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State of the art in managing road traffic noise: summary report

June 2017

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1 Executive summary

A key recommendation emerging from the final summary report written by the Conference of European Directors of Roads' working group on Road Noise 2009–2013 was that national road authorities (NRAs) should use innovative noise-related research undertaken by CEDR members when defining the scope of the CEDR Task Group Road Noise 3 work programme.

The latest innovative research in the areas of noise reducing pavements, noise barriers, and cost-benefit analysis (CBA)/cost-effectiveness analysis (CEA) was comprehensively reviewed and assessed by CEDR Task Group I6 (Road Noise).

The main objective of this research review was to collate results and make the latest innovative research findings as well as the main conclusions from previous CEDR noise task groups available to CEDR member countries.

This summary report identifies key issues and potential research topics for a possible 2018 Noise Research Call. It also presents recommendations for each of the research areas considered.

1.1 Noise reducing pavements

The subgroup working on noise reducing pavements addressed some of the key issues that CEDR NRAs may encounter when considering using such pavements as a noise mitigation measure during the planning, construction, and maintenance of national road schemes. Issues considered included the procurement of noise reducing pavements as well as potential costs, the importance of high-quality construction, acoustic performance during their lifetime, and incorporation of the parameter of noise into pavement management systems.

Recommendations:

- *CEDR recommends that NRAs evaluate the possibility of integrating the use of noise reducing pavements into the planning of new roads and the on-going maintenance of the existing road network following guidance provided in the ON-AIR Guidance Book on the Integration of Noise in Road Planning.*
- *CEDR recommends that NRAs give consideration to the development of specifications and performance standards relating to noise reduction to be used in the tendering process for noise reducing pavements.*
- *CEDR recommends that NRAs develop a common approach to integrating noise parameters into pavement management systems.*
- *CEDR recommends commencing demonstration projects to facilitate on-site visits to proven practice projects of noise reducing pavements on motorways and inner-city roads.*

1.2 Noise barriers

In relation to noise barriers, issues considered included the working principles of noise barriers, costs, European acoustic standards for barriers, considerations when installing new barriers, and monitoring barrier lifetime performance and innovative barrier solutions.

Recommendations:

- *CEDR recommends that when procuring noise barriers, NRAs insist on CE marking in accordance with EN 14388:2005 and set requirements based on laboratory-based test methods (EN 1793-1 and -2) and, in the future, on in situ test methods (EN 1793-5 and -6).*

- *CEDR recommends that NRAs undertake an asset acceptance assessment to ensure that new noise barriers are fit for purpose and meet NRA requirements.*
- *CEDR recommends that NRAs regularly monitor the actual condition of noise barriers in order to obtain basic information on future maintenance costs.*

1.3 Cost-benefit analysis and cost-effective analysis

Finally, cost-benefit analysis and cost-effective analysis were addressed to highlight the need for NRAs to use such tools when addressing noise impacts from roads. The use of various noise indicators and associated cost factors were considered and shortcomings were addressed; in particular, the current status of disability-adjusted life-years (DALYs).

Recommendations:

- *CEDR recommends that NRAs aim to achieve a greater knowledge of the cost factors relating to road traffic noise.*
- *CEDR recommends that NRAs invest in the development and dissemination of knowledge of using CBA/CEA for more effective noise abatement by organising workshops on the adoption and use of CBA and CEA in NRA practices.*
- *For CEDR NRAs that do not currently have a methodology for conducting CBA/CEA, the subgroup report provides examples of CBA and CBE that can be modified to take account of specific national requirements.*

1.4 Final remarks

Applying the knowledge presented in this report and the associated subgroup reports may lead to cost reductions for NRAs in the planning, construction, and maintenance phases of both new road projects and existing roads, as well as potentially reducing the number of noise-annoyed people living in close proximity to motorways.

However, it is clear that further work is needed to fill knowledge gaps and promote the use of common methodologies across CEDR NRAs. These steps may include the further research topics identified.

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3 Table of abbreviations

AC	asphalt concrete
CBA	cost-benefit analysis
CE	European conformity marking
CEA	cost-effectiveness analysis
CEDR	Conference of European Directors of Roads
CEN	European Committee for Standardization
DALY	disability-adjusted life-years
dB	decibel
dB(A)	decibel (A-weighted)
DISTANCE	Developing Innovative Solutions for TrAffic Noise Control in Europe
DL_α	minimum absorption value
DL_R	minimum sound insulation
EN	European Standard
LNP	low-noise pavement
NRA	national road authority
ON-AIR	Optimised Noise Assessment and Management Guidance for National Roads
PMS	pavement management system
SMA	stone mastic asphalt
QUESTIM	QUietness and Economics STimulate Infrastructure Management
WHO	World Health Organization

4 Introduction

Over the past decade, many of the member countries of the Conference of European Directors of Roads (CEDR) have undertaken a range of innovative noise research projects, generating results that may be of significant interest and benefit to other CEDR members. Although this research currently exists, similar research has been duplicated in other jurisdictions due to a lack of communication among national road authorities (NRAs) represented in CEDR. One of the recommendations formulated in the CEDR Road Noise 2009–2013 final summary report was that NRAs should use the available information on noise-related research when defining the scope of the CEDR Task Group Road Noise 3 work programme. This recommendation is now considered to be the basis of the task group I6 (Road Noise) within CEDR's Strategic Plan 2013–2017.

5 Objectives of CEDR's Task Group I6 (Road Noise)

The main objective for the task group on road noise was to collate results and make the latest innovative research information as well as the main findings from previous CEDR noise task groups available to CEDR member countries. It is anticipated that this should avoid duplication of research efforts across member countries and contribute to preserving NRAs' precious financial resources. The group also examined how noise mitigation measures are implemented in the planning, building, and maintaining processes for new and existing road infrastructure, in order to find solutions to managing road traffic noise issues, focusing on cost-effectiveness and improving traffic noise quality along national road networks.

Due to the limited time resources available to members of the group, the initial scope of the work was reduced to the provision of three subgroup reports, focusing on the following three research areas:

- noise reducing pavements,
- noise barriers, and
- cost-benefit analysis and cost-effectiveness analysis.

The three subgroup reports focus on areas that are essential to achieving reductions in road traffic noise and providing information on the most cost-effective solutions available to NRAs. Applying the knowledge presented in the reports may lead to cost reductions for NRAs in the planning, construction, and maintenance phases of new road and existing road projects as well as potentially reducing the number of noise-annoyed people living in close proximity to motorways.

6 Noise reducing pavements

6.1 Introduction

Tyre/road noise is generated by contact between tyres and pavements. For passenger cars, tyre/road noise becomes the dominant source of road noise at speeds over 35 km/h; for heavy vehicles, it becomes the dominant source of road noise at speeds over 60 km/h. For this reason, pavements are a key factor when considering road noise on both urban roads with speed limits of 50–60 km/h and on national roads and motorways with higher speed limits. The noise generated by tyres on a road surface is mainly determined by the surface texture and properties of the pavement.

It is widely accepted that noise abatement at source is generally more successful and cost-effective than reducing noise using barriers or by installing noise insulation in buildings. Noise reducing pavements have been proven to be the most cost-effective approach to mitigating road traffic noise at source even when the reduced lifetime of a pavement is considered. While the use of noise reducing pavements is slowly increasing across CEDR member countries, there is still a reluctance in some member countries to use such pavements due to the durability concerns associated with them and, in the case of porous pavements, perceived safety issues. The primary goal of this subgroup report on noise reducing pavements is to provide evidence that will demonstrate that the use of such pavements is a viable option to reducing noise at source on new and existing road infrastructure. It will also address some of the key issues that CEDR NRAs may encounter in relation to working with noise reducing pavements during the planning, construction, and maintenance of national road schemes.

6.2 Issues

- *Constructing a high-quality noise reducing pavement*

  Considerable engineering skills are required to construct durable and effective noise reducing pavements. A noise reducing pavement should not only be assessed on its ability to mitigate noise but also on how well it performs from a safety perspective and its ability to withstand operational requirements such as winter maintenance. Constructing noise reducing pavements requires the use of high-quality materials and skilled contractors as well as the establishment of comprehensive quality control procedures during the construction process. These procedures should address all processes at the mixing plant, delivery to the construction site, and all activities at the construction site itself. Contractors need to gain experience when it comes to working with noise reducing pavements. Initially, it is a process of trial and error: it takes time for the contractor to become familiar with the materials and how such pavements behave when they are laid. In order to obtain an appreciation of the difficulties entailed in working with noise reducing pavements, it is recommended that CEDR NRAs visit member countries that have already built up expertise in working with such pavements.

Figure 1: Example of two-layer porous asphalt

- *Cost and lifetime of noise reducing pavements*

  Generally, there is the perception that the costs associated with using noise reducing pavements are higher than those associated with using non-noise reducing pavements. These elevated costs are mainly attributed to what are in some cases higher construction costs and their shorter life expectancy. However, this is not the situation in all CEDR member countries. In the Netherlands, for example, the total cost of replacing dense asphalt concrete (non-noise reducing) is 23 EUR/m^2, while changing from dense asphalt concrete to noise reducing porous asphalt (LNP) or replacing porous asphalt is 16 EUR/m^2. With regard to maintenance costs, the annual maintenance costs for maintaining dense asphalt concrete and porous asphalt are the same, amounting to 1.22 EUR/year/m^2.

  However, several CEDR member countries have encountered durability problems with noise reducing pavements that have resulted in reduced working lifetime when compared with dense asphalt pavements. In the Netherlands, however, the average lifetime of dense asphalt concrete is 18 years and 17 years for one-layer porous asphalt.

- *Noise reduction of pavements during their lifetime*

  Road/tyre noise emissions from both standard pavement types and noise reducing pavements increase over time. The increase normally follows a more or less linear function, but is normally a little higher for the noise reducing types. Based on the conclusions arising from the QUESTIM (QUietness and Economics STimulate Infrastructure Management) research report (2012 Transnational Noise Research Call), it has been proven that the ability of some pavements to mitigate noise begins diminishing during the early lifecycle of the pavement. A range of factors—including climatic zone, traffic intensity, quality of sublayer, builder experience, and quality control—can contribute to diminished acoustic performance. It is important to understand that older pavements, while they may appear structurally sound, have generally lost some of the ability to mitigate road tyre noise. Therefore, when stating the overall ability of a pavement to mitigate noise, it is recommended that the average noise reduction over the lifetime of the pavement be used. This means that the average lifetime noise reduction effect of a pavement is defined as a difference in decibels, relative to the average lifetime effect of a national reference pavement, if such a reference pavement exists in a member state. All types of noise reducing pavements have their own specific average lifetime reduction. These noise reductions are valid both close to the road and at a considerable distance from the road.

Table 1: Expected average lifetime noise reduction from the main types of noise reducing pavements

Main types of noise reducing pavements:	Average lifetime noise reduction in dB relative to: dense asphalt concrete AC 11	stone mastic asphalt SMA 16
Noise reducing cement concrete pavements	0 - 1.5	1.5 - 3.0
Noise reducing thin layer pavements	1 - 3	2.5 - 4.5
Noise reducing split mastic asphalt	2.5	
One-layer porous asphalt	2 - 4	3.5 - 5.5
Two-layer porous asphalt	3.5 - 5.5	5 - 7

- *Incorporation of noise as a parameter into pavement management systems*

  Road engineers select the type of pavement to be used for surface renewal on the basis of specified criteria such as durability, lifetime, price, safety, winter maintenance, etc. Currently, however, noise is often not considered an important criterion. Due to the number of noise-annoyed people living in close proximity to major roads, the issue of incorporating noise as a parameter into pavement management systems (PMS) was considered in the QUESTIM report. The research indicated that while there are many stand-alone tools available that could be used for a preliminary assessment of some environmental elements at project level, there is a lack of consistent methodologies and robust tools at network level. It is anticipated that pricing road noise internally, within a network level pavement maintenance model, will advance the understanding of how the impacts of these externalities can influence the overall cost and development of strategies for road maintenance programmes.

  A system for integrating the cost of noise 'per km' depending on pavement type and age has been developed in Denmark and is described in the ON-AIR Guidance Book on the Integration of Noise in Road Planning. The QUESTIM project also developed a methodology for integrating noise into PMS using the strategic noise mapping data that was seen as providing the best coverage across road networks.

  It is anticipated that the integration of noise into PMS may enhance the use of noise reducing pavements in the pavement renewal process. It is recommended that CEDR NRAs give consideration to the integration of noise into their PMS in those cases where such a formal system exists.

- *Procuring noise reducing pavements*

  When procuring noise reducing pavements for a specific project, it is important not only to specify friction and rolling resistance criteria, but also the level of noise reduction the pavement should achieve in order to meet designated noise limit values. It is only in recent years that noise has become a performance criterion for procuring pavement works. Issues may arise in relation to assessing the level of noise reduction a new pavement delivers, particularly if the parameter of noise reduction is to be used as a performance indicator.

An important issue arises across European countries in determining the level of noise reduction that noise reducing pavements can deliver. The problem is that every country uses a different 'normal' pavement, which is usually a non-noise reducing pavement, as a reference or standardised pavement to compare the level of noise reduction achieved by a noise reducing pavement.

CEDR NRAs should give consideration to specifying and checking the level of noise reduction a pavement delivers post construction in order to ensure that they are getting noise reducing pavements that meet the specifications set out in their specific works requirements. Different systems have either already been developed or are currently being developed in the Netherlands, Denmark, and other countries. Research undertaken by the QUESTIM project into procedures for monitoring the acoustic quality of infrastructure based on the standardised method of measurement should be considered when developing such an asset acceptance procedure.

- *Possible topics for the 2018 Noise Research Call*

Based on the subgroup report, the following research topics could be considered for the 2018 CEDR Research Call:

- Enhancing the long-term performance (durability and noise reduction capabilities) of noise reducing pavements
- Improving our knowledge of the impact of winter maintenance on porous pavements in different climatic zones
- Optimising the noise-reduction potential of cement concrete by focusing on pavement surface texture
- Developing an asset acceptance methodology to be adopted by CEDR member countries

6.3 Recommendations

- **CEDR recommends that NRAs evaluate the possibility of integrating the use of noise reducing pavements into the planning of new roads and the on-going maintenance of the existing road network following guidance provided in the ON-AIR Guidance Book on the Integration of Noise in Road Planning.**

- **CEDR recommends that NRAs give consideration to the development of specifications and performance standards relating to noise reduction to be used in the tendering process for noise reducing pavements.**

- **CEDR recommends that NRAs develop a common approach to integrating noise parameters into pavement management systems.**

- **CEDR recommends commencing demonstration projects to facilitate on-site visits to proven practice projects of noise reducing pavements on motorways and inner-city roads.**

7 Noise barriers

7.1 Introduction

Noise barriers are the most widely used form of noise mitigation on European roads managed by NRAs. However, the costs of using barriers are high. When CEDR NRAs invest budgets in the provision of noise reducing measures, their main objective is to achieve good value for money, despite the initial costs. The subgroup report on noise barriers provides a comprehensive insight into the working principles of these noise reducing devices and the various acoustic and non-acoustic standards and guidelines used to ensure the performance of these devices.

7.2 Issues

- *Working principles of noise barriers*

  Although noise barriers come in many different designs and are constructed using a wide variety of materials, e.g. timber, metal, concrete, recycled plastics, etc., they all serve the same basic purpose, namely to reduce noise levels at noise-sensitive receivers.

  There are three mechanisms that influence the acoustic performance of any noise barrier: sound diffraction, sound transmission, and sound reflection/absorption. A correctly designed noise barrier will reduce noise primarily by influencing the length of the propagation path between the source and the receiver (sound diffraction). For a barrier to be effective, the amount of sound passing through it must be significantly less than that diffracting over or around it.

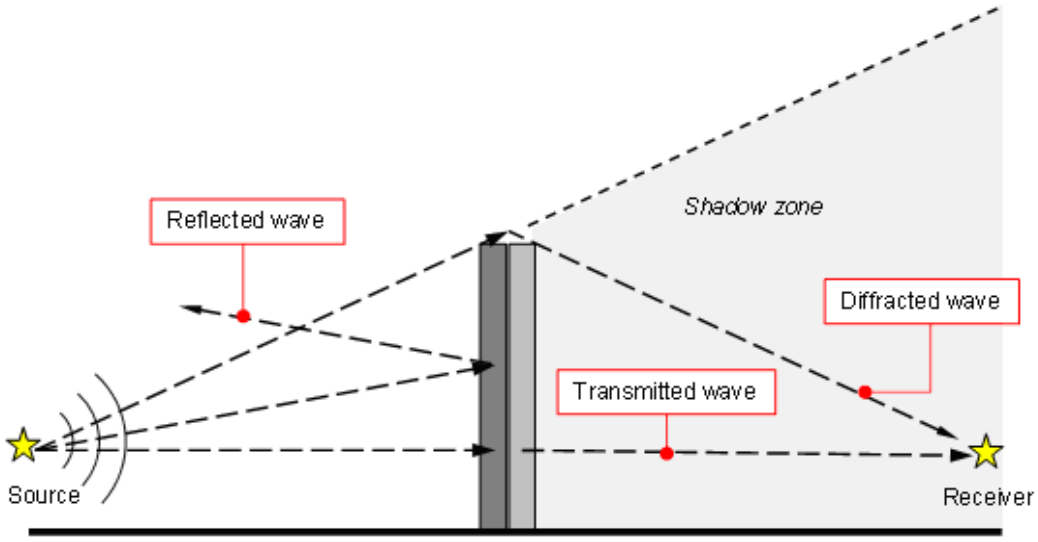

Figure 2: Mechanisms affecting noise barrier performance

A noise reduction of 10 dB(A) is obtainable at ground level in the area immediately behind a barrier of considerable height with sufficient insulation and absorption values. Noise barriers are relatively ineffective at distances of greater than 250 metres from the road due to the

limited alteration of the propagation path. In such cases, the sound pressure level reduction, measured as LAeq, is limited to a few dB(A).

It is important to accurately inform citizens of the likely reductions in noise levels that may be achieved by the erection of a new noise barrier. This can be undertaken by holding information meetings and producing brochures, noise maps, audiotapes, etc. The advantage of this approach is that future misunderstandings can be avoided. However, it is essential to understand that while individuals located at noise-sensitive receptors 'behind' newly installed noise barriers may experience much lower noise levels, the noise source will still be audible.

- *Noise barrier costs*

It is very difficult to compare actual prices of noise barriers across member countries because each NRA has its own method of calculating the price of a noise barrier. In the Netherlands, for example, there is an all-inclusive price for noise barriers with a height of 4 metres of €2,053 per m. In Spain and Belgium, the average price for a 4-metre-high barrier is between €1,000 and €1,200 per m, in Estonia €700 per m, and in Italy between €850 and €1,300 per m. In the report, 'Value for Money in Road Traffic Noise Abatement' 'produced by the Road Noise group in the previous CEDR strategic plan, the reference price for 4-metre-high barriers was €1,600 per m. This value is based on all barrier material types.

- *European acoustic standards for road noise barriers*

NRAs seek to procure acoustically durable noise barriers that are cost effective and have minimal maintenance requirements.

European standards for noise barriers and related devices acting on airborne sound propagation (road covers, claddings, and added devices) are written by CEN/TC226/WG6. These standards can be subdivided into three main sub-packages: acoustic characteristics, non-acoustic (mechanical and safety) characteristics, and long-term performance. It is important to note that these test methods focus on intrinsic characteristics of performance, i.e. the performance of the individual materials or components rather than how the product is used or installed.

With respect to the acoustic element of these standards, it is advisable that NRAs include the following requirements in NRA and contract specifications for noise barriers and related devices:

- CE markings, based on the harmonised European product specification EN 14388:2005;
- a minimum absorption value (DL_α) of at least 10 dB, based on the European standard EN 1793-1;
- a minimum sound insulation (DL_R) value of at least 25 dB, based on the European standard EN 1793-2 (currently under revision).

It is noted that both standards EN1793-1 and EN1793-2 use laboratory-based test methods.

In addition, the *in situ* test methods defined in EN 1793-5 and EN 1793-6 (currently under revision) should also be considered in NRA and contract specifications. This would allow

assessment against the initial acoustic performance and lifetime performance values (if the latter exists) declared by the manufacturer as part of the CE mark for the noise barrier.

It is, however, recognised that there are practical issues that may prohibit the use of the technique at any location. Unless acoustic monitoring equipment can be suspended robustly over the top of a noise barrier and accurately positioned, then having ready access to both sides of the noise barrier is necessary in order to apply the EN 1793-6 method. In the absence of suitable access points, the use of the *in situ* test methods will probably be restricted to application during barrier construction for conformity-of-production assessments. Furthermore, ensuring the health and safety of assessors is a key requirement for NRAs. Where barriers are located at the edge of the carriageway, then the ability to undertake acoustic assessments may be dictated by whether or not a hard shoulder/emergency lane is present.

- *Newly installed noise barriers*

  As previously noted, test methods under EN 14388 focus on intrinsic and non-extrinsic characteristics of performance. Therefore, despite optimistic results achieved in the laboratory, issues often arise during and after the installation of barriers. The weakest points—and thus the main source of acoustic leaks—occur at the interfaces between components of the noise barrier, e.g. joints between panels, foundation, and posts. Good-quality design/manufacture, including the adoption of appropriate protective measures during design/manufacture, selection of the appropriate type of barrier for specific locations, and installation/maintenance according to the manufacturer's instructions, are all key factors in ensuring a long and robust service life.

  To ensure that the noise barrier is fit for purpose and to avoid future issues, it is necessary to undertake some form of assessment or asset acceptance, such as a project sign-off, compliance with contract requirements, or conformity-of-production of the barrier. As recommended by the QUESTIM research report, visual inspections and acoustic assessments of newly installed barriers should be undertaken. The timing and scale of such assessments should be given due cognisance. The collection of such initial *in situ* acoustic performance data is also relevant if an NRA wishes to monitor the acoustic performance of the installed barrier over its working lifetime.

- *Monitoring noise barriers over their working lifetime*

  It is important that barriers fulfil not only the acoustic requirements at installation, but also maintain their long-term acoustic durability for their designed working lifetime. It has been identified that there is a lack of published data on the long-term acoustic *in situ* performance of noise barriers. Further noise measurement data is required, even though acoustic degradation over time is not currently a significant issue.

  In addition to the long-term acoustic performance, it is also important to monitor the actual condition of the noise barriers. Regular monitoring programmes for the barriers on a network should be set up in order to obtain information on future maintenance costs.

  In view of the logistical and practical criteria required to perform acoustic assessments, it is expected that visual assessments will be the preferred option for monitoring the condition of noise barriers. It is, however, noted that in the absence of manufacturer/supplier data on

long-term acoustic durability, NRAs may wish to perform at least occasional acoustic assessments to collate their own data.

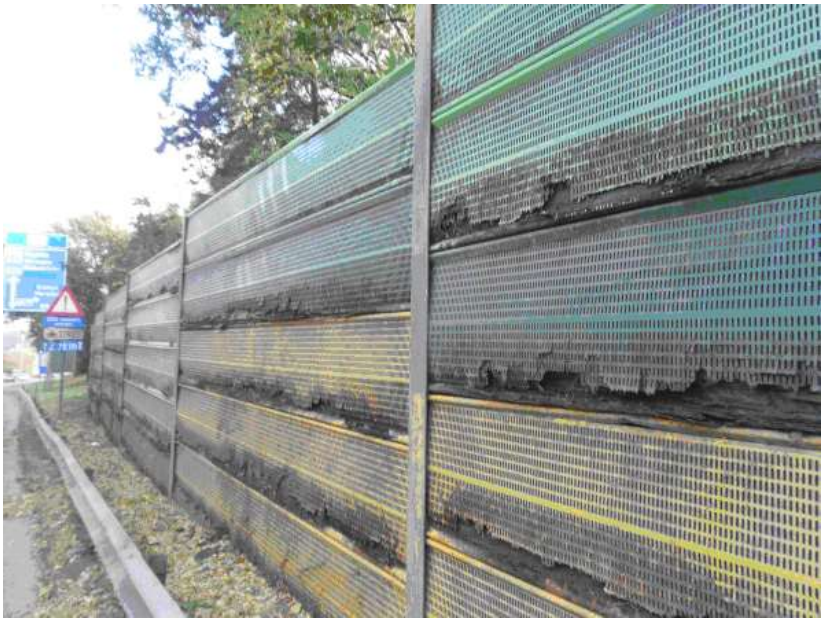

Figure 3: Example of a noise barrier with evidence of significant degradation

- *Innovative noise barrier solutions*

  As considered by the QUESTIM and DISTANCE (Developing Innovative Solutions for TrAffic Noise Control in Europe) research reports, innovative noise barrier solutions can generally be considered to be solutions that either use more innovative designs or materials for the construction of the acoustic elements or have additional secondary functions, such as power generation. The DISTANCE research report concluded that the following designed and secondary functions are currently available and may offer the greatest benefits to NRAs: noise barriers incorporating photovoltaic elements, integrated noise and safety barriers, enhanced visual aesthetics (including the use of transparency) to appropriately match the noise barrier to its installation environment, and green barriers.

  A recommendation from the 2012 Transnational Road Research Programme Call: Noise end-of-programme event workshop held in Hamburg in September 2015 was that there should be a large-scale demonstration project for additional secondary functions of noise barriers. In addition, it was recommended that a database of all innovative solutions including barriers be established.

- *Possible topics for the CEDR Call 2018*

  Based on the subgroup report, the following research topics are considered possible for the CEDR Call 2018:
  - Improving the long-term quality of noise barriers
  - *In situ* test methods that do not require the carriageway side of the barrier to be used by operators and/or equipment (for safety reasons)

- Correlating results of *in situ* test methods (EN 1793-5 and -6) and laboratory-based methods (EN 1793-1 and 2)
- Reviewing and compiling published data on the long-term acoustic *in situ* performance of noise barriers

7.3 Recommendations

- **CEDR recommends that when procuring noise barriers, NRAs insist on CE marking in accordance with EN 14388:2005 and set requirements based on laboratory-based test methods (EN 1793-1 and -2) and, in the future, on in situ test methods (EN 1793-5 and -6).**

- **CEDR recommends that NRAs undertake an asset acceptance assessment to ensure that new noise barriers are fit for purpose and meet NRA requirements.**

- **CEDR recommends that NRAs regularly monitor the actual condition of noise barriers in order to obtain basic information on future maintenance costs.**

8 Cost-benefit analysis and cost-effectiveness analysis

8.1 Introduction

It is the objective of every NRA to achieve maximum return or value for money from their annual expenditure budgets. It is therefore essential to assess the cost and benefits of noise reducing measures to ensure the selection of the most noise-efficient and cost-effective solutions to reduce road traffic noise. It is important that the costs associated with road traffic noise impacts are considered in the decision-making process for any policy, programme, or road project. Incorporating road traffic noise into cost-benefit analysis (CBA) or cost-effectiveness analysis (CEA) sends a clear message that CEDR NRAs are addressing noise issues in a considered and pragmatic way.

The main purpose of the subgroup report on CBA and CEA is to provide an introduction to the background and approaches used for the evaluation of noise impacts using CBA/CEA. It also provides examples of how such methods are used in different CEDR member countries, ranging from simple to more complex methodologies.

8.2 Issues

- *CBA, CEA, and noise indicators*

  CBA is an economic technique that attempts to quantify and compare the economic benefits and disbenefits with the costs associated with a particular policy, programme, or project for society as a whole. In CBA, monetary values are assigned to both costs and benefits, including road traffic noise associated with road projects and mitigation measures, e.g. noise reducing pavements or noise barriers. CBA uses noise indicators such as road traffic noise exposure, noise annoyance, sleep disturbance, and health impacts. To monetise the effects on noise, the noise indicator used is multiplied by cost factors.

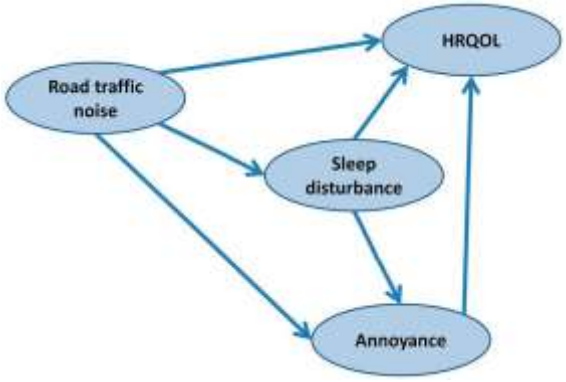

Figure 4: Model for the relationships between road traffic noise, sleep disturbance, annoyance caused by road traffic noise, and health-related quality of life (HRQOL) (after Héritier et al., 2015)[1]

[1] Harris Héritier, Danielle Vienneau, Patrizia Frei, Ikenna C. Eze, Mark Brink, Nicole Probst-Hensch, and Martin Röösli (2015) The association between road traffic noise exposure, annoyance and health-related quality of life (HRQOL). Int. J. Environ. Res. Public Health 2014, 11(12), 12652-12667; doi:10.3390/ijerph111212652

CEA is useful for comparing alternative policies, programmes, or projects in order to achieve the greatest outcome in terms of costs. It presents alternatives in order to identify the most appropriate option for achieving the most effective result in terms of reducing the noise impact at the lowest cost. CEA compares costs and non-monetised effects, based on the same noise indicators as CBA.
A noise indicator such as disability-adjusted life-years (DALYs), representing the health endpoint of the exposure-response relationships for noise, would be appropriate for both CBA and CEA. However, calculating DALYs is currently complicated due to the limited scientific data available on the relationship between road traffic noise and specific health effects. It is anticipated that the forthcoming World Health Organization (WHO) environmental noise guidelines for the European region will provide more comprehensive information on the disease burden. For future assessments, it may be possible to use DALYs. However, until such time, lower level noise indicators such as noise exposure or noise annoyance have to be utilised when undertaking CBA/CEA.

- *Cost factors for noise indicators in CBA*

  In order to undertake CBA, it is important that CEDR NRAs have reliable cost factors for noise indicators. This will allow these factors to be used in CBA for environmental impact assessment studies of road projects, noise action plans, planning strategies for road traffic noise reductions, etc. At present, cost factors for noise exposure differ substantially between CEDR member countries. This is attributed to the way each individual CEDR member country monetises its main CBA noise indicators such as noise annoyance and health effects. Additionally, there are CEDR member countries where no methodology currently exists when considering noise in CBA/CEA.

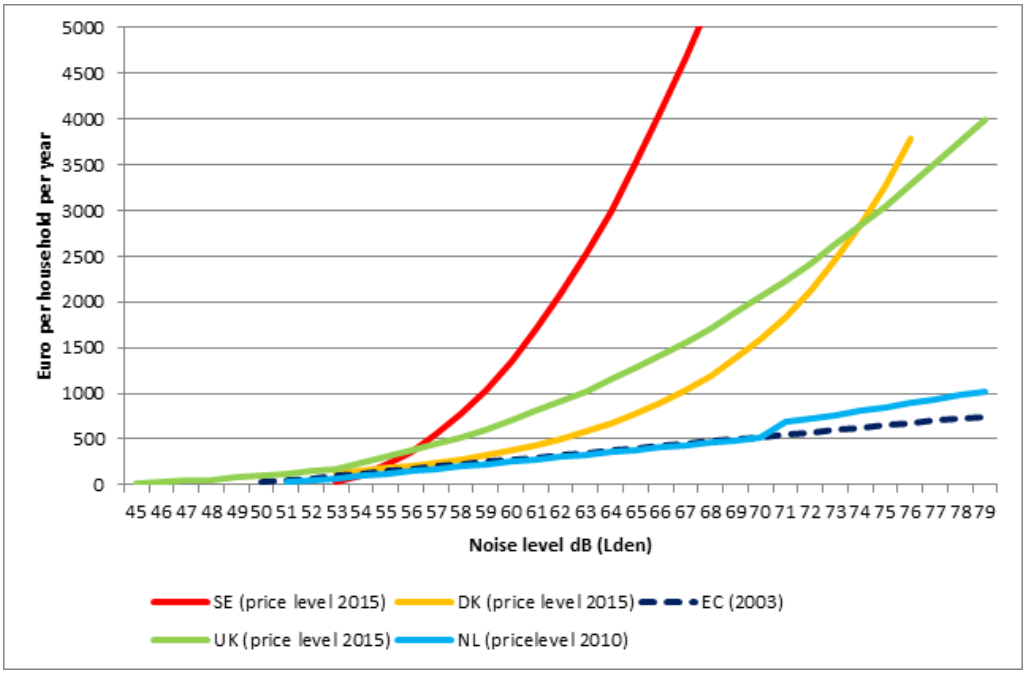

Figure 5: Cost factors for road traffic noise

The issue of significant differences in cost factors applied or the absence of same is only beginning to be considered. No consensus regarding the economic evaluation of road traffic noise exists between CEDR member countries. Research, dissemination, and member state adaptation is required before this issue can be resolved.

- *Possible topics for the CEDR Call 2018*

  Based on the subgroup report, the following research topics are considered possible for the CEDR Call 2018:
  - Identifying the rationale behind the use of different cost factors in Europe for the same noise indicators
  - Reviewing and revising the various cost factors, particularly health effects, considering new sources such as the forthcoming WHO environmental noise guidelines for the European region

8.3 Recommendations

- **CEDR recommends that NRAs aim to achieve a greater knowledge of the cost factors for road traffic noise.**

- **CEDR recommends that NRAs invest in the development and dissemination of knowledge of using CBA/CEA for more effective noise abatement by organising workshops on the adoption and use of CBA and CEA in NRA practices.**

- **For CEDR NRAs where no methodology currently exists to undertake CBA/CEA, the subgroup report provides examples of CBA and CBE that can be modified to take account of specific national requirements.**

Ref: CEDR report 2017/03
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