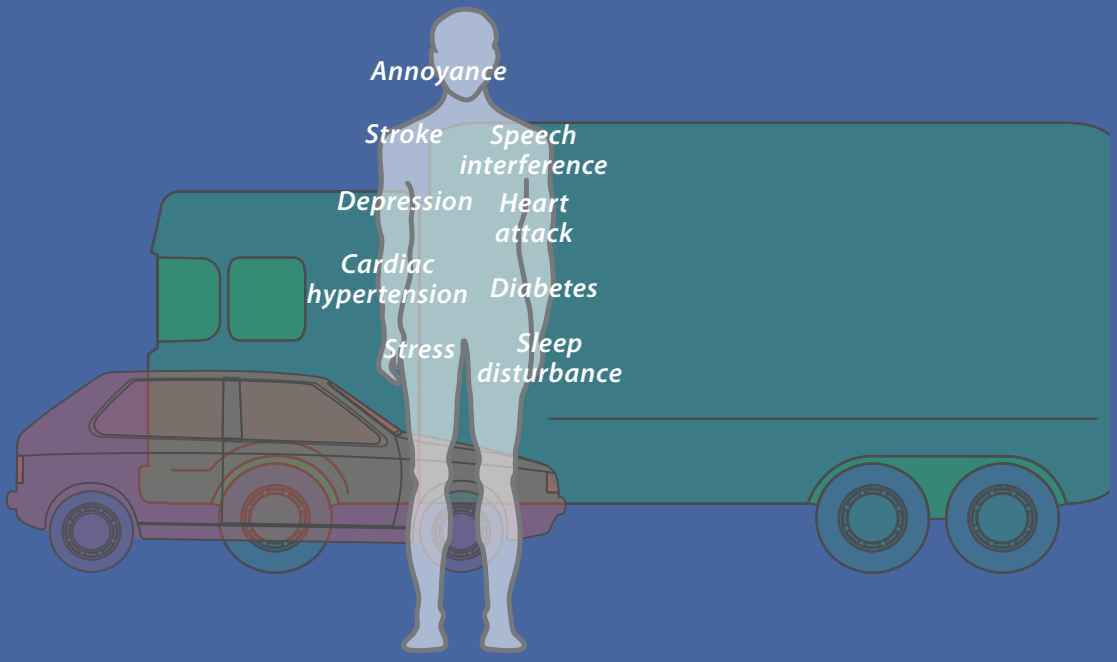
International Council of Academies of Engineering and Technological Sciences, CAETS

Quieter Cities of the Future



Lessening the Severe Health Effects of Traffic Noise in Cities by Emission Reductions

A report from
The CAETS Noise Control Technology Committee and
the International Institute of Noise Control Engineering

Tor Kihlman, Wolfgang Kropp, and William Lang
Rapporteurs

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Quieter Cities of the Future

ISBN 978-91-980973-7-5

Printed by
Reproservice, Chalmers University of Technology
Göteborg, Sweden
May 2014

ACKNOWLEDGEMENTS

This report was prepared by the rapporteurs. Special thanks are to be given to the following panelists who assisted in the drafting process:

Wolfgang Babisch
Thomas Beckenbauer
Kaj Bodlund
Hans Martin Gerhard
Michael Jaecker-Cueppers
Foort de Roo
Ulrich Saemann

The rapporteurs are grateful to the stakeholders whose representatives participated in the forum. They shared their expertise, insights, and ideas to establish a collegial atmosphere. Representatives of regulatory agencies, governments, universities, and consultancies also participated in the forum. The organizations that expressed their interest in the forum were:

ALD DEGA, Germany
Chalmers University, Sweden
Continental AG, Germany
Federal Environment Agency, Germany
Mueller BBM, Germany
Porsche AG, Germany
TNO, Netherlands
Volvo Group, Sweden

Thanks also to Johannes Werner who made a recording of the entire forum, to Peter Carlsson who provided a transcript from the recording, and to Jens Forssén who assisted in the writing of the report.

Thanks to William Salmon, CAETS Secretary-Treasurer, who provided advice on the scope of the forum as sponsored by the CAETS Noise Control Technology Committee.

Generous support for this project was provided by the International Institute of Noise Control Engineering.

Finally, thanks to Chalmers University of Technology for posting the SOURCE BOOK of the forum on the website,
http://www.ta.chalmers.se/

This report is also posted on the CAETS website,
www.caets.org

The health effects of traffic noise are severe and constitute a threat to public health

PREFACE

Road traffic noise is a worldwide problem. It is the major noise source in the cities. Immission goals, mainly in the form of guideline values, were already formulated in many countries in the 1960s. In contrast to many other environmental areas, these values have not been strengthened since then. When first formulated, the goals were based on criteria for speech interference and on what was known concerning influence on sleep and annoyance. Now, the scientific basis for health-based targets has become much stronger.

It is a demanding task to decrease the adverse health effects of traffic noise. There is no single technological fix available either on the source side or on the immission side. No organization by itself can do much to improve the situation. A conserted action by several involved bodies is needed but is non-existent today.

The purpose of the CAETS Forum in 2013 was to clarify the effectiveness of present methods and policies used by each separate body and to investigate the possibilities to achieve a substantial change. The forum was unique in bringing together noise control experts covering the whole chain from source to receiver including the health effects of the resulting immissions. Participation was by invitation only. The panelists were given specific questions to answer within their respective fields of knowledge. The panelists as well as other participants were specialists from the automotive industry, academia, public authorities, and consultants.

The forum was broader than the title indicates as it also covers measures on the immission side. The road traffic noise problems cannot get reasonable solutions only through emission reductions even with foreseeable best technology. But it was also clear, that present methods to measure and describe the emissions are neither sufficient nor adequate from an immission stand point.

In this report the most important findings from the forum are given. Based on these findings, conclusions were drawn on what is needed and what can and should be done in terms of policy to substantially reduce the adverse health effects of traffic noise.

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All presentations and discussions on which the report is based are included in the SOURCE BOOK, ref [1], which is posted on the website of Chalmers University of Technology, Applied Acoustics: http://www.ta.chalmers.se/

SUMMARY

The adverse health effects of traffic noise are comparable to the health effects of road traffic accidents. Most cases of mortality are in areas where noise immission levels are less than 10 – 15 dB above WHO's proposed intermediate targets. The EU Environmental Noise Directive, END, from 2001 has not led to sufficient actions to decrease the health effects. Neither source-related measures alone nor measures in the transmission path alone, can solve the problems. Both are necessary and concerted action by several parties is needed. There is no clarification of the individual responsibilities of the parties involved.

The recent decision in the EU on a change in the type test method for new vehicles, ISO 362, and stricter limit values may give a reduction in L_{den} of 2 dB in 20-30 years. The type test method is inadequate as an instrument to control city traffic noise emissions. New methods for requirement setting are needed so that the sources can be better controlled for improved traffic noise management, such as night time speed limits, low-noise public transportation, and quiet vehicles for community services.

Rolling noise is an important part of the emissions. It depends on tyre and road surface properties. Limit values and labelling data for tyres are based on tests on the ISO smooth surface. There are conflicts between different performance criteria. Today's tyres have little potential for further noise reduction; an optimstic estimate is 3 dB on the smooth ISO test surface. Furthermore, the test methods for tyres are not relevant for common rough road surfaces. "Quiet pavements" are important to decrease rolling noise. There is no regulation on road surfaces with respect to their acoustic performance. There is no incentive for road "owners" and industry to improve the acoustic quality of road surfaces. Development of methods is needed.

A source-related measure besides "quiet pavements" is speed control esp. at night-time in sensitive areas. This is no effective method if not combined with noise emission limits for the vehicles at speeds well below 50 km/h. Heavy vehicles are more specialized than cars. Options here are to set special limits for public transportation vehicles, delivery vehicles, etc. which need requirements set when purchasing the vehicles. Quieter powertrains than the diesel engine may be an option in some applications.

Traffic noise is mostly taken into account too late in the planning process and in a too limited way. Improved urban sound planning is necessary to decrease the effects of the traffic noise. Available tools are traffic management; surfaces with better sound absorption on ground, facades and roofs; special low barriers; rows of trees; and effective use of the buildings' shielding to achieve quiet areas and quiet sides. Presently used methods noise for mapping can lead to the erroneous conclusion that the traffic noise at its present high levels is unavoidable and that the health effects must be accepted.

A noise reduction program, based upon a revised END as a framework directive is recommended. It should demand compulsory immission goals, compulsory action plans to reach these goals and much improved information to the public regarding the health risks. With this program the adverse health effects could be substantially reduced in a period of 20 years.

Several means to get a better acoustic climate in the cities are easiest to apply in compact cities and are in line with measures to tackle climate change. They can be developed into real win/win situations.

Background, Scope, and Purpose of the Forum

INTRODUCTION

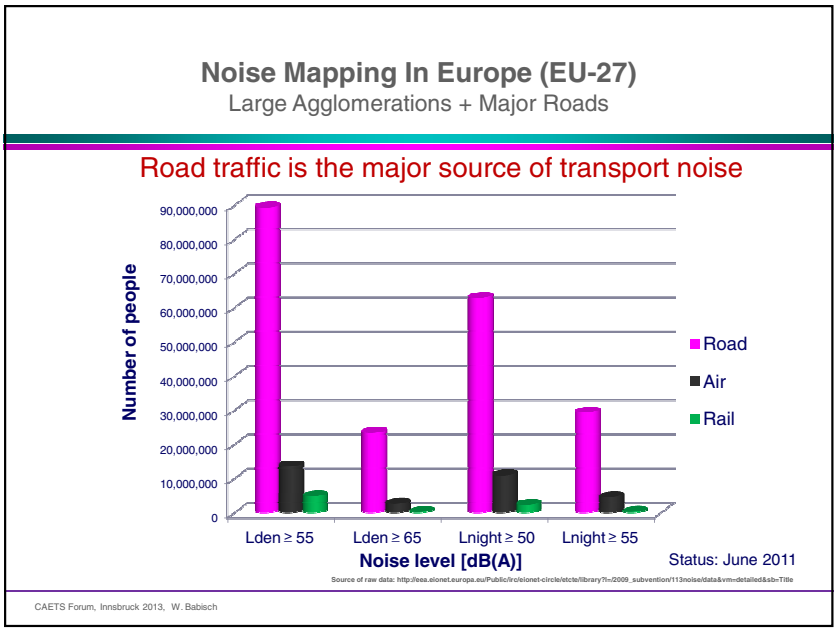
Political actions to tackle the environmental noise problem have hitherto been very insufficient. The severe health effects revealed in recent years should raise political interest and lead to action.

Noise reduction at the sources is one instrument to achieve a better environment. There are internationally agreed-to test methods and limit values for road vehicle noise emissions linked to type approval of new vehicles. This work on methods and limit values is performed by UNECE/WP29/GRB. Noise limits for new vehicles have had some impact over the last 40 years for heavy vehicles at low speeds but practically no effect upon the noise emitted from cars at any speed. The test methods are not effective tools in the work to accomplish a better acoustic environment.

In collaboration with UNECE/WP29/GRB and the EU, a new test method (called B), intended to be more relevant, has been developed. At the time of the forum, the political process in the EU was not yet finished. Nonetheless, it was assumed that the new test Method B would be adopted and new limit values set. This has now been confirmed.

Rolling noise caused by the interaction between tyres and pavement is dominant over the driveline noise in many traffic situations. It depends both on the tyres and the pavements. In the EU there is a directive dealing with noise limits and the labelling of tyres. The test method is unsatisfactory and can lead to false conclusions by customers and authorities.

The pavements have a strong influence on the rolling noise. Methods to classify the pavements with regard to their acoustic properties are lacking.



The Environmental Noise Directive, END, was adopted by EU in 2001. It demands noise mappings, development of action plans, and information to be provided to the public. At present the END neither requires that action plans be completed nor that specific maximum immission levels be met. The END has led to extensive noise mappings and action plans in the EU of varying quality.

The noise mapping has shown that close to 90 million people in Europe suffer from noise levels where most people become annoyed, where sleep is disturbed, and where severe adverse health effects are to be feared. It shows there are vast areas where the acoustic environment is unhealthy. The negative health effects of the noise are substantial and urban citizens are at risk. In hot spots the noise levels are up to 20 dB higher than should be accepted. A healthy acoustic environment for all our citizens is not reachable in the near future but substantial improvements are possible.

This CAETS forum was a follow-up to the 2008 June CAETS workshop on the design of low-noise transportation vehicles that was held at the Institute of Sound and Vibration Research, Southampton, U.K. That workshop focused on technological possibilities to reduce the noise emissions from traffic.

Neither city and building planning alone nor emission control is sufficient to solve these problems. Both are necessary. No party can solve the problem alone. Each one has to contribute and, in fact, be pressed to do as much as possible.

The task for this forum was to find out what is possible to achieve with the best of today's known technology and planning instruments to improve the acoustic environment in our major cities. The task was also to clarify if the political and administrative tools are adequate and effective to force each actor to do his best for a better acoustic environment for all citizens. How much can be accomplished if all actors do their best? What is possible to substantially improve the acoustic environment? What are the lead times?

The forum was unique in its program to address the whole chain from the noise sources to the health effects of the resulting immissions. The goal was to clarify technological possibilities for each one of the different actors to provide an acoustic environment that is healthier for the citizens. All participants were senior engineers or scientists from the automotive industry, government, or academia.

Scope And Purpose Of The Forum

- To clarify to what extent present methods for noise emission reductions are effective political instruments to radically decrease the adverse health effects of city traffic noise.
- To clarify shortcomings of the present methods, and
- To clarify the extent and limitation of the different parties' responsibilities.

The topics addressed in the Forum were:

1. Health effects and WHO immission guideline values
2. Urban sound planning
3. END and action plans
4. Relation between type test emission data and radiated power
5. Possible emission reductions
6. Spectral requirements
7. Road surfaces
8. Test methods
9. Distribution of responsibilities between different actors
10. Possibilities/limits to fulfill immission goals

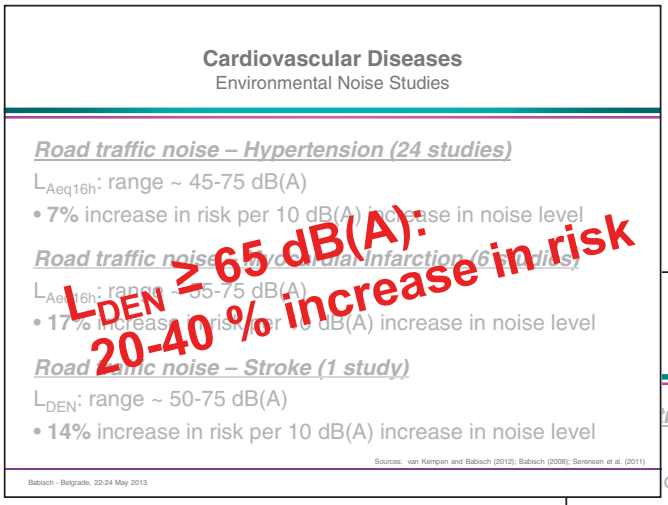
Rather than letting the invited panelists talk about self-chosen topics, they were asked to address questions relating to their expertise. In abbreviated form the panelists' answers to the questions were required in advance. The answers could then be orally expanded in the forum. The contributions from the first two panelists were intended to give the background. Comments and questions followed each presentation.

General Topics Related to the Questions to be Treated in the Forum

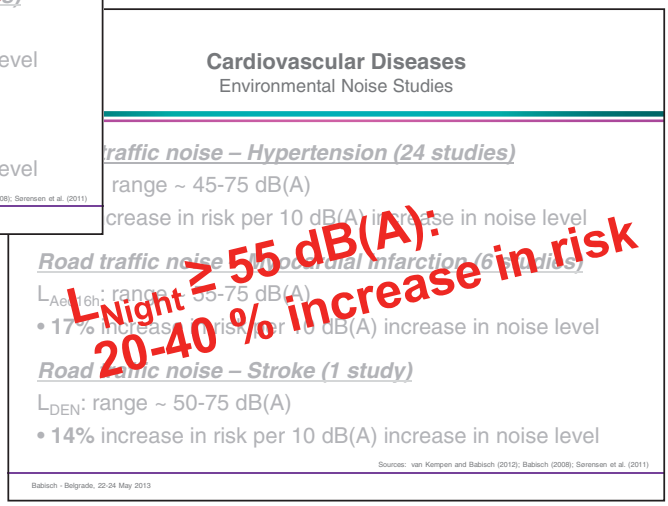
Health effects of traffic noise

Based on presentation by Wolfgang Babisch

Adverse health effects of noise occur in particular when noise interferes with intended activities such as communication or sleep. The situational context is therefore important. Noise cannot be discussed in purely toxicological terms as in the epidemiology of air pollution. Decibels do not behave like microg/m3. The special thing about noise is that we can hear it. The human organism is primed to pick up sound. It continuously processes and analyses the acoustical information it receives, including unwanted sound (= noise). It has no "earlids."



In the past 30-40 years, the adverse effects of noise have been measured and discussed in terms of annoyance. However, even high levels of annoyance have not led to any strong political actions. This is one reason why direct health effects are now being studied in more detail.



Traffic noise can result in severe health effects such as high blood pressure, cardiac infarctions, strokes and diabetes causing much suffering and also premature death. According to WHO, it is the second major environmental health problem in Europe after air pollution. Studies have shown increasing risks when living in dwellings exposed to noise levels, L_{den} above 55 dB outside windows. The risks increase with time. There is no habituation during night; even those who report no sleep disturbance show vegetative reactions. At $L_{den}>65$ or $L_{night}>55$ the risk for cardiovascular diseases increases by 20-40 percent. This means that there are millions of victims suffering from these noise related health effects. The recommended interim targets, IT, $L_{day}<65$ dB and $L_{night(outside)}< 55$ dB are well justified.

Attributable Mortality (2004)

European Region, High Income* (Population: N = 407 Millions)

Disease	WHO Polynomial L_{den} >60 dB(A) **	WHO Trend L_{den} >60 dB(A) ***	Update Trend L_{den} >60 dB(A) ****	Update Trend L_{den} >55 dB(A) ****
Hypertensive heart disease	---	---	1,332	2,574
Ischaemic heart disease	11,196	26,933	13,808	26,622
Stroke	---	---	14,592	27,892
Diabetes mellitus	---	---	2,979	5,713
Total fatal cases:			**32,711**	**62,801**

* 25 countries (EU 27 = 27 countries)
* * WHO Burden of disease from environmental noise (2011), polynomial exposure-response curve, categorical analysis (Babisch, 2008)
*** Continuous exposure response curve, trend analysis (Babisch 2008)
**** Continuous exposure response curves, trend analysis (van Kempen & Babisch 2012), Babisch 2013 submitted, Sørensen et al. 2011, 2012

CAETS Forum, Innsbruck 2013, W. Babisch

Based on known risks, the number of premature noise-related deaths from heart diseases, stroke, and diabetes in the European region has been investigated. It is estimated that in the EU high income countries, the number is above 60,000 cases annually. Most cases are in moderately exposed groups.

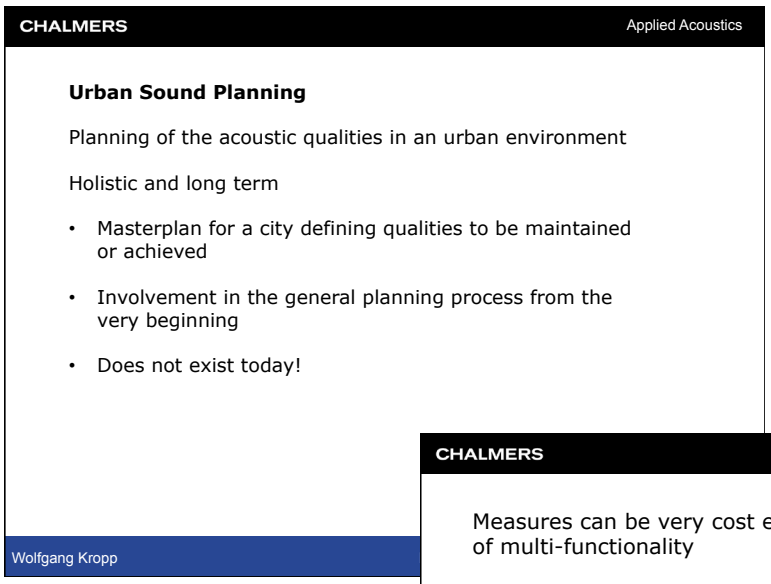
Urban Sound Planning for a Good Acoustic Environment, Important Factors and Possibilities

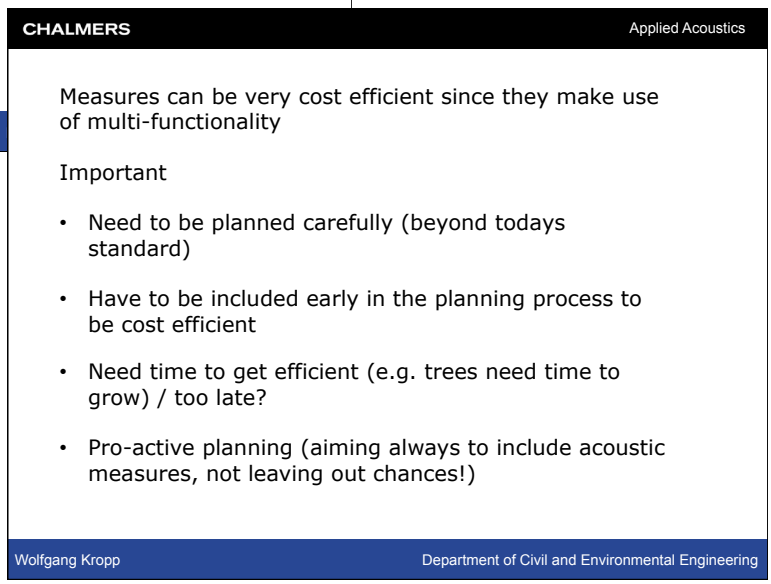
Based on presentation by Wolfgang Kropp

Creating an acceptable acoustic outdoor environment is an extremely complex task. Creating as well as preserving environments, which are supportive for health and wellbeing in a sustainable manner, is an even bigger but unavoidable task with the growth of the urban population and the ongoing densification of the cities. Working with this task suffers from the fact that the acoustic environment is often considered very late in a planning process. The time perspective is then rather short and the focus is mainly very local. Acousticians are only involved when a problem occurs and the problem needs to be solved immediately.

What is needed is a process of urban sound planning from the "very beginning" where a master plan is established which defines the acoustic qualities in a city which should be achieved and which should be maintained. Such a process has to be included in all planning issues. Urban sound planning has to move from reactive to pro-active measures, i.e. always endeavour to include positive measures for the urban acoustic environment.
To achieve this, a series of pre-conditions have to be fulfilled:

– We need educated specialists who can cover the whole area of urban sound planning including all relevant fields of acoustics, who have a deep understanding of planning processes such as traffic and spatial planning, and who are able to communicate the needs of urban sound planning in an appropriate way;





– We need tools which allow planning with sufficient accuracy the multitude of measures available for designing urban acoustic environments;

– Finally, we need reliable and complete input data concerning sources of noise.

The latter is crucial and in today's situation not available. What is needed is detailed information about sound power from individual sources. Only if frequency content for the individual sources under realistic working conditions is available will a careful and reliable design of an urban environment be possible. In addition communities and the planners must have control of the sources over time.

For many sources this information is today not available. This is especially true for road traffic which is the dominant source of noise in urban environments. The type approval method for road vehicles omits all spectral information and is not related to relevant driving cycles. In addition it combines the contributions from propulsion and tyres in an undefined way. This will have severe consequences in the future. A low-noise surface might not be applicable as an efficient tool for road traffic noise reduction if the balance between tyre noise and propulsion noise is changed in favor of higher propulsion noise.

Today's State Regarding Emissions and Possibilities to Achieve Good Acoustic Environments in Cities

Expected effects of recent political decisions in the EU

Based on presentation by Foort de Roo

A revision of the internationally agreed test methods and limit values for road vehicle noise emissions has been discussed for a long time. The work has been carried out within UNECE/WP 29/GRB in special cooperation with the EU. A somewhat modified method, referred to as Method B, has been proposed. Most important is the transition from the current test method called Method A, based on the old ISO 362, to a new version based on the new version of ISO 362 published in 2007. The data from Method B are intended to better represent the vehicle noise emission under typical city traffic conditions, speed limit 50 km/h, than the old, Method A.

The new method, as well as the old, is based on maximum sound pressure levels at pass-by. The measured noise is a mixture of drive-line noise and rolling noise. Important is the test surface, the ISO test surface. It is very smooth, much smoother than normal roads.

By the time of the forum, the political process in the EU was not yet finished. The present status (Feb 2014) is that the Commission, the Parliament, and the Council have come to an agreement on new limit values and adoption of Method B. It is in conformity with the Council proposal, see slide below. The agreement has not yet been finally confirmed by the Parliament.

The new limit values and Method B have been estimated to give a reduction of 2.5 dB in Lden after 20 years. A similar estimate has been given by Paviotti et al. [3]. They have estimated that the effect of the decisions within EU will not exceed 2 dB during the next 30 years.

The estimates of the effects are based on simplified assumptions concerning the relation between type-approval data and resulting immissions in the cities with a speed limit of 50 km/h from future vehicles complying with the new limit values.

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September 19, 2013
Foort de Roo
CAETS Forum - Health effects

TNO innovation for life

Impact study of three limit value proposals (1)

Estimated reductions of maximum noise emitted by single passing accelerating vehicle

Single vehicle pass. (Accel) ΔL_{max} [dB(A)]	Cars	Vans	Buses	Lorries	HDVs	Average
Current situation	0,0	0,0	0,0	0,0	0,0	
EU Parliament	- 4,4	- 3,7	- 1,5	- 0,3	+ 0,3	- 1,9
Council	- 4,5	- 3,9	- 2,8	- 1,3	- 1,4	- 2,8
EC	- 4,6	- 4,4	- 4,0	- 2,0	- 2,0	- 3,4

Estimated reductions of L_{DEN} *caused by traffic flows*

Traffic noise ΔL_{DEN} [dB(A)]	Residential street - Intermittent traffic	Residential street -Free flowing traffic	Main street - Intermittent traffic	Main street - Free flowing traffic	Arterial road	Urban Motor Way	Rural Motor Way	Rural Road	AVERAGE
Current situation	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	
EU Parliament	2,2	1,7	2,6	1,8	1,7	1,7	1,9	1,5	1,9
Council	3,1	2,3	3,4	2,3	2,3	2,3	2,3	2,2	2,5
EC	3,7	2,7	3,8	2,5	2,5	2,5	2,5	2,4	2,8

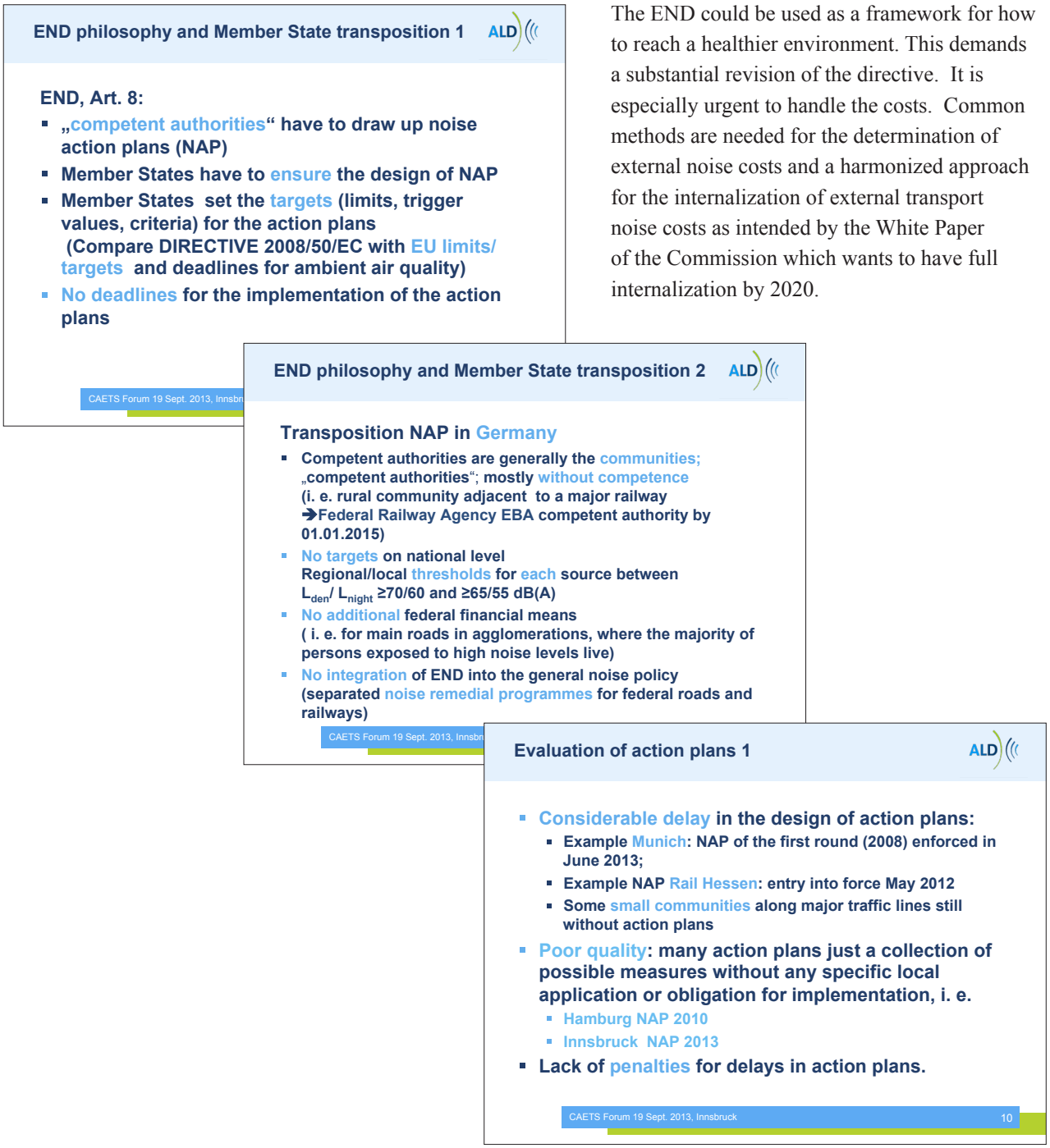
The correlation between Method B data and low-speed emissions has not been investigated and is probably lower than with normal urban driving. For high-speed traffic, the correlation may be good with the tyre rolling noise test.

The ISO 362 data give no information about the directivity and spectrum of the noise.

Possibilites and Limitations to Achieve Good Acoustic Environments Through Mitigation Measures in the City

Based on presentation by Michael Jaecker-Cüppers

The END demands "adoption of action plans by the Member States, based upon noise-mapping results, with a view to preventing and reducing environmental noise where necessary and particularly where exposure levels can induce harmful effects on human health and to preserving environmental noise quality where it is good." The competent authority is usually the local community. Quite often the communities have low competence in noise control. Further, the directive does not demand that the action plans are specific, sufficient, or followed. On the local level, mainly measures on the immission side are possible.



The END could be used as a framework for how to reach a healthier environment. This demands a substantial revision of the directive. It is especially urgent to handle the costs. Common methods are needed for the determination of external noise costs and a harmonized approach for the internalization of external transport noise costs as intended by the White Paper of the Commission which wants to have full internalization by 2020.

Redesigned street in Berlin with bicycle lanes and tempo 30 during the night.

In its 2009 guidelines for Europe, WHO has set L_{night}<55 dB as the interim target for healthy dwellings. There is a substantial gap between common traffic noise levels and levels that are not unhealthy. The gap between existing traffic noise levels in hot spots and the WHO interim targets is of the order of 20 dB. In more common situations in cities, where most of the victims of the adverse health effects are found, the gap is typically 10 dB. There is no way to eliminate even this gap with source-related measures alone, but the gap can be decreased with new and concerted actions.

The noise mapping in 2008 in Berlin and the subsequent action plan showed that 340,000 citizens were exposed to night noise levels up to 20 dB above the interim target. The action plan included a night speed limit of 30 km/h on several inner urban main streets. Some streets were redesigned and in some cases improved maintenance of the road surfaces or even low-noise surfaces were applied, even though not in a systematic way. A maximum reduction of 5 dB(A) was obtained within four years and the number of persons exposed to L_{night}>55 dB was reduced to 300,000. With a 5 dB reduction, another 15 dB are still needed at the most critical hot spots.

The present system is not effective for any major improvement of the acoustic environment. The new type approval approach for the cars with mixing of operational situations, constant speed and acceleration worsens the situation. Further, it's not at all clear who is responsible for complying with the limits. We have up to now no instruments to enforce optimized road surfaces, and we have no quantified or mandatory targets for traffic avoidance or modal split improvement. The problem of the responsibility share can only be solved by an integrated approach with mandatory and quantified objectives for each involved party.

Technology for Lower Rolling Noise

Based on presentations:
Tyres for Lower Rolling Noise
Presented by Ulrich Saemann
and
Pavements for Lower Rolling Noise
Presented by Thomas Beckenbauer

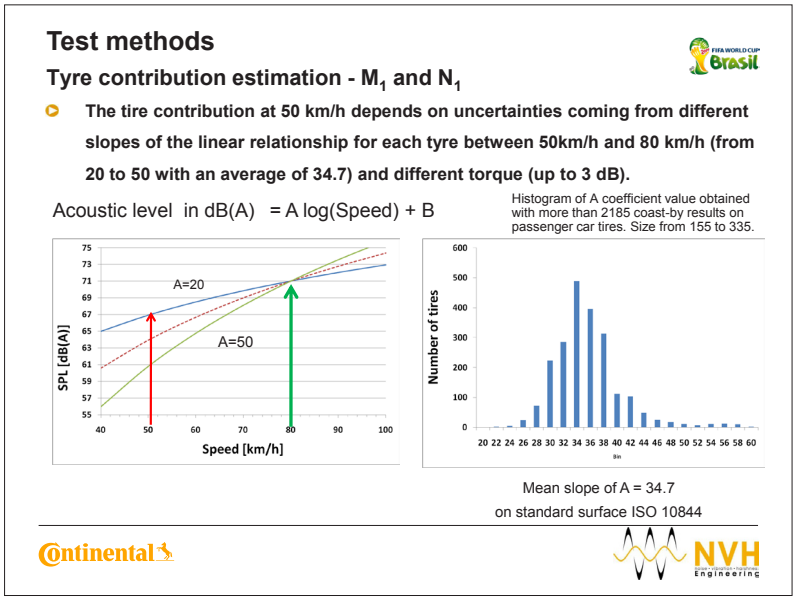
In general tyre and road cannot be decoupled when discussing tyre/road noise. It is the interaction between both which determines the noise generation. For both tyre and road surfaces there exists a multitude of functions besides low-noise performance such as rolling resistance, durability, wear, wet friction, etc.

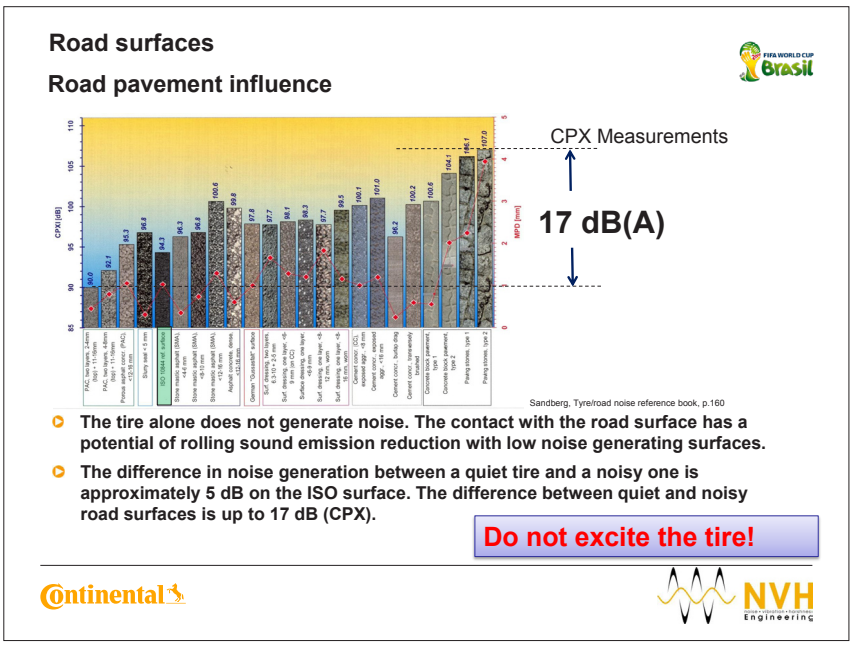
This fact might lead to conflicts. Measures taken for noise reduction at the tyre might have a negative impact on other performance criteria such as rolling resistance or dry and wet grip. Due to the conflict between different performance criteria, today's tyres seem to have little potential for further noise reduction. An estimation of 3 dB on the ISO surface is already very optimistic. See figure below.

The double regulation for tyres (inside the R117 and the tyre limit regulation 661) formulated at two different driving speeds (50 km/h and 80 km/h) leads to tyres with high speed dependence of the noise emission. In this way the limits at 80 km/h can be fullfilled and the tyres can be very quiet at 50 km/h as needed by vehicle manufacturers. However, for speeds well above 80 km/h the tyres might be much noisier due to the high speed dependence of the noise emission.

As A-weighting is used for tyres on a very smooth road this might be an appropriate measure. However, on rough roads and for tyres with a very well-optimised tread pattern, low-frequency content might be high but this does not influence the A-weighted levels. The use of the ISO surface for optimisation of tyres gives a strong focus on tread pattern optimisation. However, on normal road surfaces such optimised tread patterns will not give the same reduction as on a smooth ISO surface due to the excitation of the tyre vibrations which are then mainly determined by the road roughness and not by the tread pattern. Similar conclusions can be made for the rolling resistance. It is tested on a smooth steel drum. The test values are not representative for the performance on real road surfaces.

The noise emission from different tyres have different speed dependences.





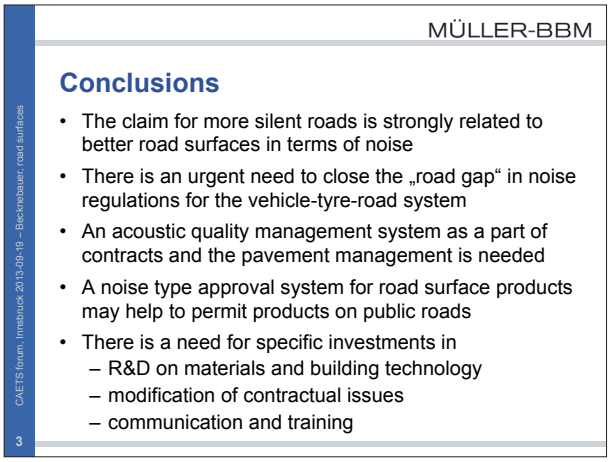
The rolling noise emission varies substantially depending upon pavement.

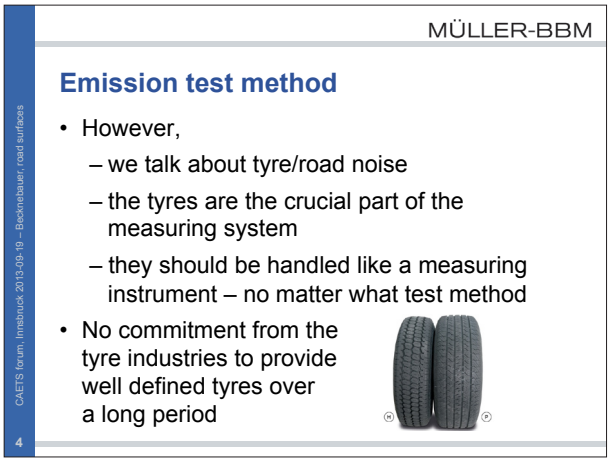
When it comes to road surfaces, the situation is somewhat different. Today there exists knowledge to build low-noise road surfaces. However, since there is no regulation on road surfaces with respect to their acoustic performance, there is no incentive for road owners and industry to improve the acoustic quality of road surfaces. The lack of a regulation for road surfaces is certainly a consequence of the difficulties with respect to implementation of such regulations. The main pre-conditions for implementation are:

- An unequivocal acoustic test method,
- A comprehensive evaluation background, and
- A reliable forecasting method with respect to aging effects.

Only if these conditions are satisfied, can an acceptable acoustic contractual concept be formulated for the construction industry which allows for implementing regulations.

However, these three pre-conditions are difficult to achieve. The acoustic test method depends on reference tyres independent of measurement method. Tyres are aging which changes their properties with respect to noise generation. There is only one single tyre (SRTT tyre) which is guaranteed by the manufacturer to be available at least for the next 10 years. Reference tyres do not exist, at least not for all required situations depending on speed or vehicle type. Finally there is a lack of methods to predict the aging of surfaces with respect to their acoustic performance.





Technology for Quieter Vehicles – Challenges and Needed Lead Times

Presented by
Hans-Martin Gerhard, cars
and Kaj Bodlund, heavy trucks.

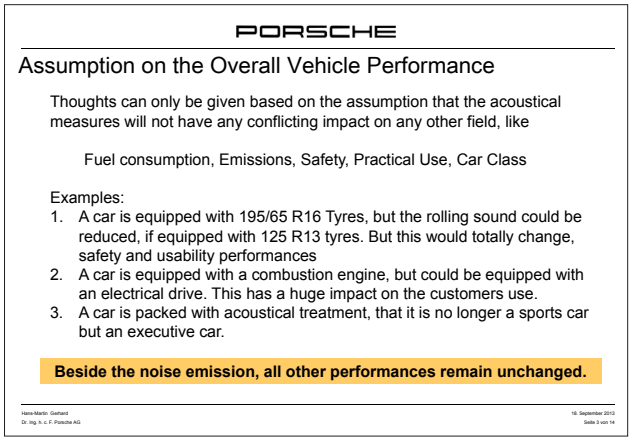
Discussions and evaluations regarding possible reductions of the noise emissions from road vehicles are mostly based upon the type approval system, linked to the ISO test method 362. See page 9 above. Its task is the harmonization of requirements on road vehicles, i e an approval system for the products so they can be marketed, sold and used internationally. Its original purpose was not to limit traffic noise.

This procedure is not effective to control the noise immissions from dense traffic. The recent decision within the EU is estimated to give a reduction of not more than 2,5 dB in L_{den} from urban road traffic in a period of 20 years.

Directivity, spectrum or emitted acoustic power are not measured. These are of importance for the immissions caused by the road traffic in an urban environment.

Questions in the forum were to explore the possibilities to further reduce the emissions from the road vehicles. The conditions for heavy vehicles and cars are quite different.

It was stressed by the panelist Hans-Martin Gerhard from the car industry that the assumption must be that the acoustical measures will not have any conflicting impact on any other field like fuel consumption, exhaust emissions, safety, practical use or car class. This standpoint could be questioned.


PORSCHE

Assumption on the Overall Vehicle Performance

Thoughts can only be given based on the assumption that the acoustical measures will not have any conflicting impact on any other field, like

Fuel consumption, Emissions, Safety, Practical Use, Car Class

Examples:
1. A car is equipped with 195/65 R16 Tyres, but the rolling sound could be reduced, if equipped with 125 R13 tyres. But this would totally change, safety and usability performances
2. A car is equipped with a combustion engine, but could be equipped with an electrical drive. This has a huge impact on the customers use.
3. A car is packed with acoustical treatment, that it is no longer a sports car but an executive car.

Beside the noise emission, all other performances remain unchanged.

Hans-Martin Gerhard
Dr. Ing. h. c. F. Porsche AG
18. September 2013
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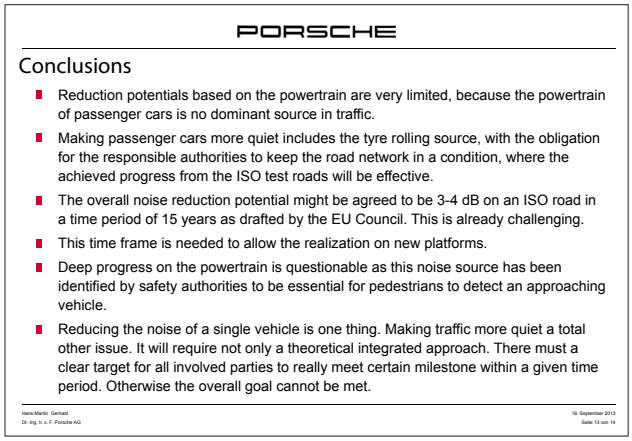
PORSCHE

Conclusions

- Reduction potentials based on the powertrain are very limited, because the powertrain of passenger cars is no dominant source in traffic.
- Making passenger cars more quiet includes the tyre rolling source, with the obligation for the responsible authorities to keep the road network in a condition, where the achieved progress from the ISO test roads will be effective.
- The overall noise reduction potential might be agreed to be 3-4 dB on an ISO road in a time period of 15 years as drafted by the EU Council. This is already challenging.
- This time frame is needed to allow the realization on new platforms.
- Deep progress on the powertrain is questionable as this noise source has been identified by safety authorities to be essential for pedestrians to detect an approaching vehicle.
- Reducing the noise of a single vehicle is one thing. Making traffic more quiet a total other issue. It will require not only a theoretical integrated approach. There must a clear target for all involved parties to really meet certain milestone within a given time period. Otherwise the overall goal cannot be met.

Hans-Martin Gerhard
Dr. Ing. h. c. F. Porsche AG
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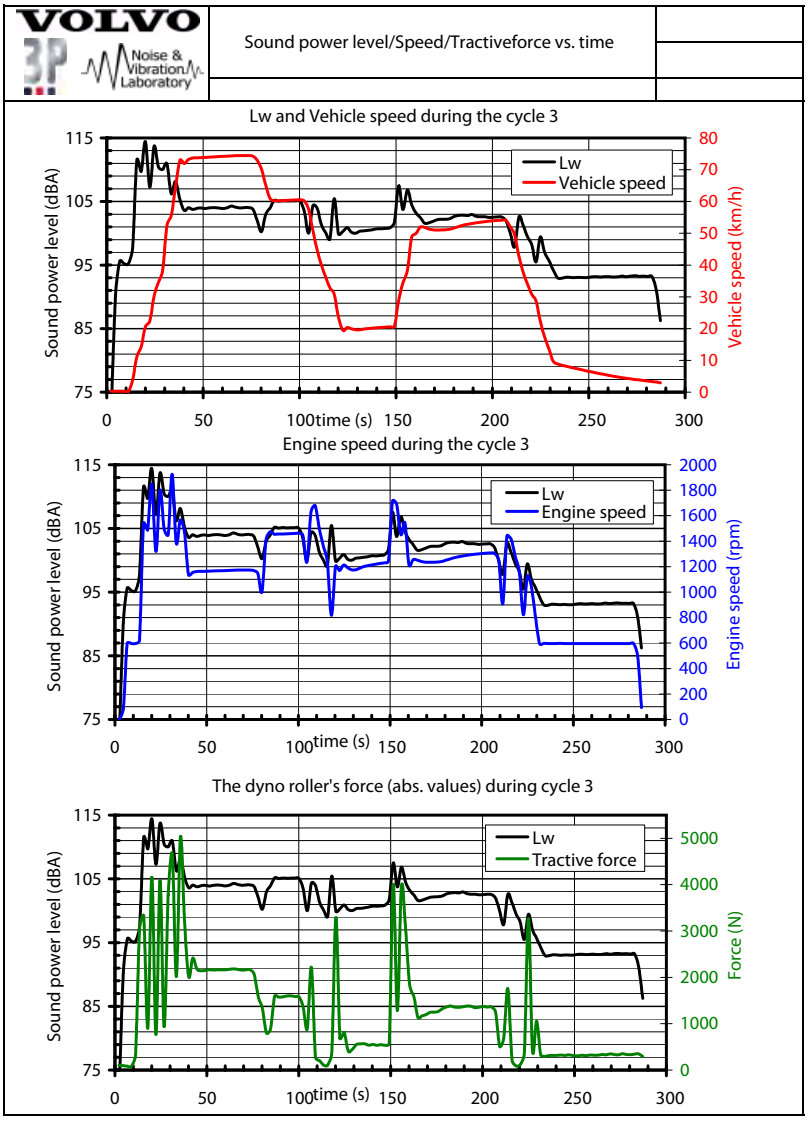
For many car models, the rolling noise and the powertrain noise under the test conditions are of the same order of magnitude with some small variations depending upon car class. Further reductions of powertrain noise makes only a small difference because the test is depending upon tyres that are quiet on the smooth ISO surface. The possibilities to develop much quieter tyres appear very limited. It would require narrower tyres which would not satisfy other requirements on the performance.

At higher speeds the rolling noise dominates which means that tyres and roads are determining. At speeds well below 50 km/h, the power train noise dominates but the fulfillment of the limits set for 50 km/h does not imply that cars are quieter at 30 km/h than at 50 km/h. Electric drive would mean lower noise emissions at low speeds.

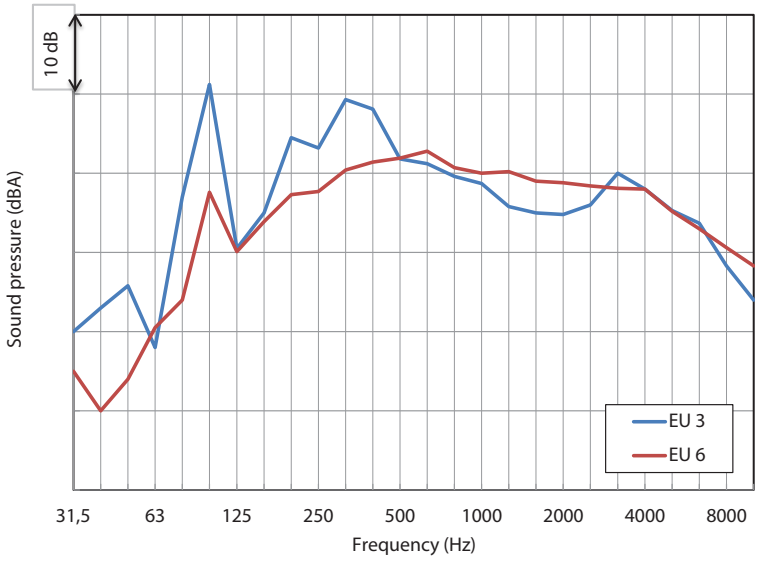
The quiet electric vehicles have given rise to an unexpected new problem. It has been argued that they are so quiet at low speeds that they may cause a risk for blind persons. Therefore, the US Congress has decided on a law that these quiet vehicles must have an acoustic warning system, called AVAS (Acoustic Vehicle Alerting System). Unfortunately, it seems that these systems may be compulsory also in Europe. This is regretable. According to available information, this issue appears to be a non-problem in reality. The risk for accidents in reality has been found very low. But the AVAS, if demanded, may become a problem in otherwise potentially quiet areas.

For heavy trucks the power train noise normally dominates over the rolling noise in the test. Most heavy trucks have diesel engines. It is technically difficult to decrease the noise emission from these engines more than marginally and it demands very long lead time for each dB. According to the panelist Kaj Bodlund, the type test has low correlation with a “city cycle test”.



The noise emission from a heavy truck with diesel engine is better correlated with engine speed than with vehicle speed.

The noise emission from a heavy truck varies both with vehicle speed and engine speed. The noise emission is better correlated with engine speed than with vehicle speed. One way to decrease the noise from the diesel powered trucks that was proposed in the forum is to use “geo-fencing”, i e to use external electronic means to limit vehicle speeds and engine speeds depending upon location to ensure that speed limits are kept and that the engine speeds are limited.



Comparison of maximum drive-by noise results for a Euro 3 and a Euro 6 muffler

The sharpened requirements on exhaust gases, EURO I to EURO VI, have led to mufflers with much increased volume that are more than 10 dB more effective at low frequencies than before. This is very positive for the indoor noise levels with closed windows

Truck noise emission often has a strong directivity; the radiation forwards is much stronger than sidewise. This is important for the urban noise but does not influence the pass-by test level.

Heavy vehicles are used for more specified purposes than cars. There are special city busses, vehicles for delivery, vehicles for garbage collection, etc. In many cases the noise problem may have little to do with the drive-by test according to ISO 372. Examples are stop and start at bus stops, noise from a process linked to use of the vehicle, rattling body noise, etc.

The method to make the power train quieter is to encapsulate the engines. This can lead to problems with overheatings and fires. Encapsulation is not a tool which can be used on all heavy trucks but for vehicles for special demands. For some of these services other engines with fewer noise problems may be a better solution to accomplish quieter city traffic. City busses with electric drive are a good example. Reasonable lead times for the development of such quieter vehicles for specific use is 5 – 10 years to get a 5 dB emission reduction.

Means to accomplish healthier acoustic climates in cities

Tor Kihlman and Wolfgang Kropp

CONCLUSIONS AND RECOMMENDATIONS

The forum

The forum was restricted to road traffic noise. It covered the whole chain from the vehicles on the road to the health effects caused by the traffic. The forum participants were all senior scientists or specialists from industry, authorities, consultants and academia. The conclusions are based upon the findings presented in the preceding sections. The costs and benefits of reducing the adverse health effects of traffic noise have been briefly discussed on page 10.

Present situation

Close to 30 million EU citizens are exposed to road traffic noise levels above the WHO short term intermediate targets, IT, L_{night}<55 dB or L_{day}<65 dB. They live with 20-40 % increased risk for severe diseases and premature death due to the traffic noise. The scientific evidence is comprehensive. The citizens should be much better informed about the health risks. The key question is to what extent the health effects can be accepted.

Environmental noise policy within the EU is ineffective. Existing methods to tackle the problems have major deficiencies and are partly misleading.

The Environmental Noise Directive, END has not led to much quieter cities in general; there are no compulsory immission targets that must be fulfilled or compulsory demands that action plans must be executed. The noise mapping according to the END is based on oversimplified calculation methods.

The present system to limit the noise emissions from road vehicles is not an effective tool to reduce the resulting noise immissions from traffic. It has limited relevance for the immissions from dense traffic in built up areas. The limit values recently decided are rather close to what is possible to achieve under the ISO 362 test system, method B, but this does not imply that vehicles cannot be quieter under other operational conditions.

The testing and labelling of tyres are not representative for the performance of tyres on many types of ordinary road surfaces.

A new policy is needed

The environmental noise problem is extremely complex and must be managed in a fundamentally new way. In the forum, there was a total consensus that nobody has or takes the responsibility and authority to really decrease the health effects of the traffic noise.

The noise issue is normally not considered sufficiently early in the general planning. If it is not required to reduce the health effects, they will not decrease. If it is not required to fulfill immission level targets, they will not be reached. But with firm actions it is reasonable and possible to reach WHO's intermediate targets within a 20 – 30 year period but it must be required to do that. This is not sufficient but a necessary first step to a more healthy situation.

The fraction of citizens highly noise exposed is closely related to the city planning from the general plan to the details of the buildings. Therefore, the focus should be on the process of urban sound planning. This urban sound planning must include:

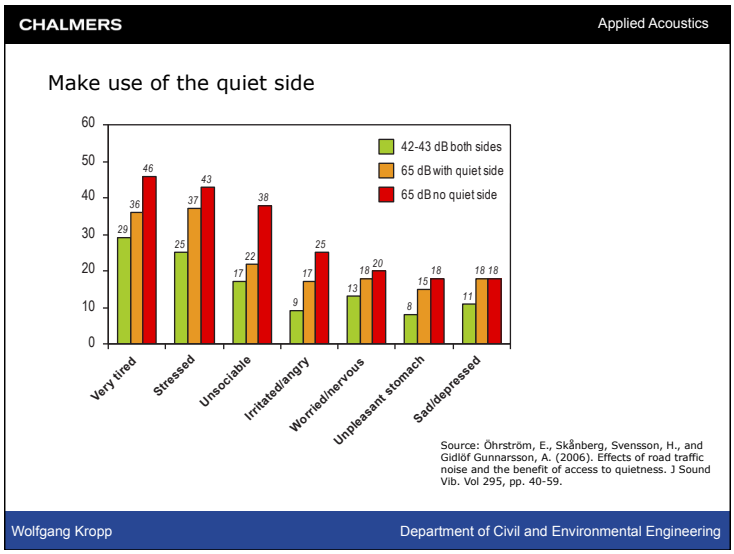
1 Strong influence on city planning from master plan to detailed building design.
2 High level involvement in the traffic management.
3 Source management with respect to immission control.

Several means to get a better acoustic climate in the cities are easiest to apply in compact cities and are in line with measures to tackle climate change. It can be developed into win/win situations. [4].

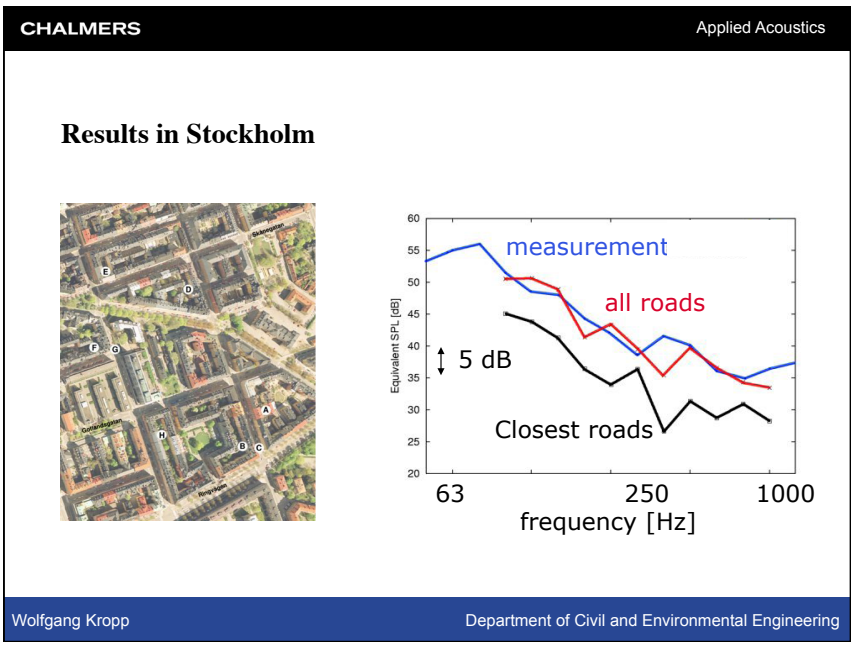
There is no single technological fix but with a combination of measures the adverse health effects of the traffic noise in cities could be substantially reduced. Actions are necessary on many levels but must be led by one responsible body. It is also important to observe that for almost each of these means, a high level of expert competence is necessary. Sufficient expert competence is lacking within the public authorities. Also on an expert level, e g among consultants, the broad and deep competence for urban sound planning is insufficient. The chain science/technology – policy – practice is weak and needs to be improved.

Strong influence on city planning

The traffic noise in a city varies much from location to location. Quiet and noisy places are often close to each other. These characteristics of the noise situation in any city are determined by its network of main roads and how the buildings in the vicinity of these roads are oriented and designed. An important part of the task to decrease the health effects of traffic noise is to make planned use of the shielding from buildings. The big noise level variations are not so much dependant upon variations in source strength but of variations in shielding and sound absorbing conditions. The shielding from the tall buildings may give rather quiet areas and locations. The noise levels in these quiet places depend upon the effectiveness of the shielding and the total radiated noise power from all the traffic within a vast neighbourhood and how this power is absorbed. The immission situation is therefore closely related to the city planning from the general plan to the details of the buildings.



Effects of road traffic noise and the benefit of access to quietness.



Noise levels in shielded courtyards. Comparison between measured and calculated data.
Black curve: Only the emissions from the closest streets considered.
Red curve: The emissions from the streets in a wider area considered.

A new discipline, urban sound planning, needs to be developed. The noise problem must be given a strong influence on city planning and construction from an early stage and further through the process including influence on the design of the buildings and their shielding and sound absorbing effects. Also, the acoustic properties of the road surfaces in the area are essential.

Commonly used noise prediction methods are inadequate. More advanced noise calculation methods which take into account such important factors as absorbing properties of ground and building facades and roofs, plantings, low barriers, etc must be used.

Quiet areas and quiet sides of buildings are important and also to some extent a compensation for the adverse effects from high noise exposure of other parts of a dwelling. It is an important part of the urban sound planning to save and further develop such areas.

The AVAS systems for increased audibility of electric vehicles at low speeds may lead to partial destruction of quiet areas. The positive and negative health effects of AVAS must be better clarified and judged.

High level involvement in the traffic management

Traffic planning and management is crucial to achieve healthier cities.

Traffic avoidance, mode shifts, low speed limits especially at night-time must be part of the planning for healthier cities. Demands must be set on limited noise emissions on public transportation systems, goods delivery systems, garbage collection, street cleaning, among others.

Quieter transportation such as bicycling and walking as well as public transportation must be promoted. It is important to have such noise emission properties from the public transportation systems that the emitted noise gets substantially less than that from individual transportation by car for the same flow of passengers.

Source management with respect to immission control

As stated, the present type approval system for noise emissions from road vehicles is not a useful tool for traffic noise management. The method is not intended for that purpose. With regard to the present type test and classification system, the noise limits cannot be set much stricter. Some problems with the present system are: Mixture of rolling noise and powertrain noise, measurements in two specified drive modes only instead of a drive cycle with a variation of speeds and operation, no information or specified demands on spectrum, directivity or emitted sound power.

A major technological problem especially when it comes to cars, is to develop tyres which are much quieter than today's. For cars further reductions of the powertrain noise have negligible influence on the measured noise level as it is the rolling noise from the tyres on the smooth ISO surface that determines the test result. To decrease the immissions, separate requirements on the powertrain at low speeds are needed.

For heavy vehicles, the difficult technological task is to make the diesel engines much quieter. Lead times of the order of a decade are probably needed to lower the noise levels one or two dB. The way to make these vehicles quieter in a shorter time perspective is to encapsulate the engines. This could be developed for special purposes in a few years but is not a method that is appropriate for all vehicles. But it can be used for special vehicles such as those for public services in the cities. Electrification is another possibility for some applications.

This implies that the requirements upon how to measure and describe the noise emissions from the different road vehicles need reformulations. Also, methods to measure and describe the acoustic properties of different road surfaces are important both for calculations of noise emissions and for contractual purposes.

Relevant standards for purchasing "quiet" services are needed. It is not sufficient that the vehicles fulfill the general minimum requirements in the present type test. Examples are stop and start noise at busstops, handling noise from vehicles making night deliveries or community services.

What is needed is data and specific requirements so that the resulting noise emissions for different vehicle compositions, speeds and speed limits can be forecasted and reduced. Needed are separate data and limits for rolling noise and powertrain noise under a number of driving conditions at different speeds including speeds both well below and above 50 km/h. (Cf drive cycles for exhaust gas emission regulations.) With such data, the authorities could make better use of traffic management and speed control as effective instruments for traffic noise control, e g by setting lower night-time speed limits. The quantities needed are the acoustic power and spectrum for the vehicles with rolling noise excluded and separate data for the tyres. Speed control methods must be "low noise", i e electronic control and not bumps which easily lead to frequent braking and acceleration and extra noise.

The rolling noise must be treated separately. It depends both on the tyres and the road surfaces. Methods to measure and specify these properties need to be better developed, also to be applicable for road contracts. This is a difficult task considering the realities under which road contracts are performed. Also, the present method to characterize and label tyres is insufficient and can lead to erroneous conclusions, (not only for noise but also for rolling resistance).

Recommended actions in the EU to achieve reduced adverse health effects of the environmental noise, especially road traffic noise in cities

DG Environment has the responsibility for the environmental effects of the traffic noise. This includes a responsibility to decrease the health effects as these are considerable.

The Environmental Noise Directive, END, is scheduled to be revised shortly. This is a timely occasion to develop an effective policy to reduce the adverse health effects. The END in its present form is not effective but it could be if substantially revised. It could be developed into the framework directive to reduce the adverse health effects of environmental noise.

There is no single technological fix. However, with a combination of measures the adverse health effects of the traffic noise in cities could be substantially reduced. Actions are necessary on many levels but must be led by one responsible body. Sufficient expert competence/understanding must be secured.

The directive should emphasize that action plans should also promote local opportunities to reach further than to the WHO short term intermediate targets.

Parts of the directive that need substantial revision and development are:

Compulsory immission goals should be set to be fulfilled within 20 years. Reasonable limits in this step are the WHO short term interim target values, L_{night} <55 dB and L_{day} <65 dB for dwellings. If the goals are not compulsory, very little action can be expected. Considering the health risks, these intermediate targets do not represent any high goal, but a reasonable first step possible to reach in 20 years.

Compulsory action plans to reach these targets in existing and new situations. It must also be mandatory to follow up these action plans and report the results every 5 years to the Commission. These reports should give not only "mapping data" but also descriptions of measures undertaken in planning and building to approach and reach the targets. The action plans must safeguard that new unhealthy situations are avoided.

The concept *competent authority* must be defined. Authorities that are given responsibility must be able to implement the measures that are needed for the action plan.

Better information to the public. Noise maps of today's type are not adequate. The information should be in the form of both levels and easily understandable with clear statements of the health risks.

Develop acoustic test methods and demands for vehicles for community services including public transportation relevant for urban sound planning. (C f END, Article 1, Objectives, point 2.)

Develop acoustic test methods for pavements relevant for road contracts

The importance of *urban sound planning* and a clear description of what it means should be given a separate article in the END.

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[4] Kihlman, T., **Noise policy – integration with climate and natural resource policies**, Noise/News International, Vol 21, no 2 2013

Appendix A

Roundtable Attendees

Lessening the Severe Health Effects of
Traffic Noise in Cities by Emission Reductions

A CAETS NCTC Forum
Hotel Central, Innsbruck, Austria
September 19, 2013

Wolfgang Babisch *	Federal Environment Agency, Germany
Thomas Beckenbauer *	Mueller BBM, Germany
Hans Bendtsen	Road Directorate, Denmark
Truls Berge	Sintef, Norway
Kaj Bodlund *	Volvo Group, Sweden
Hans Martin Gerhard *	Porsche AG, Germany
Colin Grimwood	CJG Environmental Management, UK
Michael Jaecker-Cueppers *	ALD DEGA, Germany
Tor Kihlman	Chalmers University of Technology, Sweden
Wolfgang Kropp *	Chalmers University of Technology, Sweden
William Lang	Noise Control Foundation, USA
Gaetano Licitra	ARPAT, Italy
James Mcintosh	Roads Victoria, Australia
Foort de Roo *	TNO, Netherlands
Ulrich Saemann *	Continental AG, Germany
Joachim Scheuren	Mueller BBM, Germany
Johannes Werner	MUI, Austria
Henk Wolfert	DCMR, Netherlands

*Panelist

Appendix B

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L. John Leggat, CAE
Jean Nicolas, CAE

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Royal Academy of Engineering, UK
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Philip Nelson, FREng

National Academy of Engineering, USA
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Appendix C

Organizations

Advancing Noise Control Engineering

The International Institute of Noise Control Engineering (I-INCE) is an international, nonprofit, nongovernmental consortium of more than 40 member organizations with interests in the control of noise and vibrations that produce noise. I-INCE was chartered in Zürich in 1974 on the basis of Swiss Civil Law. The objectives of I-INCE are to sponsor annual international congresses on noise control engineering in the INTER-NOISE series as well as other specialized conferences, and to promote cooperation in research on the application of engineering principles for the control of noise and vibrations. I-INCE undertakes technical initiatives and produces reports on important issues of international concern within the I-INCE field of interest.

The International Council of Academies of Engineering and Technological Sciences, CAETS, is an independent nonpolitical, nongovernmental organization. It represents 26 national academies, one academy per country. Among its objectives CAETS advises governments and international organizations on technical and policy issues related to its areas of expertise, contributes to the strengthening of engineering and technological activities to promote sustainable economic growth and social welfare throughout the world, fosters a balanced understanding of the applications of engineering and technology by the public, and provides an international forum for discussion and communication of engineering and technological issues. CAETS has taken up the noise issue with the mission to promote policies leading to a less noisy environment. This work is handled by the Noise Control Technology Committee (NCTC) of CAETS.

CAETS NCTC's role is to focus on engineering control of the world's dominant noise sources and to supply decision-makers with unbiased information on possibilities to make our environment less noisy. The committee offers a new perspective on the noise policy issue. The stakeholders in this issue are numerous—legislatures, government agencies, local authorities, manufacturers, trade associations, non-governmental organizations, advocacy groups, the public, and others. The mission of the CAETS committee is to be that of an impartial expert witness without affiliation.

The health effects of road traffic noise in cities are severe and constitute a threat to public health. Immission goals in the form of guideline values were formulated in many countries in the 1960s. The guidelines have remained rather unchanged but have often been much exceeded in practice. Now, the scientific basis for health-based targets has become strong.

A one-day forum was held in Innsbruck in September 2013. Its purpose was to clarify the effectiveness of present methods and policies. The forum was unique in bringing together noise control experts covering the whole chain from source to receiver including the health effects of the resulting immissions.

There is no single technological fix available to decrease the adverse health effects. The road traffic noise problems cannot get reasonable solutions only through emission reductions even with foreseeable best technology. Present methods to measure and describe the emissions are neither sufficient nor adequate.

Conclusions were drawn on what is needed and what can and should be done in terms of policy to substantially reduce the adverse health effects of traffic noise.
A concerted action by several involved bodies is needed.

International Council of Academies of Engineering and Technological Sciences, CAETS