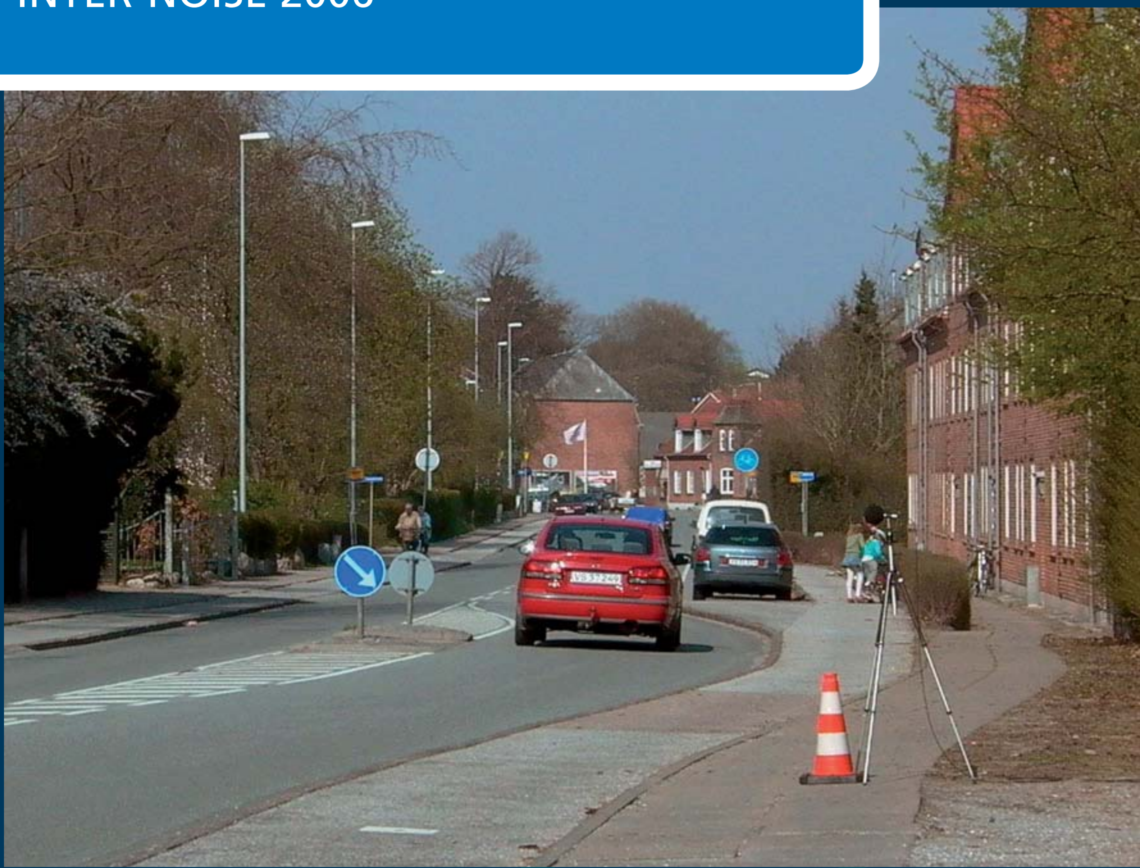
Traffic management and noise

-INTER-NOISE 2006



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Road Directorate
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Contents

Preface

This paper on traffic management and noise was presented by Hans Bendtsen at the Inter-noise conference in December 2006 in Honolulu, Hawaii, USA. The results presented in the paper are based on the work carried out in the EU research project *Sustainable Road Surfaces for Traffic Noise Control* called SILVIA. The paper presents the outcome of the work carried out by an international working group in task 5.3 of the SILVIA project. The main part of this work was to carry out a European literature survey on the relations between traffic management and noise. The working group had the following members:

- Jürgen Haberl, Vienna University of Technology (TUW), Austria.
- Ulf Sandberg, Transport Research Institute (VTI), Sweden.
- Greg Watts, Transportation Research Laboratory (TRL), United Kingdom.
- Hans Bendtsen, Road Directorate/Danish Road Institute.

Forord

Denne artikel om "traffic management" og støj blev præsenteret af Hans Bendtsen på Inter-noise konferencen i december 2006 i Honolulu, Hawaii, USA. Resultaterne der præsenteres i denne artikel er baseret på arbejde gennemført i EU´s forskningsprojekt "*Sustainable Road Surfaces for Traffic Noise Control"forkortet* SILVIA. Artiklen præsenterer arbejde udført af en international arbejdsgruppe i arbejdspakke 5.3 i SILVIA projektet. Hoveddelen af dette arbejde bestod i at gennemføre et internationalt litteraturstudie af relationer mellem "traffic management" og støj. Arbejdsgruppen havde følgende medlemmer:

- Jürgen Haberl, Teknisk Universitet i Wien (TUW), Østrig.
- Ulf Sandberg, Statens vej og transportforskningsinstitut, Sverige
- Greg Watts, Transportation Research Laboratory (TRL), England.
- Hans Bendtsen, Vejdirektoratet/Vejteknisk Institut (VI).

1. Introduction

This paper is produced on the background of the EU research project *Sustainable Road Surfaces for Traffic Noise Control* called SILVIA [1]. The paper presents the outcome of the work carried out by a working group in task 5.3 of the SILVIA project. The main part of this work was to carry out a European literature survey [2]. The objective for this was to investigate traffic management measures in order to highlight their capacity for noise control and to evaluate the possibilities and effects of combining traffic management measures with the use of noise reducing pavements especially in urban areas. The main objective was to describe recommendations for road administrators with respect to additional noise reducing measures. The ongoing EU project *Quieter Surface Transport in Urban Areas* called SILENCE [3] is among many subjects also focusing on traffic management and noise reductions.

Traffic management measures such as environmentally adapted "through" roads, 30 km/h zones, road humps, roundabouts, restrictions on traffic in special periods, speed control etc are used on many urban roads in Europe. These measures are usually applied to improve traffic safety, typically by reducing the speed, and to "calm" residential areas from the environmental impact caused by the traffic in order to make the areas more pleasant to live in for the residents and more agreeable to shop and walk in. The term "traffic management" can be described as an application of different strategies and measures to change the flow of traffic on roads in order to reduce the speed of vehicles passing by and/or to reduce the traffic volume itself. This will all have an effect on the environmental noise caused by vehicles.

The first part of the paper is focused on analyzing the relations between speed and noise. The effects of uneven driving patterns with accelerations and braking are included. This is analyzed on the background of prediction models like the Nordic Method [4] and the Harmonoise model [5] developed in an EU project. The second part of the paper contains the main results from the comprehensive European literature survey [2] where the task was to find and compile existing relevant knowledge on relations between traffic management and noise. On this background final results and recommendations are developed.

Rumble area with paving stones

Roundabout

Traffic calming by paving stones in the center of the road

Traffic calming by road narrowing

Road hump

Figure 1. Examples of different traffic management schemes from Denmark.

2. Speed and noise

2.1. Constant speed

There are some general relations between noise levels and traffic volume, the percentage of heavy vehicles as well as the speed which are integrated in the different national methods for noise prediction. These relations can be seen in Table 1 to 3 for situations with constant speed. The tables are produced by the use of the Nordic Noise Prediction Method [4].

Table 1. Noise reduction caused by a 10 km/h reduction in speed (driving with constant speed) based on new Nordic emission data from 2000 [6].

Change in speed	Noise reduction light vehicles	Noise reduction heavy vehicles
From 60 to 50 km/h	2.1 dB	1.7 dB
From 50 to 40 km/h	2.7 dB	2.1 dB
From 40 to 30 km/h	3.7 dB	2.7 dB

Table 2. Noise reductions caused by reductions in the traffic volume based on the Nordic prediction method [4].

Reduction in traffic volume	Reduction in noise
10 %	0.5 dB
20 %	1.0 dB
30 %	1.6 dB
40 %	2.2 dB
50 %	3.0 dB
75 %	6.0 dB

From Table 1 it can be seen that a speed reduction of 10 km/h for light vehicles reduces the noise by 2 to 4 dB depending on the starting point. For heavy vehicles the reduction potential is 2 to 3 dB. For speed reductions of 10 km/h in the speed range from 110 to 60 km/h the noise reduction will be about 1 to 2 dB for roads with 10 % heavy vehicles.

In some cases traffic management is used to reduce the amount of traffic on a road and/or to reduce the percentage of heavy vehicles. From Table 2 it can be seen that a 10 % reduction of traffic only leads to a 0.5 dB noise decrease, whereas a 50 % reduction decreases noise by 3 dB. On a road with 10 % heavy vehicles the noise will be reduced by 1 to 2 dB if all the heavy vehicles are removed (se Table 3).

Table 3. Noise reductions caused by reductions in the percentage of heavy traffic based on the Nordic prediction method [4].

Reduction in percentage of heavy vehicles	50 km/h	80 km/h
From 5 to 0 %	0.7 dB	1.0 dB
From 10 to 0 %	1.4 dB	1.9 dB
From 15 to 0 %	2.0 dB	2.6 dB

2.2. Uneven driving pattern

The driving pattern also has an influence on noise levels, although uneven driving patterns usually do not dominate under normal driving conditions. The effect of uneven driving patterns can be seen in Table 4. This table is precented in [2] based on the Harmonoise model [5]. At moderate accelerations the noise can increase by around 2 dB where such accelerations occur (which may be on rather limited locations) depending on the mix of vehicles. This is a little less than the increase achieved by a speed increase of 10 km/h. It is therefore important to design speed reduction measures in such a way as to avoid accelerations and decelerations as much as possible and to ensure that the accelerations do not occur at or near the position of dwellings or other noise-sensitive areas.

Table 4. The influence on noise emission of uneven driving pattern (acceleration /deceleration). The noise influence is presented in relation to a reference case of constant speed of 50 km/h based on the Harmonoise Model [2, 5].

Acceleration/ deceleration	Vehicle type	Noise influence	Note
1 m/s^2	Light	+1.7 dB	Moderate acceleration
2 m/s^2	Light	+4.5 dB	High acceleration
0.5 m/s^2	Heavy	+ 2.1 dB	Moderate acceleration
1 m/s^2	Heavy	+ 4.5 dB	High acceleration
- 1.0 m/s^2	Light	- 0.8 dB	Slow deceleration
- 2.0 m/s^2	Light	- 1.17 dB	High deceleration
- 1.5 m/s^2	Heavy, 2 axles	- 4.5 dB	Moderate deceleration

3. Traffic management measures

3.1. Result of literature study

In Table 5 the main general results of the SILVIA literature survey on traffic management and noise are summarized [2]. The effect on noise is based on estimates of up to approximately 10% heavy vehicles. The effect on noise of the different traffic management measures depend very much of the precise design and implementation of the measures as well as on how they are accepted by the drivers. Generally it can be concluded that reductions in average noise levels (L_{Aeq}) of up to 4 dB can normally be achieved but in special situations even higher reductions may be reached. But some speed reducing measures like rumble areas and paving stones may increase noise. Vertical deflections such as humps and cushions can reduce the average levels due to significant speed reductions but the maximum levels may increase due to body rattle noise produced as some vehicles (especially empty container lorries) negotiate the deflections. The actual reduction in the average level will depend critically on the percentage of heavy vehicles in the traffic stream.

Table 5. General conclusion from the SILVIA literature study on the relations between different traffic management measures and their effect on traffic noise [2].

Traffic management measure	Potential noise reduction (L_{Aeq})
Traffic calming / Environmentally adapted through roads	Up to 4 dB
30 km/h zone	Up to 2 dB
Roundabouts	Up to 4 dB
Round-top/circle-top road humps	Up to 2 dB
Flat-top humps	Up to 6 dB increase
Narrow speed cushions	Up to 1 dB increase
Night time restrictions on heavy vehicles	Up to 7 dB at night
Speed limits combined with signs about noise disturbance	1 – 4 dB
Rumble strips of thermoplastic	Up to 4 dB increase
Rumble areas of paving stones	Up to 3 dB increase
Rumble wave devices	0 dB

3.2. Conclusions and recommendations

In the SILVIA literature study on the relations between different traffic management measures and their effect on traffic noise [2] the following general conclusions and recommendations in relation to noise were drawn:

- Speed reductions reduce noise.
- The noise from heavy vehicles can in some cases increase due to increased gear shifting and body rattle noises.
- In order to achieve a reduced speed it is normally not enough just to install speed limit signs. It is also necessary to redesign and rebuild the road so that the physical layout matches the intended speed.
- Visual speed reducers are often effective in reducing noise.

- It is important to achieve as smooth a driving pattern as possible.
- It is important to minimise uneven driving patterns. This can be done by having appropriate distances between speed reducers.
- It is important to achieve driving patterns where the vehicles are not brought to a complete stop as this generates more noise from decelerations and accelerations.
- Speed reducers which displace the vehicles to the left or to the right are often
- effective in reducing noise, especially in the case of heavy vehicles.
- Speed reducers which change the vertical height of parts of a road (like some types of road humps) can in some cases be problematic in relation to noise, especially for heavy vehicles, where body rattle noises can produce large peaks in noise levels as these vehicles cross the vertical deflections.
- The use of rumble areas, for example with paving stones, increases noise.
- There are reports of cases with increased perceived annoyance even though the average noise level has decreased.
- There are reports on increases in the perceived noise annoyance because of impulse-like noise, rattling in the bodywork or cargo of heavy vehicles, as well as short-time changes in the sound level and frequency caused by gear shifting or changing in engine revolutions due to acceleration or braking of a vehicle.
- Speed reducers, which change the vertical height of parts of a road, may produce perceptible levels of vibrations in nearby houses. This depends on the type of soil and distance from the vertical deflection to the nearest house foundations. Serious annoyance has been reported especially where houses are close to road humps built on soft ground such as peat soils and alluvium deposits.
- Speed reductions generally have a good effect on traffic safety.

These were the general conclusions. In the literature study a few exceptions with well functioning cases were found that do not follow these conclusions. For example the Austrian “Multifunctional noise protection facility” where dynamic speed limit signs make the drivers reduce speed and by doing so the noise is reduced too [2].

In an older Danish report [7] it has been suggested that 5 dB should be added as a “penalty” to the actual noise level if impulsive noise or similar is occurring (for example where rumble areas/strips or paving stones are used) to compensate for the increased perceived annoyance. Such an addition to the actual noise level is known from the Danish practice of administrating of external noise from industry in situations with impulsive noise and tonal noise. It must generally be concluded that more research is needed to investigate and quantify the effect of impulsive noise from road traffic, especially in relation to certain types of speed reducers.

A general recommendation could be, on the background of the existing knowledge, to place speed reducers which change the vertical height of parts of a road as far as possible from dwellings.

4. Combination of traffic management and noise reducing pavements

It is obvious that it can be a good idea to combine traffic management measures and the use of noise reducing pavements in noise abatement schemes. Generally there does not seem to be any technical arguments for not combining these measures of noise abatement. However, it must be noted that porous pavements can be damaged at bends, junctions and roundabouts where turning forces at the tire/road interface are relatively high. This must be taken into consideration when applying porous pavements on roads specially constructed to reduce speed. Speed reducers which displace the vehicles to the left or right may also be problematic for the durability of porous pavements, because this will make the vehicles drive in curves for short distances. Other types of noise reducing pavements may be used in such cases.

The SILVIA *Guidance Manual for the Implementation of Low-Noise Road Surfaces* is a compilation of the key research and findings of the SILVIA project [8]. In this SILVIA manual the noise reducing effect of different pavement types are documented. On urban roads with speeds in the range from 40 to 60 km/h noise reductions of 1 to 4 dB can be achieved by using for example noise reducing thin layers or porous pavements in relation to a dense asphalt concrete reference pavement with 11 mm maximum aggregate size [1]. At higher speeds the noise reducing potential for these pavements may be up to 6 dB or even more. This noise reduction is of the same magnitude as or higher than the reduction which can normally be achieved through traffic management measures.

Noise reducing pavements and traffic management measures may influence the frequency distribution of road traffic noise in various ways, and this can have an influence on the total noise reduction. For simplification it can anyway be recommended to add (on a dB basis) the effect of the two types of noise reduction. It is therefore generally on urban roads possible to obtain noise reductions of 3 to 8 dB by combining the use of noise reducing pavements and traffic management measures. On highways with high speeds the potential for noise reduction may even be up to 10 dB if it is possible to reduce the speed significantly.

Generally noise reducing pavements have a better reduction effect on noise from light vehicles than on noise from heavy vehicles. This means that if a traffic management measure such as an environmentally adopted street or a 30 km/h zone has an effect on reducing the percentage of heavy vehicles, the beneficial effects of the noise reducing pavements will be increased.

5. Research needs

The SILVIA literature study on the relations between different traffic management measures and their effect on traffic noise [2] has shown that noise reductions due to introduction of traffic management schemes can result in both positive and negative responses from the people living along the roads. In some cases social surveys have shown a significantly reduced perceived annoyance and in other cases the perceived annoyance has increased even though the measured average noise levels have decreased. As the main goal of noise abatement is to improve the life quality for people there is a need for further research in this field. Research themes could be:

- 1. The effect of different designs of road humps and cushions on the perceived annoyance.
- 2. The effect of different types of rumble areas and strips on the perceived annoyance.
- 3. Development and optimization of traffic management schemes in order to reduce the perceived annoyance as much as possible.
- 4. Investigation and quantification of the effect on the perceived annoyance of impulsive noise from road traffic, especially in relation to certain types of speed reducers like humps and rumble areas.
- 5. The effect on the perceived annoyance when combining traffic management and noise reducing pavements in order to reduce noise.
- 6. Very few references have been retrieved in the literature where the use of advanced information technology and automatic traffic steering and management has been developed and investigated. Therefore there is also a need to focus on this field in research and development projects. In this research it will also be relevant to focus on projects where noise reducing pavements are included.
- 7. There is also a need to further develop and test speed reducers such as rumble-wave devices which can generate noise inside the vehicles but at the same time do not have any negative effect on the noise along the roads.

Some of these research challenges are taken onboard the EU project SILENCE [3] which started in 2005.

6. Acknowledgements

The authors will like acknowledge the qualified work carried out in conducting the SILVIA literature study on the relations between different traffic management measures and their effect on traffic noise [2] by:

- Jürgen Haberl, Vienna University of Technology (TUW), Austria.
- Ulf Sandberg, Transport Research Institute (VTI), Sweden.
- Greg Watts, Transportation Research Laboratory (TRL), United Kingdom.

These specialists worked together with the authors of this paper in the SILVIA project.

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