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Quiet Traffic – A Joint Effort of Industry, Academia, and Agencies to Reduce Transportation Noise

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Abstract

Traffic noise has become a severe environmental problem with ever more people feeling affected by and complaining about it. To help achieve objective and subjective perceived noise load reductions, manufacturers and operators in the fields of road / rail / air traffic, academia and research institutions, and government agencies have decided to join forces in a cross-sector research network in Germany. The network provides

- A platform for communication and exchange of information
- A new cooperative structure with transparent and interdisciplinary R&D projects.

By concentrating their efforts, the partners will optimize use of resources, minimize costs, and increase output. So far, five subject areas have been established to explore solutions for noise reduction at the source, quieter traffic routes and operational procedures:

- Dose/effects on humans (provide guidance and pinpoint efficient ways to lower the most disturbing effects from noise exposure)
- Low-noise road traffic (tire-road interaction, noise at expansion joints);
- Low-noise trains and tracks (wheel-rail interaction, propulsion noise)
- Low-noise transport aircraft (engine and airframe noise)
- Common technologies and methodologies concerning noise sources, propagation, and prognoses.

To further strengthen noise abatement efforts and introduce innovations faster and more effectively national efforts will be coordinated with EC-programs.

1. Introduction

“One day man will have to fight noise as bitterly as cholera and pestilence!” Nobel Laureate Robert Koch, 1910

Mobility is a basic human need and an essential precondition for economic growth. But mobility on roads, on rails, and in the air is associated with noise. With more and more people feeling affected by and complaining about noise, traffic noise has become a severe environmental problem. In Germany, located in the heart of Europe and with a high population density, more than 50% of the population feel affected, 70% by road traffic noise, 40% by air traffic noise, and 20% by rail traffic noise. With traffic density on the rise, noise pollution will increase considerably over the years to come. If “livability” in communities affected by traffic noise is to be maintained or even enhanced without letting noise bottleneck economical development, measures must be taken to reduce noise levels created on roads, rails and near airports.

To help support noise abatement measures, manufacturers and operators, academia and research institutions, and government agencies have decided to join forces. Led by DLR, the German

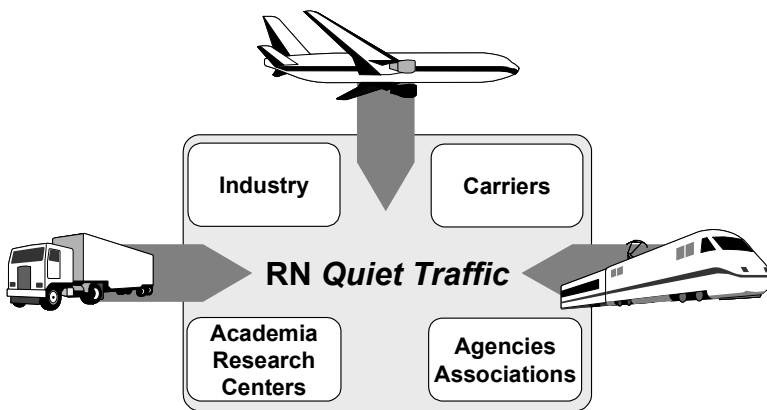


Fig. 1: Research Network Quiet Traffic: Across branches - interdisciplinary; ca. 70 Partners

Aerospace Center that is also active in ground transportation research, they have established a research network in Germany, dedicated to traffic noise abatement [1, 2]. The network provides an open scientific platform for communication and exchange of information, and cooperation in transparent and interdisciplinary R&D projects. By combining their research efforts, the partners aim to increase their output and optimize the use of resources.

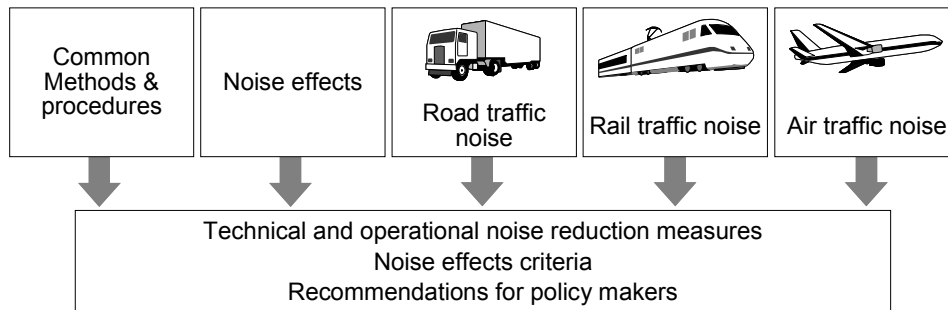
2. Network Concept and Goals

To achieve an objective and subjective reduction of perceived noise loads the network pursues these strategic goals:

- Enhance noise awareness and demonstrate scientific responsibility
- Study noise effects on humans, specifically psychosocial effects, consequences on sleep, health, and performance; formulate criteria und limit values
- Analyze transportation noise; explore technical solutions and introduce corrective measures to attenuate noise, support low-noise vehicle design, quieter routes and operational procedures
- Establish valid scientific and technical bases for traffic management, regulations, and standards; issue recommendations for policy makers

- Coordinate all traffic related noise abatement efforts

To this end five subject areas have been established – Fig 2:



In the three major transportation sectors – rail / road / air – research efforts in the first phase concentrate on a) dominating noise sources where b) short to medium term solutions seem feasible.

Accordingly, in the field of **road traffic**, 1st phase activities are directed toward reducing tire-road noise. These comprise:

- Low-noise tire design
- Optimized tire-wheel house combination
- Tire-surface interaction
- Sound absorbing surface materials (asphalt, concrete)
- Low-noise expansion joints (road-bridge transitions)

Next in line will be efforts to reduce noise coming from the vehicle power train (fan, motor, driveline, exhaust). Exterior aerodynamic noise of today's production cars is not a major problem right now but needs to be dealt with once tire-road noise levels come down.

In **rail traffic**, both regional and long distance, the major noise sources are propulsion system components and brakes. In the 1st phase, network activities include:

- Ventilation system noise
- Braking noise

Prevailing at medium speeds is rolling noise, coming from the wheels, rails and tracks and their interaction. Wheel track interaction also is the source for low speed curve squealing. Research is allotted to:

- Rail web damping
- Optimized rail anchors
- Continuous anchoring
- Slab tracks

Secondary measures like use of sound insulation materials and covers on engines and cars are currently not included.

In **air traffic** objectionable aircraft noise comes from the engines and increasingly -with advances in propulsion technology- the airframe. While network activities in these areas are expected to pick up next year when funding is believed to become available on a broader scale, ba-

sic noise attenuation research is presently conducted by DLR. In the field of jet and engine noise DLR concentrates on fan noise reduction, especially

- Optimized fan design
- Suppression of disturbing discrete tones by active noise control (ANC).

To cope with airframe noise, the most attention currently is directed towards:

- High-lift devices
- Landing gears
- Gear wake/flap interaction

Activities include wind tunnel source noise studies, modeling, and flyover tests for data collection and verification.

3. Cross-Sectional Research

In addition to the straight forward approach of attenuating noise in the individual transportation sectors as described above, network efforts encompass two additional research fields: “Common methods and procedures” and “Effects on humans”. Work in these fields addresses issues relevant to all sectors and provides guidelines for targeted research to overcome the most pressing problems and provide solutions that contribute most effectively to reducing noise immission levels. Instead of isolated measures these solutions will take into account technical, operational, and regulatory measures.

3.1 Development of common methods and procedures

The following research projects have been put forward so far:

- Sound locating methods: In the past, 2-D microphone array techniques have been successfully applied to identifying noise sources on landing transport aircraft. These methods are further refined, and systems are developed for application to rail and road vehicles in drive-by tests as well as for source location in rotating machinery like open rotors and fans.
- Sound immission prognosis: Perceived noise level prediction methods are to be developed to serve as major tools for land-use planning near traffic noise polluted areas. They include experimentally validated sound propagation modules that take into account the effects of topography, meteorology and acoustic ground impedance. Isolated and combined exposure to acoustic signals from multiple traffic noise sources will be evaluated.
- Acoustic simulation procedures: Activities deal with computational methods for aerodynamic noise generated by the flow around vehicle geometries and with the application of energy flux methods to study structure born sound propagation in typical vehicle structures.
- Traffic management: Strategies for noise control thru traffic management and urban land-use planning will be investigated, including telematics-based urban traffic management systems.
- Broadband noise: Broadband noise of rotating machinery is a pertinent feature of rail and road vehicles as well as aircraft. The proposed project includes experimental and numerical studies directed towards the development of a numerical prediction tool.
- Takeoff and landing procedures: The noise reduction potential of acoustically optimized operating procedures is investigated based on an empirical prediction tool for the noise radiated from transport aircraft. Fly-over tests are to provide the experimental basis for the pre-

diction tool and to validate the optimized flight procedures. The study also includes flight simulator tests to examine the pilot's workload under changing flight procedures.

The first and third project listed above are underway, the last is likely to be approved soon, while the remaining projects are still under consideration.

3.2 Noise effects on humans

Noise induced health impairments and economic consequences of restraints on mobility are areas of conflict. All aspects have to be considered that can help alleviate noise pollution problems. In addition to lowering emission levels and impulse occurrence, research on human-specific effects taking into consideration acoustic features and non-acoustic variables will establish directions for targeted noise reduction measures. In the 1st phase, predominantly laboratory based studies will look at psychosocial noise effects and influence on speech intelligibility, cognitive performance; sleep disturbance, and finally state of health; mood, annoyance, and performance. Specifically the following issues will be addressed:

- Frequency spectra,
- Time of day variance
- Weighing specific transportation noises (bonus malus system)
- Simultaneous occurrence of traffic noises
- Confidence building by information

As a contribution to studying noise effects, DLR is currently investigating the influence of nocturnal aircraft noise on sleep, subjective well-being, and performance, the motivation being a higher demand for nighttime flights, growing noise exposure of communities near airports and the lack of primary studies. The investigation consists of four laboratory studies, two field studies to validate the lab studies [3]. Taken together the total will amount to 2500 proband nights. In the sleep lab volunteers are subjected to noise events between 4 and 128 times per night for 13 consecutive nights with sound pressure levels between 50 and 80 dB(A). Several physiological parameters are being recorded simultaneously. Preliminary results based on 64 subjects and 832 laboratory nights have recently been published [4]. Combined, the high methodological effort and large sample size will provide statistically secured data. The data are needed to protect the health of residents, help define nighttime flight noise criteria, and provide planning and management guidelines for airports and communities, and recommendations for policy makers regarding regulations and certification. The results will be part of an effort to build a criteria catalog for all traffic branches.

4. European Dimension

Traffic noise pollution is not a problem of individual states. Traffic - and the noise that comes with it - crosses borders. According to EC data, 25% of the population of EU member states - corresponding to nearly 100 million people - suffer from unacceptable noise levels. There are already several national and EC noise reduction programs. But to fight noise effectively, more coordination and cooperation is required; and noise abatement needs a higher priority in policy making. Thus, the EC Noise Policy (2000) calls for "a more coherent, extensive and more effective approach to noise management". The research network "Quiet traffic" will support and con-

tribute to European cooperation because joint research and harmonized standards, procedures, and infrastructures in EU provide added value and are a more efficient and faster way to achieve results.

5. Outlook

Work topics and 1st phase goals are summarized in Table 1:

		Work topics	Goals – 1st Phase
Noise effects		<ul style="list-style-type: none"> • sleep and health • performance and physiological functions • psychosocial reactions 	<ul style="list-style-type: none"> • noise criteria and descriptors day/night, frequency, level, duration • noise limits
Noise reduction	Road	<ul style="list-style-type: none"> • tire-road interaction noise • surface effects 	<ul style="list-style-type: none"> • reduction by 3dB
	Rail	<ul style="list-style-type: none"> • wheel-rail interaction noise • track effects • cooling fan noise 	<ul style="list-style-type: none"> • simulation techniques • emission reduction <ul style="list-style-type: none"> - wheel-track system - 3dB - Diesel engines - 10dB
	Air	<ul style="list-style-type: none"> • engine noise • airframe noise • active/passive noise reduction 	<ul style="list-style-type: none"> • emission reduction <ul style="list-style-type: none"> - individual sources - 6dB

In addition to projects that will be dealt with in the 1st phase, several topics have been identified for the continuation of the program, based on priority and available funds. The future course of work will also be determined by the results obtained in the ongoing work. In addition, an advisory panel with experts from federal and state government agencies, academia, institutions and interest groups will closely follow and evaluate the work in progress and make recommendations.

To ensure that research results are quickly made available to all partners in the network and the public, several instruments for dissemination of information will be employed. In addition to the rapid publication of results, these include biannual workshops (the first two took place last year), status seminars and international conferences.

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