on the notion of speech privacy.

3.3.1 The masking noise level required for speech privacy

From the mix of sounds in the soundscape, in this case focus is set on human conversation and all other sounds are regarded as background or ambient noise. Human speech is a very special kind of sound. If it is received by the persons it was meant for, communication is realised. Speech reaching ears of non-intended receivers however can be very intruding, and therefore annoying to those receivers, in particular if it is intelligible; secondly, the fact that the message is picked up by a third party violates the intimacy of the conversation. Especially in the last case speech privacy is said to be insufficient. Speech privacy can be described as the degree in which conversation (in an adjacent room) cannot be overheard. It can be defined as a quantitative notion that is commonly used to derive requirements for the sound insulation of partition walls, in offices, hospitals etc. The base of this concept is: masking of the speech signal by background noise. This can be expressed in a simple form in the formula:

$$SP = L_m + D - L_s - P \qquad [2]$$

where:
SP = measure for speech privacy
L_s = vocal output of the speaker (L_p at 1m distance, A-weighted)
D = sound attenuation from talker (1 m distance) to listener (ear position)
L_m = masking sound level at the listener's position (A-weighted)
P = weighting term; see under.

In the weighting term P the degree of confidentiality and other non-acoustical influences can be taken into account. In general, the value of P ranges from 5 to 10 dB. For positive values of SP the speech privacy is said to be sufficient; for negative values complaints are to be expected.
If the masking sound level L_m is not constant, the minimum sound level should be taken (e.g. the 95%-level L_{95}, the sound level that is exceeded for 95% of the time) and not the equivalent sound level, because "masking" implies continuity.

Consider a multifamily building, each apartment having a balcony. For pairs of source (talker) and receiver (listener) position on balconies next to or above each other the speech privacy SP can be calculated. Assumptions must be made with regard to speech effort (typical level 60 dB(A) at 1 m distance), and the weighting term P; here P = 10 is taken. The other terms are variables, describing the environment: the background noise and attenuation. In other words, assuming certain standard values for speech volume a relationship should exist between background noise level and the sound attenuation between neighbours. From this, for each instance the background noise level L_{mn} required to mask the speech signal can be calculated. This level L_{mn} can be used as an indicator for (an important aspect of) the quality of the urban design.

$$L_{mn} = 70 - D \qquad [3]$$

D is the sound attenuation from talker (1 m distance) to listener (ear position).

It must be emphasised that L_{mn} is a notional sound level, determined by architectural properties. L_{mn} can be calculated from these architectural data or measured in the field or in a mock-up.
For all pairs of source and receiver positions calculations can be made of the resulting sound attenuation, and so for the required masking noise level L_{mn}. For each (receiver) position, only the highest value of L_{mn} is important.
Low values of L_{mn} indicate good speech privacy, e.g. 30 dB(A) or below. This level of background noise is almost always exceeded by the traffic noise in the atrium and natural sounds.
Higher values of L_{mn} are no problem as long as the background noise at the receiver position meets the same levels. In general an equivalent sound level of 50 dB(A) is regarded as (still) acceptable; corresponding L_{95} values will be in the range of 40-45 dB(A). When the required value L_{mn} exceeds 55 dB(A) a dilemma arises: if the masking sound is "sufficient " it will become disturbing itself, otherwise speech privacy is insufficient. This indicates that the design of the balconies and the building should be improved, by increasing distance or shielding, or by reducing reflections.

The values of the required masking noise level can be judged as shown in Table 1.

Required masking noise level L_{mn}.	Assessment
30 dB(A)	Very good
35	Good
40	Reasonable
45	Average
50	Insufficient
55	Poor

Table 1. Rating of the required masking noise level L_{mn}.

3.3.2 Use of the Required Masking Noise Level

It must be emphasised that the Required Masking Noise Level is a notional quantity, dependent only on the architectural properties of the exterior spaces and their relationship. As such, it can be used as a target value, e.g.: "the value of L_{mn} shall not exceed 45 dB(A) in project Y". The target value to use will depend on the practical possibilities, and on the ambient sound level present or expected in the area of interest, i.c. on the façades of the dwellings.

The aspects speech privacy and (traffic) noise annoyance each define a noise limit. The limit for noise annoyance is set at L_{amb} = 55 dB(A); the bold horizontal line in Figure 3 should not be exceeded. At the same time, L_{mn} should be smaller than L_{amb} , to insure sufficient speech privacy; this is expressed in the inclined line. If both limits are taken together a triangular area in the graph results, designated with a plus sign, where both requirements are met. In the upper part of the graph, ambient noise is annoying; in the lower right hand part (at the right from the inclined line) speech privacy is insufficient, both areas being designated with a minus sign.

Low ambient sound levels are favourable, but demand more attention for speech privacy. In general this can be achieved by increasing the sound attenuation between speaker and listener or more specific: increasing distance, making effective noise barriers (closed fences or wind screens) between balconies or gardens and suppressing the relevant sound reflections, for example by sound absorptive treating of walls (dense vegetation like ivy), or balcony ceilings.

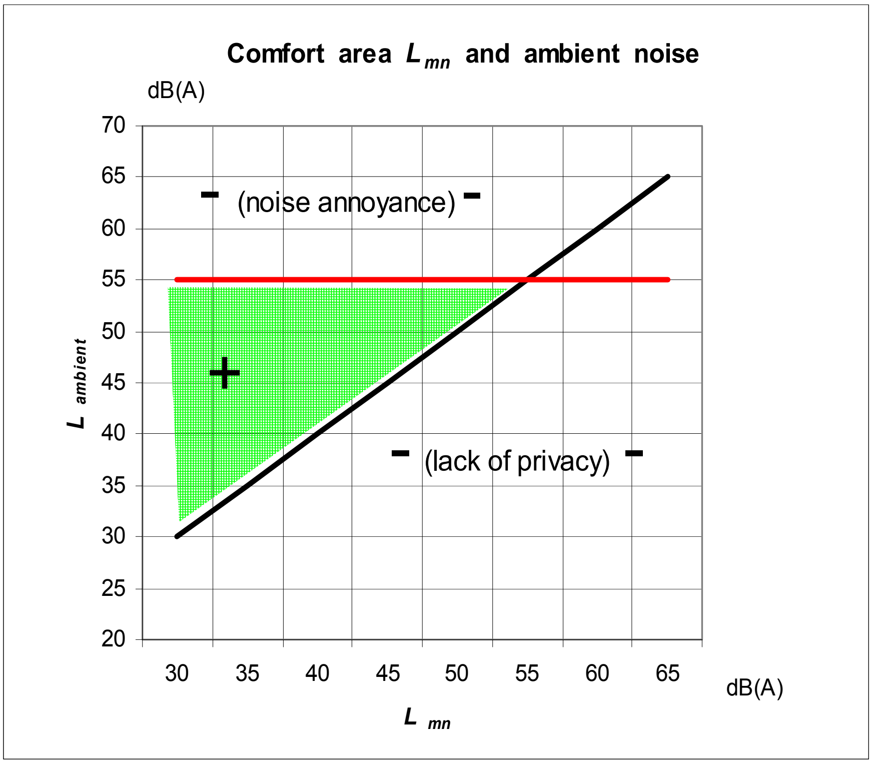

Figure 3. Comfort area (+) for the combined aspects of noise annoyance (ambient sound level) and speech privacy (required masking noise level).

4 Conclusion

Soundscapes, interpreted in a wide sense, embrace the subjective description of the acoustical environment as well as orientation, speech privacy and speech communication. They play certainly a significant role in the mental geography of residential environments, but seem difficult to manage. Where the visual aspects are easily recorded and communicated by means of photography and sketches, sound remains too volatile for many urban designers. The result is that soundscapes are often treated step motherly. To facilitate a more mature approach tools are necessary that can be used by non-acousticians. In this paper some examples of tools were presented.

Not all knowledge required to construct the necessary tools is available yet. Research into the comprehensive soundscapes and their effects on residents (and visitors) is required.

The fact that tools are feasible and useful in one discipline (acoustics) might hopefully induce research in and between other disciplines into the development and application of similar tools too.

5 Reference list

Dongen, J.E.F. van, H. Vos, L.C.J. van Luxemburg, T.M.J. Raijmakers (1998). *Dosis-effect relaties voor geluid van buren [Response functions for neighbour's noise]*. Ministerie VROM/DGM Publikatiereeks Verstoring nr 2.[in Dutch]

ISO 9921-1 (1996). International Standard, *Ergonomic assessment of speech communication – part 1*. International Organization for Standardization. 1996.

Meijdam, J.C. (1989). *Stadsgeluid anders bekeken (A different view upon city sounds)*. OSPA report TU Delft, Faculty of Architecture, June 1989 [in Dutch]

Meijdam, J.C. (2000). *Akoestische kwaliteit (Acoustical quality)*. GELUID nr 3, July 2000 [in Dutch]

Menzel, M.A. (1989).*Bijlmermeer, grensverleggend ideaal [Bijlmermeer, innovative ideal]*. dissertation Delft University Press, Delft. The Netherlands (in Dutch)

Neufert , E. and P. (2000). *Architects' Data Third Edition*. Blackwell Science. Oxford.

Ruiter, E.Ph.J. de (2004). *Reclaiming land from urban traffic noise impact zones, "The great canyon"*. (ISBN 90 9018 656-5). Zoetermeer 2004, also available at www.library.tudelft.nl/dissertations

Schulte-Fortkamp, B. (2001). *Accepting the soundscape- does it influence the noise annoyance?* Inter-Noise 2001. The Hague, The Netherlands.