

Research for a Quieter Europe[★] in 2020



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ISBN 3-200-00224-7



EUROPEAN COMMISSION
RESEARCH DIRECTORATE-GENERAL

**An Updated Strategy Paper of the CALM II Network - Sep. 2007
(funded by the DG Research of the European Commission)**



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Foreword

The two previous editions of the CALM Strategy Paper have been published as printed brochures. These were issued in July 2002 and Oct. 2004. This Strategy Paper is an updated version of the second edition, but on this occasion it is only provided in an electronic format on the CALM website. Compared with the issue of 2004, the major changes of this updated version refer to the chapters “Environmental Noise in Europe” and “The Vision”, the research road maps as described in Section 5.3 and a slight re-structuring of the whole paper.

It is a pleasure for the members of the CALM II network to present this updated plan for future research to reduce environmental noise in Europe¹. This plan should create a solid basis for initiating and promoting research to reduce the adverse effects of noise.

Noise is one of the environmental pressures that are an important issue for citizens. In public surveys, problems with noise are often rated at the highest level together with global warming. Research is a key element in reducing the effects of sound levels that are too high. This research should include work on how noise affects people when they are at school, at university or at home, or when they visit areas for recreational purposes. The research should also deal with the reduction of noise emitted by individual noise sources, especially noise from transportation and from equipment used outdoors.

As with CALM, the CALM II initiative is the result of a close collaboration between DG Research and DG Environment the latter being the DG² responsible for coordinating the European environmental noise policy. This close collaboration should ensure that initiatives concerning research on noise reduction are in line with the requirements of the related EU directives, the EU noise policy and other environmental policies of the EU such as air quality.

¹ This Strategy Paper is a publication representing the opinion of an expert group. It is not an official EC document.

² Abbreviations used in this paper are explained at the end of the paper.

The CALM II network membership has been established with representation from three big national research programmes, from a New Member State and from the noise working groups that are supporting the implementation and further development of the Directive on Environmental Noise (2002/49/EC). In addition, a number of workshops have been held with a broad range of stakeholders in order to seek as wide an input to the project as possible.

This Strategy Paper will be revised and re-issued in September 2007 in printed format to take account of developments in the state-of-the-art concerning noise abatement and noise perception. To this end the CALM II network encourages input from all stakeholders, and in particular those who have not yet provided their comments.

It is the members hope that the work of the CALM II network will contribute to a quieter Europe. Finally, the members of the CALM II network would like to thank everyone who has contributed to this Strategy Paper.

The members of the CALM II network



Summary

Noise pollution remains high on the list of citizen concerns and noise reduction has increasingly become a focus for EU legislation and a priority for research. Starting back in the nineteen seventies, successive Directives have laid down specific noise emission limits for most road vehicles and for many types of outdoor equipment in order to control noise pollution. However, despite the enforcement of this increasingly stringent legislation on noise sources, and despite the considerable effort and progress made in noise control by the industry, there has been little improvement in the noise exposure levels suffered by citizens across Europe.

The Commission’s Green Paper on Future Noise Policy (1996) marked the start of an extended “knowledge-based” approach with a special emphasis of assessing and managing the exposure to environmental noise. This approach led to the Environmental Noise Directive of 2002 as a second cornerstone of noise policy, complementing the set of existing cornerstones of emission related directives. The Environmental Noise Directive focuses on a common approach to address environmental noise, to be executed at the national, regional and local levels according to the principle of shared responsibility. It also provides a basis for future action at the EU level. The future noise policy is built on long-term objectives mainly based on the Sixth Environmental Action Programme of 2002, the mid-term review of the Commission’s White Paper on Transport and the renewed Sustainable Development Strategy. The vision derived and proposed by CALM for the development of noise research targets up until the year 2020 is to

“avoid harmful effects of noise exposure from all sources and preserve quiet areas.”

Meeting this vision means that intensive research is required to provide a solid base for the efficient and effective control of environmental noise in future.

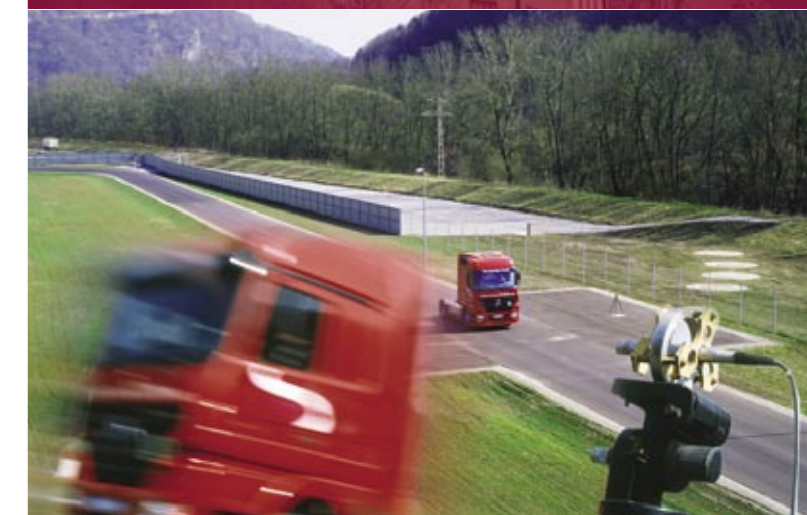
The noise research strategy must be in line with the direction of the future noise policy. The main goal of future research is, therefore, to support the implementation of the Environmental Noise Directive and the further development of noise policy.

This covers a wide range of research including assessment of noise exposure and perception, health impacts of exposure to noise, noise abatement including cost-benefit aspects, new technologies and system approaches for improved noise control at source and the further development of legislative standards.

The major sources of environmental noise to be considered are transportation (road, rail and air traffic) and outdoor equipment. Accordingly, the structure of the noise research strategy is split into perception and emission related research.



“Intensive research is required to provide a solid base for the efficient control of environmental noise in future.”



1. Introduction

Despite existing EU and national legislation targeted at controlling noise pollution, public concern and anxiety about noise remain high. The Directive on the Assessment and Management of Environmental Noise³ aims to create a quieter and more pleasant environment for European citizens within the framework of “Sustainable Development and Growth in Europe”. In order to support the ongoing development of a

“This noise research strategy plan shall contribute to current and future European research initiatives.”

comprehensive EU noise policy and the transposition and implementation of this Directive at national level, further noise research programmes have to be defined and initiated. The CALM II network⁴ is working on the further development of the strategic plan for such future noise research activities.

This Strategy Paper has been prepared by the CALM II network as an update of the second edition issued in Oct. 2004⁵, and is intended as a contribution to the current research programme⁶ and future research initiatives of

the European Community. The identification of areas requiring urgent research is also intended to inform decisions on noise research made at national level.

It is planned to further update this Strategy Paper in autumn 2007 based on developments in the state-of-the-art and new research needs.

CALM II research interests extend in principle to all sources of environmental noise such as road, rail, air and water borne transport, outdoor equipment, industrial noise, leisure activities like motor racing circuits, shooting ranges, recreational water borne craft etc. However, the focus of this paper is directed towards the main noise emitters transportation and outdoor equipment.



³ European Directive 2002/49/EC of 25 June 2002 relating to the Assessment and Management of Environmental Noise. OJ L 189, 18.07.2002, p. 12; quoted as ‘END’ in this paper. See also: <http://www.europa.eu.int/comm/environment/noise/>

⁴ “CALM II – Coordination of European Research for Advanced Transport Noise Mitigation” is a Coordination Action funded by the European Commission under the Sixth Framework Programme of the European Community for Research, Technological Development and Demonstration (2002 to 2006), contributing to the creation of the European Research Area and to innovation, Thematic Priority 6 Sustainable Development, Global Change and Ecosystems. (TCA4-CT-2005-516237, 1st Nov. 2004 – 31st Oct. 2007) See also: <http://www.calm-network.com>

⁵ CALM Strategy Paper “Research for a Quieter Europe in 2020”, Oct. 2004. See also: http://www.calm-network.com/index_preports.htm

⁶ Seventh Framework Programme of the European Community for Research, Technological Development and Demonstration Activities (2007 to 2013). Decision No 1982/2006/EC of 18 Dec. 2006 (OJ L 412, 30.12.2006, p. 1). See also: http://ec.europa.eu/research/fp7/home_en.html

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2. Environmental Noise in Europe

Nearly all human activities and the technical equipment associated with them generate SOUND. Sometimes sound is perceived as pleasant and amusing (like music). Or the activity confers some other significant benefit (like driving a car, mowing a lawn or listening to the radio), and provided that the sound level does not exceed a certain threshold, the sound is perceived as useful or informative or at least acceptable.

However, many of these sounds either exceed acceptable levels or provide no benefit to the person exposed to them and are hence unwanted, annoying, disturbing or even constitute a health risk. In this case, sound is perceived as NOISE. According to the EU legislation currently in force⁷, environmental noise means ‘an unwanted or harmful outdoor sound created by human activities, including noise emitted by means of transport,

road traffic, rail traffic, air traffic, and from sites of industrial activity, to which humans are exposed in particular in built-up areas, in public parks or other quiet areas in an agglomeration, in quiet areas in open country, near schools, hospitals and other noise sensitive buildings and areas’.

2.1. The Situation of Noise Pollution

The adverse effects of environmental noise are various and can be described in many different ways. According to the World Health Organization (WHO)⁸ “human health” is ‘a state of complete physical, mental and social well-being, not merely the absence of disease and infirmity’. Based on this definition, WHO identified a considerable number of specific adverse health effects⁹ caused by environmental noise.

These specific effects can be medical related, such as insomnia, high blood pressure, ischemic heart disease and hearing impairment, but can include also other effects like perceived sleep disturbance, psycho-physiological stress or the negative effect on the learning capabilities of children. The estimation of adverse effects is complicated by the fact that we are, in addition to being exposed to environmental noise, also exposed to other environmental stressors such as chemicals, with possible additive effects.

“Environmental noise can cause a considerable number of adverse health effects.”



⁷ Directive 2002/49/EC, OJ L 189, 18.7.2002, p.12-25.

⁸ Preamble to the Constitution of the World Health Organization as adopted by the International Health Conference, New York, 19 - 22 June 1946; signed on 22 July 1946 by the representatives of 61 states (official Records of the World Health Organization, No. 2, p. 100) and entered into force on 7 April 1948.

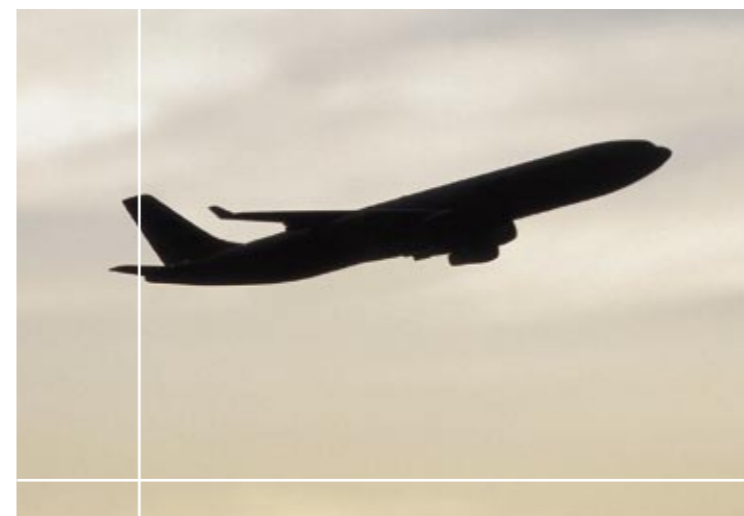
⁹ See: <http://www.euro.who.int/noise/>

“Transport noise is the main source of exposure to environmental noise.”

i

As regards exposure, the Commission Green Paper on the Future Noise Policy¹⁰ highlighted that the available data on noise exposure are generally poor in comparison to that collected to measure other environmental problems and often difficult to compare due to the different measurement and assessment methods.

It estimated however that ‘(...) around 20 percent of the Union’s population¹¹ or close on 80 million people suffer from noise levels that scientists and health experts



consider to be unacceptable, where most people become annoyed, where sleep is disturbed and where adverse health effects are to be feared. An additional 170 million citizens are living in so-called grey areas where the noise levels are such to cause serious annoyance during the daytime (...).

The available knowledge on exposure to environmental noise should however be soon improved, because,

in 2007, Member States have to publish first sets of strategic noise maps and report to the Commission harmonized statistics on exposure to environmental noise based on those maps.

On the basis of best available knowledge on exposure to noise and its related effects, external costs attributable to noise exposure can be derived by using economic models and assumptions. A wide variety of studies have examined the question of the external costs of noise to society especially transport noise which is by no doubt the main source of exposure to environmental noise. The Green Paper quoted that, for transport, these costs range between 0.2 and 2 percent of the EU GDP¹⁰. Taking the lower estimate, this implies an annual financial loss due to environmental noise of more than € 24 billions considering the today’s GDP. A recent study¹² carried out in 2004 estimated these costs to € 45 billions in 2000¹³.



¹⁰ Green Paper on Future Noise Policy, COM(96) 540 final, 4.11.1996.

¹¹ The Green Paper refers to EU-15.

¹² See: http://www.uic.asso.fr/html/environnement/cd_external/

¹³ This estimation refers to EU-15 plus Norway and Switzerland.

2.2. The Current EU Legal Framework

2.2.1. The Environmental Noise Directive

The main objectives of the END are the following:

- To assess the exposure to environmental noise using the harmonised noise indicators L_{den} (day-evening-night equivalent level) and L_{night} (night equivalent level).

“Public information about environmental noise assessment and action plans will increase awareness concerning noise.”

- To inform and consult the public about noise exposure, its effects and the measures considered to address noise, in line with the principles of the Aarhus Convention¹⁴.

- To adopt action plans based upon noise-mapping results ‘with a view to preventing and reducing environmental noise where necessary – particularly where exposure levels can induce harmful effects on health - and preserving environmental noise quality where it is good’.

- To provide a basis for developing Community strategies and measures to reduce noise emitted by the major environmental noise sources.

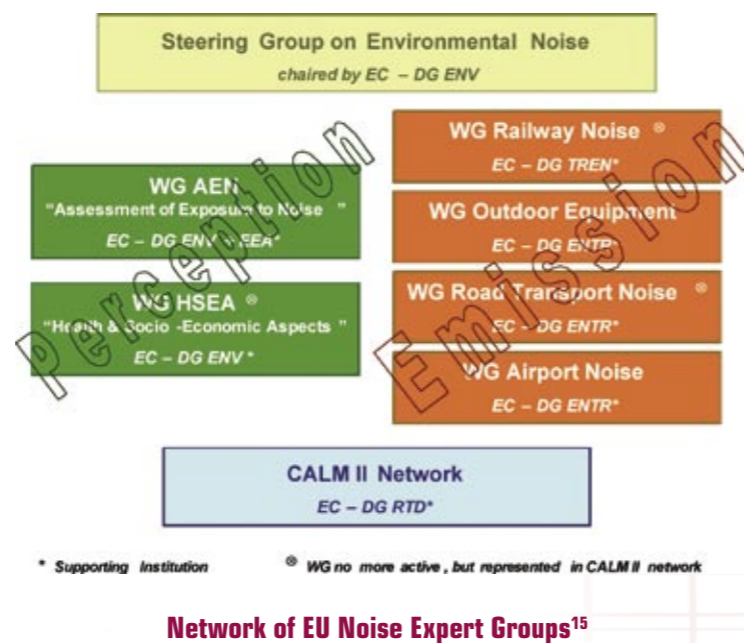
¹⁴ See: <http://ec.europa.eu/environment/aarhus/>

¹⁵ See: <http://ec.europa.eu/environment/noise/expert.htm>

The END consists of a main body and six supporting technical annexes:

- Annex I:** Noise indicators
- Annex II:** Assessment methods for the noise indicators
- Annex III:** Assessment methods for harmful effects
- Annex IV:** Minimum requirements for strategic noise mapping
- Annex V:** Minimum requirements for action plans
- Annex VI:** Data to be sent to the Commission

The technical content took into account – in line with the principle of “knowledge based approach” - the available findings of Community research and several expert groups (see scheme below) created to advise the Commission and Member States on the implementation of the directive. The annexes may be revised to take account of scientific and technical progress.



The competent authorities in the Member States have to provide strategic noise maps and action plans for agglomerations, major roads, major railways and major civil airports designated by Member States. The first round of strategic noise maps (due by 30 June 2007) and action plans (due by 18 July 2008) will concern:

- more than 130 agglomerations with more than 250 000 inhabitants (80 millions of inhabitants in total);
- more than 72 000 km of major roads with more than 6 millions vehicles per year;
- more than 5 000 km of major railways with more than 60 000 trains per year;
- 63 major civil airports with more than 50 000 movements per year.

Detailed information on authorities responsible for implementing the Directive in Member States, as well as on agglomerations, major roads, railways and airports to be covered by the first sets of noise maps and action plans, are now published on the web¹⁶.

Authorities responsible for data collection in Member States will have to report data from strategic noise maps (mainly statistics on exposure to noise from separate sources) and action plans to the Commission no later than six months after the deadlines set to deliver the noise maps and action plans.

In a declaration published in the Official Journal of the European Union¹⁷, the Commission highlighted that such data are essential in order to allow the assessment of the impacts, costs and benefits of further strategies and measures aimed at reducing environmental noise.

¹⁶ See: http://forum.europa.eu.int/Public/irc/env/d_2002_49/home

¹⁷ OJ L 189, 18.7.2002, p. 26, see: http://eur-lex.europa.eu/pri/en/oj/dat/2002/l_189/l_18920020718en00260026.pdf

¹⁸ See: Section 3.2

¹⁹ See: COM(2004)160 final, 10.3.2004 on Existing Community Measures relating to Sources of Environmental Noise, available at: <http://ec.europa.eu/environment/noise/#3>

2.2.2. The Directives Aimed at Limiting Noise of Sources

As stipulated by article 174 of the Treaty establishing the European Community, ‘Community policy on the environment shall be based (...) on the principles that (...) environmental damage should as a priority be rectified at source (...)’. Legislation at EU level governing noise emissions has, in general, a high importance. It links noise reduction measures to the source of environmental noise and its effects are therefore global rather than local. In following the “polluter pays principle”¹⁸, it encourages the development and implementation of the best available technology.

It is worth noting in addition that, according to the END, Commission’s review on the implementation of the END, due by 18 July 2009, has to assess the need for further Community measures and, if appropriate, propose supplementary measures aimed at limiting environmental noise at source.

Meanwhile, as required by the END, the Commission recently reviewed the existing Community measures relating to sources of environmental noise. This review¹⁹ was communicated to the European Parliament and Council in 2004. Basically, the regulatory focus in the past has been on the limitation of noise emissions of the most important means of transport and equipment for use outdoors.

“Promoting research in noise control at source encourages the development and introduction of the best available technologies.”

The first regulation with EU-wide application was the Directive on noise emission from motor road vehicles and dates back to 1970. Further important Directives mainly aimed at limiting transport and outdoor equipment noise followed:

- 70/157/EEC Motor vehicles
- 80/51/EEC Subsonic aircraft
- 89/629/EEC Subsonic jet aeroplanes
- 92/14/EEC Limitation of the operations of aeroplanes
- 96/48/EC Interoperability of the Trans-European high-speed rail system:
 - Technical Specification for Interoperability (TSI) relating to high-speed rolling stock - Commission Decision 2002/735/EC
 - TSI relating to high-speed railway infrastructures - Commission Decision 2002/732/EC
- 97/24/EC Motorcycles
- 2000/14/EC Outdoor equipment
- 2001/16/EC Interoperability of the conventional Trans-European rail system:
 - Commission Decision 2004/446/EC specifying the basic parameters of the “Noise”, “Freight Wagons” and “Telematic Application for Freight” Technical Specifications for Interoperability
 - Commission Decision 2006/66/EC relating to the sub-system “rolling stock - noise” and specifying limiting values for freight wagons, locomotives, multiple units and coaches
- 2001/43/EC Tyres for motor vehicles and their trailers and their fitting

- 2002/30/EC Operating restrictions at community airports
- 2003/44/EC Recreational craft

As regards equipments used outdoor, many Directives have been adopted between 1979 and 1986 to limit noise emissions from equipment such as construction machinery, compressors, generators, garden machinery etc. As the environmental situation and the technical features of such equipment changed over the years, adaptation to the new conditions became necessary. Therefore, the Directives have been revised and consolidated into the Directive 2000/14/EC²⁰, which covers some 57 different types of outdoor equipment and sets limits for noise emission or specifies the marking of sound power levels as information for the customer. This directive was amended in 2005²¹ to modify the list of equipments falling under the scope of the stage II limits applicable from January 2006.



²⁰ See: http://ec.europa.eu/enterprise/mechan_equipment/noise/index.htm

²¹ Directive 2005/88/EC, OJ L 165, 17.6.2006, p. 35

2.3. Limiting Environmental Noise and the Related Exposure

2.3.1. WHO Guidelines for Europe

Working in close co-operation with the scientific community, WHO has been developing indicators and guidelines for noise and health, and is now establishing exposure-response relationships for different health effects where long-term effects of night exposure



to noise such as long-term sleep disturbance and cardiovascular problems are being analysed.

Three particular initiatives from WHO are worth mentioning here, as they are already having consequences on policies aimed at managing environmental noise in the EU:

- The Guidelines for Community Noise²² edited in 1999 consolidating scientific knowledge on the health impacts of community noise and proposing guidance and guideline values to policy makers with a view to protect people from the harmful effects of noise, including environmental noise.

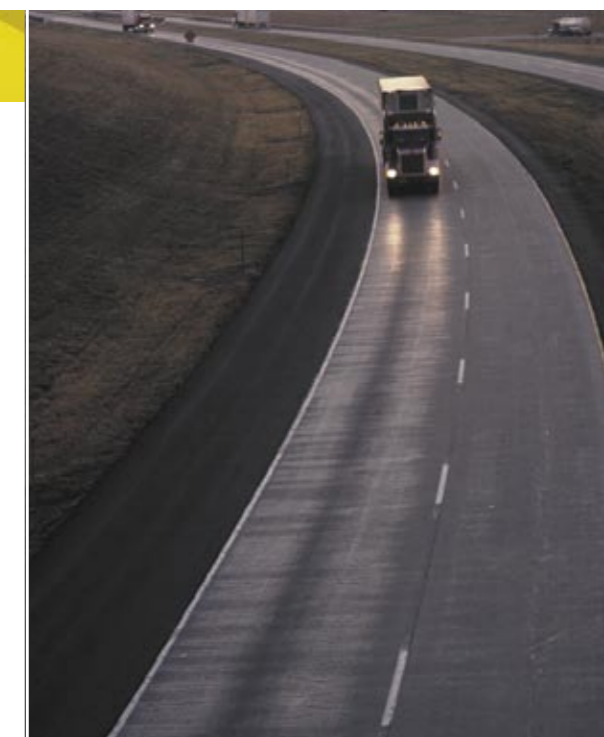
²² See: <http://whqlibdoc.who.int/hq/1999/a68672.pdf>

²³ See: http://www.euro.who.int/Noise/activities/20040721_1

²⁴ See: http://www.euro.who.int/Noise/Activities/20021203_3

- The on-going Night-Time Noise Guidelines project²³ planned to be completed in 2007 that reviewed health effects due to exposure to night-time noise and will recommend guideline night-time values for the protection of health.

- The Environmental Noise Burden of Disease project²⁴ also planned to be completed in 2007 that reviewed evidence on the relations between environmental noise doses and health effects and will provide policy makers with methodologies (dose-response) to estimate the magnitudes of health effects due to exposure to environmental noise.



2.3.2. EU Objectives on the Reduction of Exposure to Noise

Besides the END adopted in 2002 and the sources related legislations presented before, which all constitute the core legally binding requirements in this area, the reduction of exposure to environmental noise is promoted by other pieces of the EU “acquis communautaire” in the form of political guidance or commitment conveyed by EU institutions.

The below most recent ones are worth noting in this respect:

- The 6th Environmental Action Programme²⁵
- The mid-term review of the Commission’s White Paper on Transport ²⁶
- The renewed Sustainable Development Strategy²⁷

The 6th Environmental Action Programme adopted in 2002 by the Council and the European Parliament identifies “Environment and Health and Quality of Life” as one of the four environmental priority domains. Under this priority, the Programme stipulates that Community’s environmental policy should take account of WHO standards, guidelines and programmes and aim at ‘substantially reducing the number of people regularly affected by long-term average levels of noise, in particular from traffic which, according to scientific studies, cause detrimental effects on human health’.

It moreover states that priority actions in this area should consist in:

- ‘supplementing and further improving measures, including appropriate type-approval procedures, on noise emissions from services and products, in particular motor vehicles including measures to reduce noise from the interaction between tyre and road surface that do not compromise road safety, from railway vehicles, aircraft and stationary machinery’;
- ‘developing and implementing instruments to mitigate traffic noise where appropriate, for example by means of transport demand reduction, shifts to less noisy modes of transport, the promotion of technical measures and of sustainable transport planning’.

Adopted by the Commission in 2006 the mid-term review of the Commission’s White Paper on Transport acknowledges that ‘[transport] noise pollution (...) needs continuous attention’, that ‘[road traffic] noise will worsen’ and that ‘attention must also be paid to noise pollution from different modes of transport’.

The renewed Sustainable Development Strategy adopted in 2006 by the Council sets overall objectives, targets and concrete actions for seven key priority challenges for the coming period until 2010, amongst which is “Sustainable Transport”. One of the operational targets set under this key priority area consists in ‘reducing transport noise both at source and through mitigation measures to ensure overall exposure levels minimise impacts on health’.

²⁵ See: <http://ec.europa.eu/environment/newprg/index.htm>

²⁶ See: http://ec.europa.eu/transport/transport_policy_review/index_en.htm

²⁷ See: <http://register.consilium.europa.eu/pdf/en/06/st10/st10117.en06.pdf>

2.3.3. Environmental Noise Limits and Targets in the EU

For most sources, international conventions or EU legislation set limit values on noise emissions which have to be met by individual products (cars, aircrafts, trains, etc.) when put on the market.

On the contrary, the END does not set any EU limit or target values on environmental noise that would bind Member States to consider implementing noise abatement measures. Therefore the setting of such values falls exclusively in the remit of the Member States.



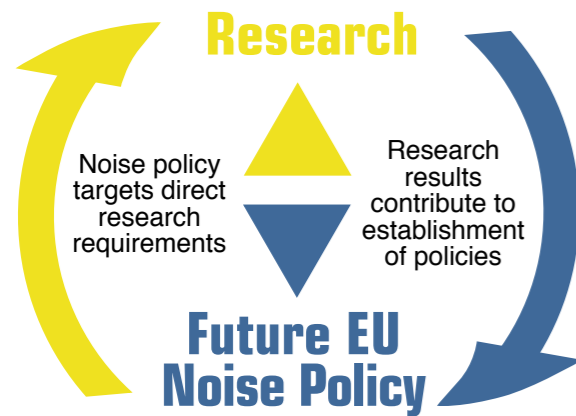
Member States obligations in this area are restricted to inform the Commission on the limit values in force or envisaged and to include such information in the action plans required by the END. The information reported so far to the Commission is made available at the web²⁸.

This information shows that Member States follow different approaches. For instance, some have set strict legally binding limits or targets whereas others publish recommended values. Some set limits triggering noise reduction measures for existing sources whereas others focus on the prevention of exposure to noise by setting maximum levels for new transport infrastructures or new buildings for instance. Some Member States set limits or targets for industries and transportation noise whereas others only focus on part of those sources. Moreover, values adopted or envisaged vary from one state to another, even for the same situations, and they do not necessarily correspond to WHO recommended values.

²⁸ See: http://forum.europa.eu.int/Public/irc/env/d_2002_49/home

3. Noise Policy and Research

3.1. The Need for Research



Research is crucially important in enhancing the knowledge base and enabling technological progress. Noise policy has to be built upon a solid base of knowledge about the roles and interactions of the essential factors of environmental noise and about the future technological possibilities.

Hence, there can be no progress in noise policy without research. The objectives of the noise policy have to be translated into specific targets and into time frames for the achievement of these targets. In many cases, the achievement of targets is dependent on new technological approaches, which must come from research initiatives. However, research is not only needed to turn regulations into practice but in many cases, initial research is needed in order to design and establish sensible regulations. Thus, research and regulation policy constitute an interactive loop.

3.2. Research-Related Aspects of Noise Policy

The overriding aim of current noise policy is to reduce the noise exposure of people in order to avoid adverse effects. Thereby, the policy has to consider some general principles which exist both at a technical level and at a legal level²⁹.

The **technical principles** refer to the management and reduction of noise emission and exposure and have a clear ranking:

1. To avoid or reduce noise at its source (“noise which is not generated cannot lead to noise exposure”).
2. To reduce noise in its propagation (measures as close to the source as possible should be preferred, because such measures protect the highest number of people).
3. To reduce noise at the receiver (these measures should only be used, if other measures are not sufficiently efficient and effective).

The **legal principles** are related to noise management, other environmental issues and sustainability.

- The polluter pays principle: persons or institutions that pollute the environment have to pay for measures to avoid or reduce the pollution or they have to pay for the harm caused by the pollution.
- The precautionary principle: in order to avoid or reduce pollution and to minimise environmental risks due to pollution, the emission of pollutants has to be avoided or reduced (using “best available technology”).

- The principle of cooperation: protection of the environment is a common challenge for the citizens, the government, the industry and all other parties involved.
- The principle of subsidiarity and shared responsibility: ensuring that decisions are made at a level that is as close as possible to the citizen, and that constant checks are carried out as to whether action at Community level is justified in view of the possibilities at national, regional or local level.

Considering these principles, in particular the technical principles, it is evident that the activities in research and technological development must cover all three technical fields of acoustics: the noise source, the noise propagation and the noise reception.

But besides these three fields related to noise mitigation, there are also other noise research topics to be considered which are of high priority for the assessment and management of environmental noise and hence for the further development of the Environmental Noise Directive. In the following chapters, such topics like harmonisation of assessment methods, deepening the insight into health effects of noise exposure and enhanced consideration of socio-economic aspects of environmental noise are subsumed under perception-related items.



“Research is crucially important in enhancing the knowledge base and enabling technological progress.”

“The first aim is to avoid noise or to reduce it at its source.”

²⁹ Volker K. P. Irmer: Do We Need a Global Noise Policy? *Internoise 2004*, Prague, 22 - 25 Aug. 2004.

4. The Vision: Less Noise by 2020

4.1. The Vision

Past noise policy in Europe has been concentrated on the regulation of noise emission from such substantial noise sources as road vehicles and outdoor machinery. Although noise emission limits have become increasingly stringent over the years, no corresponding reduction in noise immission in noise sensitive areas has been observed. On the contrary, exposure to noise in the general population may be increasing.

Although the targets in relation to this objective have been set only up to the year 2000³⁰, the aim continues to be valid and has been adopted as a long-term vision. The proposed vision for the development of noise research targets up until 2020 is to

"avoid harmful effects of noise exposure from all sources and to preserve quiet areas."

This vision is in accordance with the political target of the Sixth Environment Action Programme for the period up until 2010³².

"A strong vision for 2020: no harmful effects of noise exposure."

In response to this unsatisfactory situation, European noise policy has been revised to focus on noise reception. Therefore, based on the Fifth Environmental Action Programme³⁰, the Green Paper of 1996 defines as the aim of future noise policy that *"no person should be exposed to noise levels which endanger health and quality of life"*³¹.



³⁰ Fifth Environmental Action Programme of the European Communities: Towards Sustainability. OJ C 138, 17. 5. 1993, p.5.
³¹ Green Paper of the European Commission: Future Noise Policy. Annex I. COM(96) 540 final, 1996.
³² Decision No 1600/2002/EC of 22 July 2002 laying down the Sixth Community Environment Action Programme, OJ L 242, 10.9.2002, p.1. Art. 7: "...substantially reducing the number of people regularly affected by long-term average levels of noise, in particular from traffic which, according to scientific studies, cause detrimental effects on human health..."

4.2. Reference Targets for Future Research

Several expert groups have elaborated values for reception-related targets³³ which can be used as reference for future research designed to achieve this vision. They can be classified as follows^{34,35}:



Target Class	L _{den} (dBA)	L _{night} (dBA)	Expert Group
Minimum Target	65	55	UBA
Medium Target	55	45	WHO
Optimum Target	50	40	Dutch Ministry VROM + UBA

Targets as Reference for Future Research

Noise research and its following implementation into low-noise products will be justified, if the benefits due to the reduction measures will exceed their costs (i.e. cost-benefit ratio < 1). Basically, the monetary benefit of a noise reduction measure increases with the number of persons (households) benefiting from the lower noise exposure due to the reduction measure. A high number of benefiting persons can be reached first by global measures (i.e. noise control measures at the source) and second, if the cost-benefit analysis

considers a rather low "benefit threshold level" (e.g. near the optimum target), as the number of persons exposed to levels above the threshold increases, the lower the threshold is. Consequently cost-benefit analysis for the reduction of vehicle noise emissions should be based on benefit thresholds close to the optimum target in order to promote noise control measures at the source thereby increasing the efficiency of the measures.

4.3. Deriving Emission Targets

Although the reference targets are clear in their intention, they are difficult to translate into engineering terms. Within the CALM II network, two approaches have been developed which in due course could lead to emission targets for different noise sources. These are either a health based approach and a cost-benefit based scenario approach³⁵.

³³ Besides L_{den} and L_{night}, also other noise indicators are used, see Section 5.2.
³⁴ CALM Workshop "Road Maps for Future Research in Environmental Noise", Brussels, 16 March 2006: Contributions of Michael Jaecker-Cueppers and Heinz Steven.
³⁵ Martin van den Berg: Targets for Noise Immission. CALM Workshop "Road Maps for Future Research in Environmental Noise", Brussels, 16 March 2006. <http://www.calm-network.com>

4.3.1. Health Based Approach

As a first step, noise reception levels have to be set which guarantee the virtual absence of adverse health effects in the long term. Taking into account WHO recommendations, effect studies and limit setting practices in EU-countries, the optimum target levels of 50 dBAL_{den} and 40 dBAL_{night} are considered defensible. The next step is to take into account the differences in exposure distances e.g. airports and motorways are at larger distance from dwellings than urban streets. This leads to a series of design targets for transport vehicles in different user modes.

“The health approach leads to a series of design targets for transportation vehicles.”



4.3.2. Scenario Approach

The following steps have to be performed:

- The building of scenarios with different grades of noise measures
- Undertaking impact calculations on a number of model areas
- Calculating cost-benefit ratios

Limit values result from adapting to the best performing scenario. This approach has already been applied in the EFFNOISE study³⁶ yielding interesting results. However, further studies will be necessary to investigate the influence of various model parameters on the outcome. In the EFFNOISE study, the effect of the calculation model for instance was taken into account, and it was shown that this did not influence the order of preference for most of the scenarios.

It is not entirely surprising, but still satisfactory that these different approaches seem to give comparable results. Applying best available techniques to all equipment currently in use brings the target within reach, and seems to present not a too big challenge from the technological point of view.

5. Strategy for Noise Research

5.1. Strategic Priorities

The fundamental goals of any future research are to:

- Provide answers to open questions
- Find solutions for substantial problems
- Supply missing data

These fundamental goals have to be transformed to the requirements of the current and future noise policy. Bearing in mind the vision for 2020 and the need for increased efficiency of noise mitigation in Europe, the strategy for noise research focuses on supporting the European noise policy via its two cornerstones: the Environmental Noise Directive with its three elements assessment, information and actions which are closely related to the noise perception, and the emission-related legislation for controlling noise at source.

“Improved computation methods will enable more accurate assessment of exposure to noise.”

This leads to the two following strategic research areas which have the same high priority level:

■ Perception-Related Research

This area comprises, in particular, research on the assessment of exposure to noise, health effects and socio-economic aspects. The main aim of this research area is to provide an enhanced basis of knowledge for supporting directly the transposition of the Environmental Noise Directive. Therefore, it refers first of all to the need expressed in the END to adapt the annexes I, II and III of the END according to the technical and scientific progress.

■ Emission-Related Research

This area includes the two following research issues:

- Research which is required to further develop source-related and transmission-related noise control technologies with a special focus on the noise emission from transportation (road, rail and air traffic) and outdoor equipment.
- Research related to the further development of emission-related noise legislation.



³⁶ EU Project “EffNoise – Service Contract Relating to the Effectiveness of Noise Mitigation Measures”. Final Report, Volume I, Feb. 2004. <http://www.laermkontor.de>

5.2. Perception-Related Research

The Environmental Noise Directive has six technical annexes. For adoption by the European Parliament and Council in 2002, preliminary texts for the following annexes had been included in the Directive because of a lack of relevant information and research results:

Annex I (point 3):	Special indicators
Annex II:	Assessment methods (computation and measurement)
Annex III:	Harmful effects (dose-effect relationships)

These annexes which, in particular, are related to noise perception, need to be adapted on the basis of new research results. Progress has been made in adapting the annexes³⁷. However, there is still a clear need for research to achieve further improvements of the annexes and to support the transposition of the END. In addition, knowledge on specific subjects has to be acquired by research in order to further increase the efficiency of the EU noise policy and to continue its further development. This leads to the following research needs³⁸.

■ Advanced computation and measurement methods for more accurate assessment of noise exposure

- Advanced source modelling of aircraft noise
- Propagation modelling for noise at lower levels
- Availability and quality of noise mapping input data

including both geographical, meteorological and source related data considering also digital data sources such as geographical information systems (GIS)

- Methods using noise mapping data to estimate population exposure to environmental noise (linking noise mapping data with population location data i.e. number and location of exposed people)

All these items to be investigated are essential for increasing the accuracy and completeness of results and speeding up the assessment processes.

■ Definition and identification of urban and rural quiet areas

- Identification of most appropriate indicators and limit values
- Parameters influencing public's perception of quiet areas

Appropriate indicators and limit values are needed to define and delimit quiet areas and to determine the public response to noise exposure in quiet areas. Other influencing parameters have to be considered thereby.

■ Improvements in dose-effect relationships for L_{den} and L_{night}

- Improved relationships (especially with L_{night}) for aircraft noise
- Sleep disturbance (awakening) due to road and railway noise
- Effects of the degree of facade insulation (It has to be emphasised here that recent studies were not able to show a direct relation between the degree of sound proofing and a number of long term effects. As the investment in sound insulation runs into multi-million Euro, a study is urgently needed.)
- Effects of a quiet side of a building and of quiet areas in the neighbourhood
- Effects of noise management measures on people's perception (reaction on changes of exposure situations)
- Effects of multiple noise sources (combined effects)
- Effects of simultaneous exposure to noise and other factors such as chemicals or air pollution (see also below)
- Influence of cultural differences between countries including the effects of different patterns of social behaviour

As annoyance is widely considered to be the main effect of environmental noise, a reliable transformation of dose data into annoyance data is of high importance. Current dose-effect relationships for aircraft noise are based on older data which do not represent the status of present aircraft fleets. At present, it is not clear if and how this relates to the current dose-effect relationships. This is also true for some cases of railway noise like high speed trains. These and the other topics described above have an influence on the confidence interval of the dose-effect relationships.

■ Additional noise indicators considering specific effects

- Effect of low frequency noise and vibration
- Effect of L_{max}
- Effect of low number of noise events (determination of interval in number of events over which L_{den} and L_{night} is valid)
- Effect of quiet periods

There are indications that the above specific properties have significant influence on the noise perception, but are not sufficiently described and represented by the common indicators L_{den} and L_{night} . Research in these fields shall also lead to specific dose-effect relationships such as for low frequency noise, L_{max} and infrequent events. The occurrence of quiet periods may provide considerable benefits.



³⁷ - Commission Recommendation 2003/613/EC of 6 Aug. 2003 concerning the Guidelines on the Revised Interim Computation Methods for Industrial Noise, Aircraft Noise, Road Traffic Noise and Railway Noise, and Related Emission Data. OJ L 212, 22.8.2003, p. 49.

- Good Practice Guide for Strategic Noise Mapping and the Production of Associated Data on Noise Exposure. Position Paper of WG-AEN, Version 1, 5 Dec. 2003.

- EU-Project HARMONOISE "Harmonised Accurate and Reliable Prediction Methods for the EU Directive on the Assessment and Management of Environmental Noise". www.harmonoise.org.

- EU-Project IMAGINE "Improved Methods for the Assessment of the Generic Impact of Noise in the Environment". www.imagine-project.org.

³⁸ The list of research topics is rather long. However, it has to be noted that with clever study design many topics can be covered and resolved within one study.



■ **Advanced methods of cost-benefit assessment**

- *Improvement of benefit estimations based on SP (stated preference) method including valuation for quiet and undisturbed sleep*
- *Improved benefit estimates based on HP (hedonic price) method*
- *Improved benefit estimates due to changes in modal-split (e.g. from car transport to cycling)*

Cost-benefit analyses (CBA) are important elements for establishing action plans. Further development of the two most common methods is required to reduce uncertainties and to provide more accurate estimates.

■ **Combined effects between air pollution and noise (especially for road traffic)**

There is evidence that living close to major roads is associated with adverse health effects (respiratory and cardiovascular effects). It is assumed that air pollution is an important source for these adverse effects, but the influence of environmental noise

on cardiovascular functions cannot be excluded in these situations. In order to disentangle the role of concomitant environmental stressors, interdisciplinary research is required³⁹.

■ **Improvement and extension of noise valuation method**

- *Extension of method towards differentiating between different transport modes (road, rail, air)*
- *Influence of the pre-noise reduction level (i.e. noise level before applying the reduction measure) on the valuation of noise reduction*
- *Methods for the valuation of health impacts and other impacts of noise reduction*

For valuation of noise reduction, a value of € 25 per household/decibel/year is recommended⁴⁰. However, this value was developed only for road transport noise reduction and does not consider the influence of the pre-noise reduction level, the health impacts and other impacts of noise reduction measures like the effects on local air quality, the emission of greenhouse gases, traffic safety etc.

■ **Improved or new socio-economic instruments to promote efficient noise abatement**

Efficient instruments are required to direct consumers towards quieter products and quieter behaviour (based on positive or negative incentives related to the use of noisy devices, to the extent of noise nuisance or to the cost caused by the noise impact to the society). Further need is given for optimisation of the work split between different levels of noise abatement systems (local, regional, national, EC, international) depending on the abatement system to increase the efficiency of such split work and action plans.

³⁹ EC DG Joint Research Centre launched a co-ordinated research activity through the organization - in collaboration with EEA, WHO and the CALM network - of an exploratory workshop on "Combined Environmental Exposure: Noise, Air Pollution and Chemicals" which took place in Ispra (Italy) on 15 and 16 January 2007.

⁴⁰ Position Paper of WG-HSEA on "Valuation of Noise". 21 March 2003.



“Research support for the stakeholders means quieter products and strengthened competitiveness in the market.”

5.3. Emission-Related Research

Research on topics that are related to noise emission and transmission must follow two strategic directions. One direction is to provide support for the **further development of emission-related regulation**. The other direction is to provide support for the development of **new technologies and solutions** for the reduction of noise emission and transmission to an extent which cannot be achieved by existing technologies, but which is required to comply with the future regulation and market requirements. This includes also the technological development of solutions towards higher cost efficiency.

Following the first technical principle and most of the legal principles of noise mitigation as outlined in section 3.2, research and technological development in the fields of noise control at the source play an important role in the noise policy and research strategy. Control of transport noise at the source results in global measures which have the advantage of acting not only locally, but globally leading to a good cost-benefit ratio, in particular, if the benefit threshold is set rather low (see section 4.2). In addition, promoting research in noise control at source automatically means research support for the stakeholders in the development of new technologies to make their products quieter which strengthens their competitiveness on the international market. The production of quieter products should

provide not only reduced sound levels, but also, and most importantly, the reduction of perceived noise annoyance and adverse health effects.

The research requirements have to be focused on the main components of environmental noise which are the four noise categories of:

- Road traffic noise
- Railway noise
- Air traffic noise
- Noise from Outdoor equipment

In future, the traffic volumes for the different transport modes will significantly increase which inevitably means an increase in the number of noise sources and an increase in noise emission. Based on the situation in 1998, road traffic is likely to increase by 20 % in passenger transport and 40 % in goods transport by 2010. For the railway sector, the political target is a doubling of passenger and trebling of freight traffic by 2020. Furthermore, with regards to air traffic, a doubling of passenger transport is predicted by 2020. This means that in setting targets for future noise research the increase of future noise emission due to increased traffic volumes has to be considered. It also means that the new noise reduction technologies also have to account for this volume-related traffic noise increase.