MADRID
inter.noise 2019
June 16 - 19
NOISE CONTROL FOR A BETTER ENVIRONMENT

Combination of Noise from different Sources – an Overview

Eggers, Sebastian[1]
LÄRMKONTOR GmbH
Altonaer Poststraße 13b
22767 Hamburg

Popp, Christian[2]
LÄRMKONTOR GmbH
Altonaer Poststraße 13b
22767 Hamburg

ABSTRACT

The combination of noise from different sources is repeatedly subject of research in noise annoyance. Besides research, the summation of noise from different sources seems to be not a common topic. For example, in the European Environmental Noise Directive (END) a combination of noise from different sources is only mentioned once as a possible "supplementary noise indicator". For the END, noise maps are considered to be published separated by the source of noise. However, the perception of noise among the population is affected by a combination of all relevant noise sources and thus a mapping of the overall noise level seems to be called for.

Keywords: Noise, Combination, Annoyance
I-INCE Classification of Subject Number: 60, 61, 70

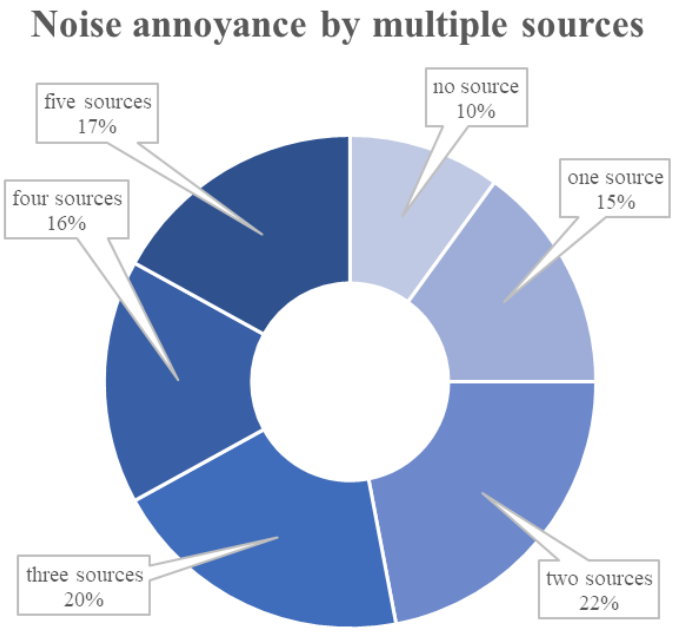
1. INTRODUCTION

Noise sensitive areas, in particular residential areas in urban areas are often affected by several sources of traffic noise at the same time. This is the case, for instance, when they are located at a point where a street and rails cross and, in addition to that, within the entry lane of an airport. In addition to traffic noise, other noise sources may also be of relevant influence. Besides commercial and industrial noise also noise from leisure and sport activities may contribute to the overall noise level.

[1] s.eggers@laermkontor.de
[2] c.popp@laermkontor.de

2. ISSUES OF NOISE FROM DIFFERENT SOURCES

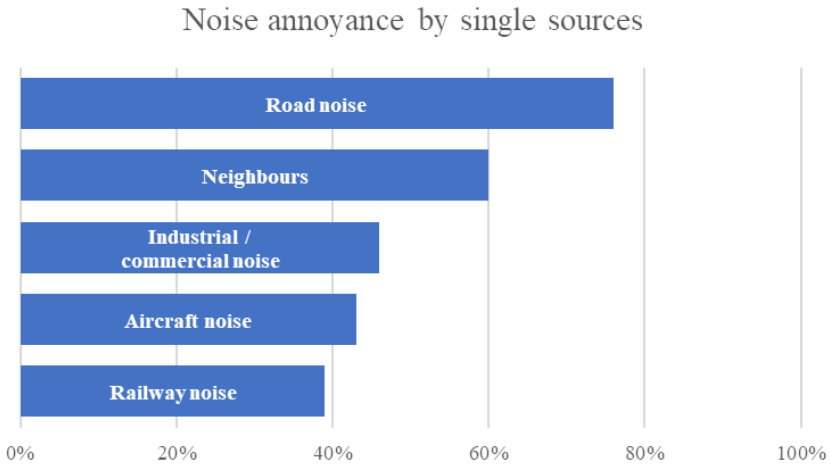
Surveys concluded by the Federal German Environmental Agency (Umweltbundesamt, UBA) show that most of the people are disturbed by two or more noise source. The results of the survey for the year 2016 [1] show that only 25 % are affected by no or only one noise source, 22 % are affected by two noise sources, 53 % by three or more (see Figure 1).



Data:
Umweltbewusstsein in Deutschland 2016, Umweltbundesamt

Figure 1: Noise annoyance by multiple noise sources (data from [1])

The results for each single noise source, with multiple choice possible, show, that road traffic is the most dominating noise source with 76 % of the people annoyed at least a little (see Figure 2).



Data:
Umweltbewusstsein in Deutschland 2016, Umweltbundesamt

Figure 2: Noise annoyance by single sources (data from [1])

3. DIFFERENT LEGISLATION

Legislation on noise differs vastly among different countries, even for European countries which have the environmental noise directive as a common base for national noise assessment.

As for Germany as an example, noise is assessed based on the noise source. The legislation distinguishes for example road and rail traffic noise (same limit values but different calculation methods), aircraft noise, industrial and commercial noise, noise from sports activities and noise from leisure activities. An overview can be found in [2].

Besides limit values, the german DIN 18005 [3] offers so called "Orientierungswerte" – orientation values – which are to be considered e.g. in urban planning. However, these orientation values apply only for a single type of noise source, traffic or industrial/commercial noise. Noise limits or orientation values for an overall noise assessment are not mentioned in national legislation.

However, in jurisdiction a limit of 70 dB(A) during daytime and 60 dB(A) during night time was established as a limit to "potential health risks". In February 2019, six researchers of noise effects from Germany, Austria and Switzerland signed a memorandum [4] stating that limits of 65 dB(A) / 55 dB(A) should be aimed for as a step towards the even lower limits of the WHO. Although these limits should apply to traffic noise, as the industrial/commercial noise has much lower noise limits, these virtually apply as overall noise limits.

4. COMBINATION OF NOISE SOURCES

A combination of noise sources aiming for a common assessment requires a practical way to merge the noise levels into singular values. Several methods exist, these can be summarized e.g. to three basic groups:

- energetic addition
- energetic addition with adaption values
- based on dose-response relations

4.1 Energetic addition

The maybe simplest method is the energetic addition of different noise levels. However, as the calculation methods not only differ in the determination of emissions but in some cases also in the transmission, the results always have an additional uncertainty deriving just from the different fundamentals. In addition, taking the German legislation and computation methods as an example, not only the computation but also the assessment differs strongly, especially regarding the time periods (with or without rest times, average for night time or loudest hour during night time) or increments (e.g. for rest times or times with higher noise sensitivity).

4.2 Energetic addition with adaption values

To take different annoyance, adaption values can be used. These are a static form of correction of noise values, e.g. based on perceived noise annoyance, spectral, tonal (impulsiveness or prominence of individual tones) or temporal characteristics. Adaption values were used in Germany (so called “Schienebonus”) for rail traffic noise (-5 dB) until 2015 (2018 for tram ways). In Austria, adaption values apply for facilities (commercial/industrial/recreational…) and construction noise (+5 dB) as well as railway noise (-5 dB) [5].

4.3 Addition based on dose-response relations

Throughout research, the dose–response functions for road, rail and aircrafts are distinctly different. These differences are not constant, as the dose–response functions are different (and not only shifted sideways). Therefore, it is in general not possible to get an impression of the total noise annoyance by simply adding the two noise sources together.

In 2004, Miedema [6] investigated the relationship between exposure to noise from multiple sources and the total annoyance. Different methods were evaluated and a so-called noise annoyance equivalents model was suggested. Using the known dose–response curves for railway noise and road noise, it is possible to add the two noise sources together. The method can also be used for other noise sources if the dose–response curves of the current noise types are known.

This method is also the basis for the German VDI 3722-2 [7]. It constitutes a pragmatic method that defines a standardized set of criteria for different sources based on a comparative value for the assessment of the local noise situation.

The method is used to calculate an appropriate sum level including all sounds (road, rail, aircraft). As a first step, the noise load for every type of noise source is determined using common calculation methods. Afterwards, the source-specific loads are normalized to the impairment value of street traffic noise (‘substitute level’). That way, a comparable level is created for each source of noise.

An example for the method basically involves the following steps (taken from [8]):

1. A residential building is affected through the sources street, rail and air traffic on the façade. The noise levels (corresponding to L_{den}) are calculated for each noise source:

   Road traffic noise: 60 dB
   Rail traffic noise: 65 dB
   Air traffic noise: 60 dB

2. The noise levels are used to determine the percentage of 'highly annoyed individuals' (% HA) for rail and air traffic. The following percentages are calculated based on the dose-response curves with the equations A5 and A6 of the VDI:

   Rail traffic: 8.6 % HA
   Air traffic: 17.5 % HA

3. These source-specific percentages for % HA are used to calculate the 'renormalised substitute level' related to road traffic noise (see VDI 3722-2 [42]). The substitute level value is the result of a correction of the determined value for % HA through the sources rail and air traffic on the road traffic value. By creating the relation to street traffic noise, it is possible to generate a comparable impairment value. The mentioned values presented in the example generate the following renormalised substitute levels according to equation A8 from the VDI:

   Rail traffic: 57.9 dB
   Air traffic: 66.4 dB

4. The two renormalised substitute levels for rail and air traffic in energetic addition with the original rating level for road traffic (60 dB) create a comparable value for the total load:

   Substitute level: 60.0 dB + 57.9 dB + 66.4 dB = 67.8 dB

5. The determined effect-related substitute level provides the basis from which to derive the % HA according to the rating function for road traffic noise. This makes it possible to generate a conclusion regarding the 'highly annoyed individuals' through multiple exposures based on the dose-effect graph of street noise:

   Overall % HA: 20.6 % HA

The VDI 3722-2 states that the calculated substitute level may not be used for other purposes than the calculation of the overall noise annoyance. The substitute level is a plain intermediate result to link the different levels of noise annoyance and is no declaration of an equivalent noise level etc.

4. REAL LIFE SCENARIO

For the city of Rostock (about 208.000 inhabitants) a combined noise map was compiled for orientation in planning processes. As noise sources, traffic (rail, tram, road, ships) and commercial noise (industrial, commercial, harbour, shunting yard) was considered. Not taken into account was noise from sports and leisure activities.

The data for road and rail traffic was derived from the environmental noise mapping with an addition of roads down to about 3.000 vehicles per day in average. In addition to industrial noise according to the IED, commercial and industrial areas were considered with their possible emissions according to urban planning.

As a result, noise levels were calculated for each source. The combination was carried out with an energetic addition, the methods of the VDI 3722-2 could not be applied as no dose-response curves for commercial noise are implemented (yet). In addition to the overall noise level, two noise levels were calculated for the groups of traffic and commercial noise.

The evaluation of the results shows that noise conflicts are more present during night time. Noise levels close to the limits of health risks are only anticipated close to major traffic ways. Although far below these limits, during the night time the commercial noise is also affecting large areas.

A comparison (fig. 3) shows, that only small areas show a relevant deviation between the noise level of the dominating source group (hatched areas) to the addition of all sources (solid areas).

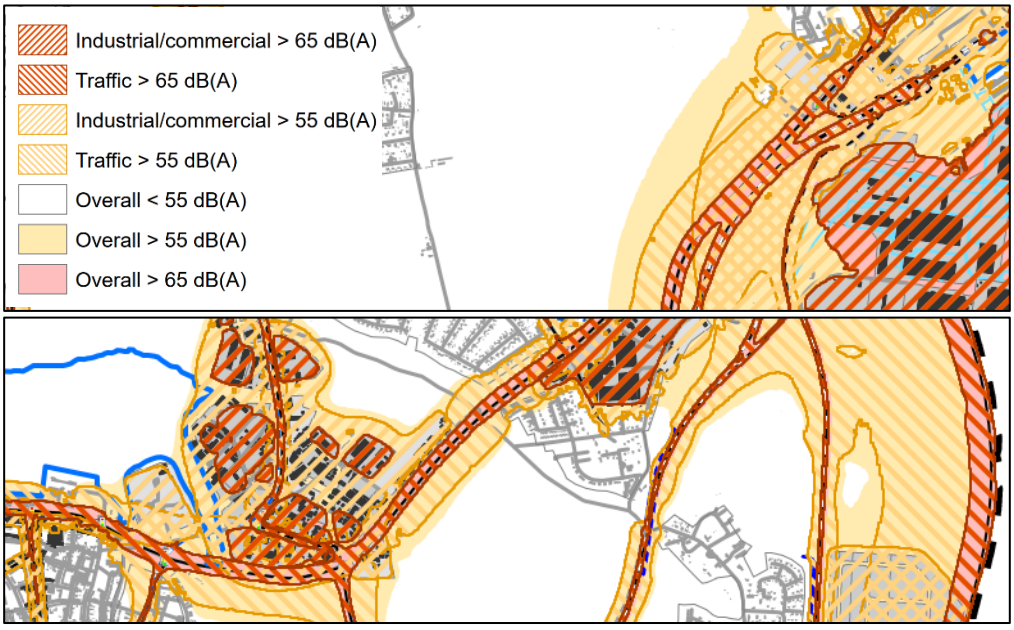


Figure 3: Examples from an orienting overall noise map

5. CONCLUSION

As surveys on noise annoyance point out, noise from multiple sources is an important issue. For the combination of noise levels, no uniform methods exist. The methods available range from simplified methods (energetic addition), also in combination with adaption values, to methods taking dose-response curves for noise annoyance as a foundation of assessment.

The mapping of noise sources for a city showed that noise from different sources seems not to be an issue when taking common noise limits into account. Thus, noise annoyance by multiple sources seems to be arising even on comparatively low noise levels. However, noise annoyance research is mainly focused on singular noise sources, a systematic review [9] found no research focusing on more than two sources.

6. REFERENCES

1. *"*Umweltbewusstsein in Deutschland 2016 – Ergebnisse einer repräsentativen Bevölkerungsumfrage*"*, Umweltbundesamt (2017)
https://www.umweltbundesamt.de/publikationen/umweltbewusstsein-in-deutschland-2016

2. "Übersicht – Grenz-, Richt- und Orientierungswerte im Bereich des Schutzes vor Lärm", LÄRMKONTOR GmbH (2018)
http://www.laermkontor.de/pdf/Faltblatt_Grenzwert.pdf

3. DIN 18005-1:2002-07, "Noise abatement in town planning - Part 1: Fundamentals and directions for planning" (2002)

4. Ministry of Transport Baden-Württemberg, Memorandum "Lärm und seine Auswirkungen auf die Gesundheit", ("Noise and its effects on health"), Stuttgart, February 2019 (2019)

5. ÖAL-Richtlinie Nr. 3 Blatt 1 – Beurteilung von Schallimmissonen im Nachbarschaftsbereich, Ausgabe 2008-03-01 (2008)

6. Miedema H.M., *"*Relationship between exposure to multiple noise sources and noise annoyance*"*, J. Acoust Soc Am. 2004 Aug;116(2) (2014)

7. VDI 3722 Part 2, *"Effects of traffic noise – Characteristic quantities in case of impact of multiple sources", Verein Deutscher Ingenieure (2013)*

8. Bendtsen et al., "ON-AIR – Optimised Noise Assessment and Management Guidance for National Roads – Guidance Book on the Integration of Noise in Road Planning" (2015)

9. Guski et al. 2017, "WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Annoyance" (2017)