

## **Road traffic noise control based on maximum noise levels and individual vehicle emissions**

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### **Abstract**

Dose-response relationships for road traffic noise exposure and the extent of annoyance are reviewed with focus on the maximum noise levels. Measurements from different streets with typical city traffic are evaluated, using the maximum noise from individual vehicles as the dose descriptor and a basis for possible reductions in the extent of annoyance. Suggestions for actions to improve noise control and decrease the extent of annoyance are presented.

### **Introduction**

Disturbance by noise is an important environmental consequence of the transportation apparatus and affects a large number of people, particularly those living in built-up areas but also those who live in quiet, rural areas where even a small number of vehicles might alter the experience of the environment. In an EC commission proposal, a goal is set to protect the EU public against unwanted noise through a Directive on the Assessment and Management of Environmental Noise (AMEN) [500PC0468]. A knowledge about the risks involved and the major acoustical determinants for noise effects on humans are prerequisites for valid noise control strategies.

A major effect of transportation noise is the development of annoyance in the exposed populations. Annoyance has been defined as a "feeling of displeasure associated with any agent or condition realised or believed by an individual or a group to be adversely affecting them" [Borsky 1972]. Important components of the effects causing annoyance are interference with ongoing activities and sleep disturbance [Öhrström and Rylander 1982].

This presentation will review the basis for control of road traffic noise in view of the relation between noise levels and the extent of annoyance in exposed populations. A model for

improved noise control will be presented and illustrated with examples from areas with different road traffic noise characteristics.

### **Dose-response relationships**

The effect of an agent on the environment or on man can be described using dose-response relationships. The establishment of good dose-response relationships is a prerequisite for adequate standards to protect the population from unwanted effects.

Sound is an example of a so called hormesis dose-response relationship. This implies that small doses are beneficial and unwanted effects do not appear till the exposure exceeds a certain limit. Because of the complex action of sounds on humans involving several cerebral centres [review in Rylander 2004], the dose-response relationships to different kinds of noises are complicated and cannot be dealt with in detail in this context.

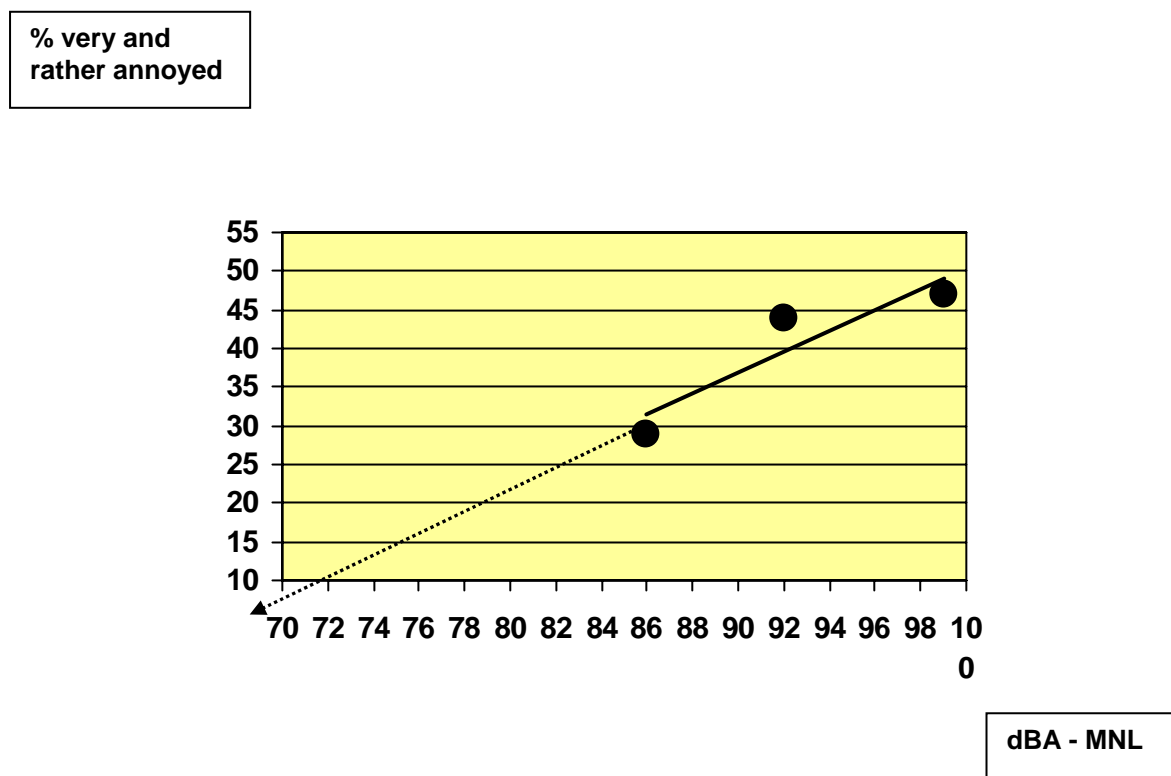
Focussing on transportation noises and simplistic acoustical descriptors of the dose, the dBA level has been universally accepted as the standard measure for exposure. For certain environmental noises such as those with low frequency content, this unit is not adequate [Persson *et al* 2001] but for road traffic noise in general it is an acceptable unit.

For road traffic noise, the dBA noise exposure is usually expressed as the average value over a certain time period, such as 24 hours, and a number of studies have reported dose-response relationships [Schultz 1978]. Other studies have, however, focused on the individual components of the noise and treated the number of events and the noise levels as separate variables. The first of such studies concerned aircraft noise [Rylander *et al* 1972, Björkman *et al* 1992]. The main result was that with an increase in the number of events (overflights), there was an increased extent of annoyance but only up to a certain number. Above this a further increase in the number caused no further increase in the extent of annoyance. At each number of events, the extent of annoyance was determined by the highest noise level from an individual aircraft, designed as the maximum noise level (MNL).

In spite of considerable reluctance from the acoustical society to accept this principle, its validity has later been supported in other studies on aircraft noise [Rylander and Björkman 1997], road traffic noise [Rylander *et al* 1986] and noise from artillery shooting ranges [Rylander and Lundquist 1996].

An extensive study on road traffic noise, involving 1872 persons in 15 areas, comprised estimations of the individual noise dose, based on area levels and corrected for distance to the road and floor level of the flat or the house [Sato *et al* 1999]. There was a good relation between the  $L_{Aq}$  level and the extent of annoyance. If the exposure was expressed as the number of events, there was no relationship but if it was expressed as the dBA level from the noisiest event, there was also a good relationship. This implies that under the exposure conditions in the study, the noise level was the most important factor influencing the risk for annoyance.

The findings from this and the previous studies suggest that the use of the maximum noise level from individual vehicles (MNL) is a practical dose measure to express the extent of annoyance in populations exposed to transportation noises. With the data from the previously mentioned traffic noise study [Sato *et al* 1999], dose-response relationships based on MNL can be used to estimate the effect of actions to decrease noise exposure as illustrated in Figure 1.



**Figure 1. Relation between the extent of annoyance and road traffic noise exposure, expressed as maximum noise level (MNL). Dashed line is extrapolation from dose-response relationship in Sato *et al* 1999.**

As an example, reducing the maximum noise level from 90 to 80 dBA will decrease the extent of annoyance from 47 to 22 % very and rather annoyed. In the following the application of this model will be illustrated using data from noise measurements in city streets with different traffic characteristics.

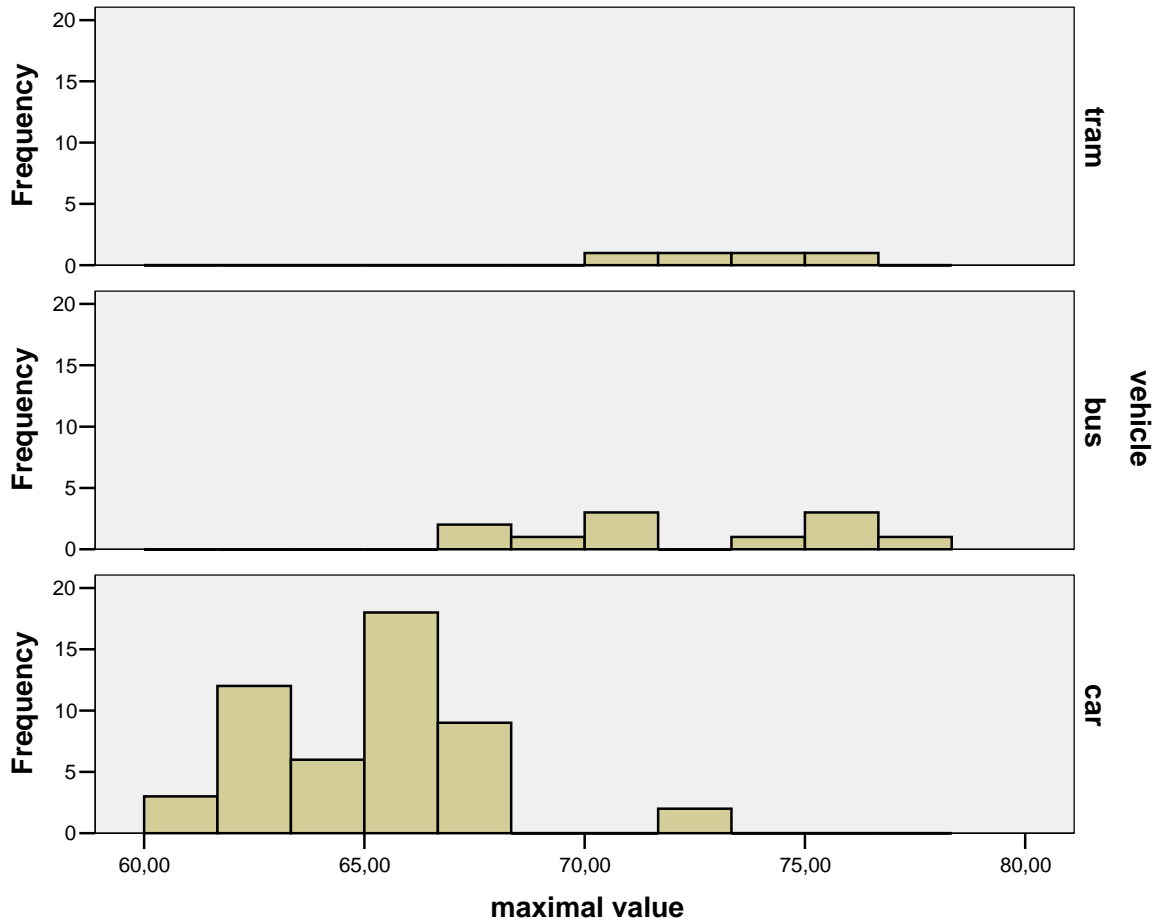
### **Material and methods**

Noise measurements were made in areas with different road traffic noise characteristics. The measurements in dBA were made with a Onsoke sound meter SM-6 at 2-3 meters from the curb side. The noise values were read and noted together with the vehicle type and notations on driving conditions if deviating from the normal. The data were recorded on the SPSS programme for statistical evaluations.

### **Results**

The results from all measurements showed that the noise levels ranged from 60 to 89 dBA for cars. There was an overrepresentation of lorries and motorcycles in the higher noise ranges which is not unexpected and agrees with earlier studies.

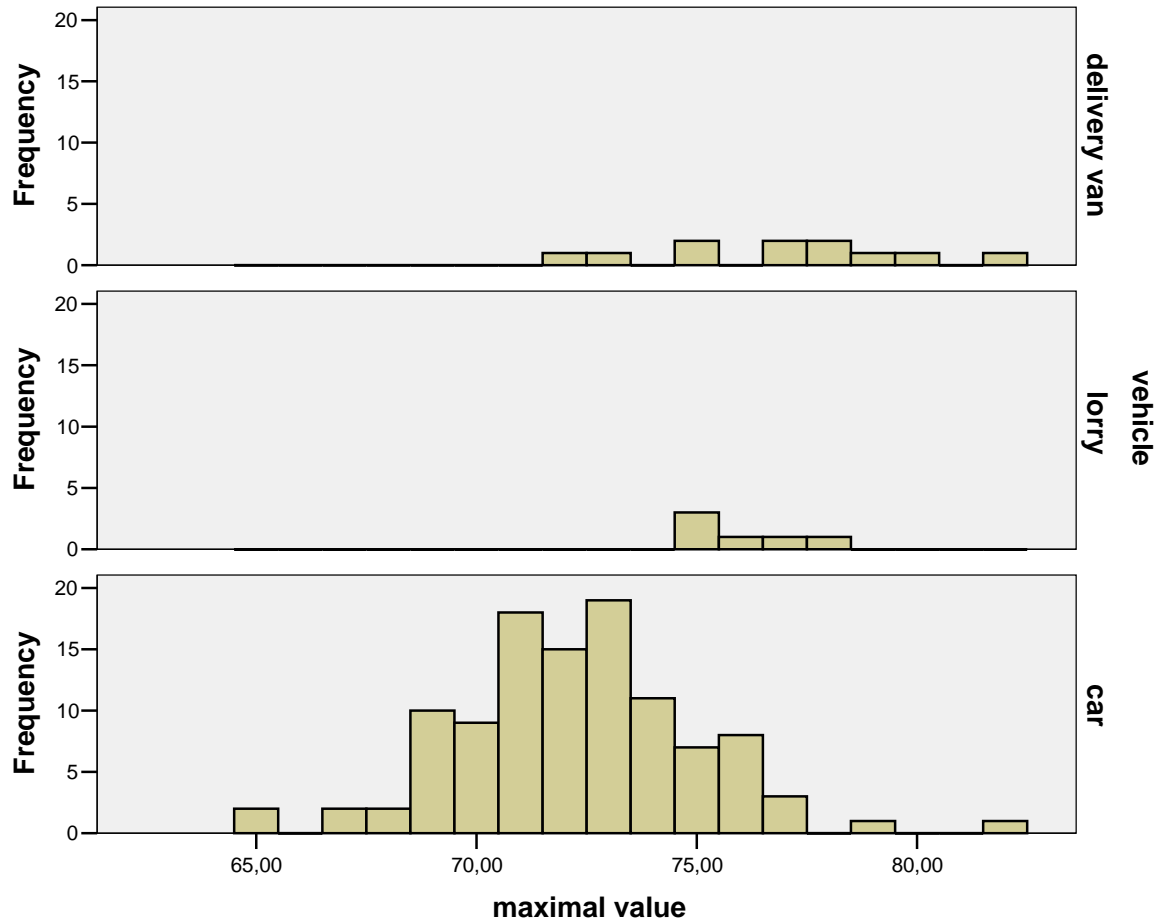
Figure 2 shows data from a city street with moderate traffic.



**Figure 2. Distribution of maximum noise levels (MNL) in a city street with moderate traffic and slow speed.**

It is seen that noise from trams and buses had the highest noise levels. The introduction of quieter trams and buses would reduce the MNL from about 78 to about 70 which means a reduction in the extent of annoyance from 19% to 5%, according to the dose-response relationship for MNL in Figure 1.

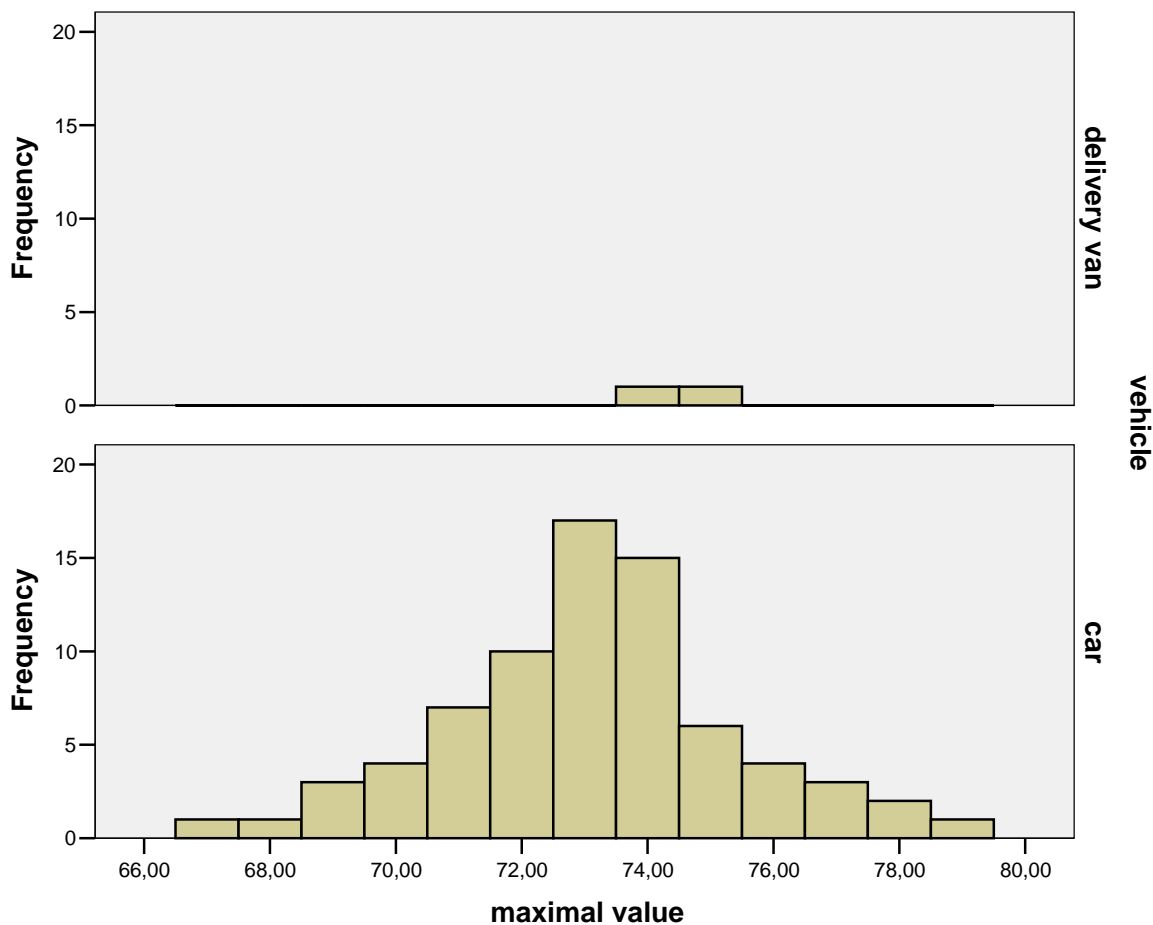
Figure 3 shows the data from a city street with moderate traffic.



**Figure 3. Distribution of maximum noise levels (MNL) in a city street with moderate traffic and high speed.**

At this site the delivery vans were responsible for the majority of noisy events. If these vehicles were quieter, the MNL would be reduced from about 80 to 75 and the extent of annoyance reduced from 22% to 14%. This requires, however, that there is also a reduction of the number of cars emitting high noise levels.

Figure 4 shows the road traffic noise in a suburban street with moderate traffic.



**Figure 4. Distribution of maximum noise levels (MNL) in a suburban street with moderate traffic and 50 km/h speed restriction..**

In comparison to the city street previously shown (figure 2), the noise levels from cars were higher (mean 73.1 vs 64.9). This is attributable to the lower speed in the city street as compared to the free flow and exceeding the speed limit in the suburban street. A decrease in MNL with further speed restrictions or better speed control would result in a decrease of annoyance from 10 to 0%.

### Comments

The data presented suggest that the maximum noise level can be used as a means to determine the extent of annoyance caused by transportation noises. The material is limited in the sense that the dose response relationship presented is based upon a single study but data from other investigations support the validity of the concept. There is also a lack of precise information on how the maximum noise levels should be defined. In a previous study on aircraft noise the definition was a levels exceeded three times per 24 hours [Björkman et

a/ 1992] but further work is required to arrive at a suitable definition of MNL for road traffic noise.

The examples from analysis of MNL from streets with different traffic characteristics illustrate various possibilities to reduce the noise exposure and thus the extent of annoyance. Different measures need to be applied depending on the character of the street and they range from speed restrictions to actions against certain kinds of vehicles. The model using MNL can also be used to predict the environmental consequences of new roads [Rylander and Dunt 1991].

A regulation of access to certain roads relating to noise emissions would also put a pressure on manufacturers of certain vehicles, in this presentation illustrated by buses and delivery vans, to undertake actions to decrease the noise emissions from their vehicles.

The results also suggest that the MNL concept could be applied for train noise. It is generally considered that this type of noise is less annoying than road traffic noise but certain data suggest the contrary [Moehler 1988]. The reason could be due to the difference between the  $L_{Aq}$  value, based on a relatively long duration of noise exposure and the MNL level. There is thus a need to further explore the application of the maximum noise principle also for this kind of transportation noise to provide an optimum protection for the population.

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