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QUIET TRAFFIC – A GERMAN INITIATIVE TO REDUCE TRAFFIC NOISE

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INTRODUCTION

The research network *'Quiet Traffic'*, founded in 1999, aims at the global reduction of noise as emitted by road, rail, and air traffic. It was initiated by the DLR, the German Aerospace Center and motivated by the already high if not unbearable noise pollution and by the fact that noise will increase considerably within the forthcoming years. As compared to 1995, freight traffic will have increased by 80 % in the year 2010. The same increase is assumed for air traffic and the increase in city traffic will then be about 50 %. Due to longer operating hours of machinery and to more deliveries 'just in time' this process is expected to be more pronounced during nighttime than during the day.

Adopting the WHO-definition of health as a complete physical, psychic and social well-being, noise abatement does not only improve the quality of life but becomes an essential element of health protection.

On the other hand, mobility is a basic human need and an essential precondition for economic growth. The goal is therefore not to reduce mobility and thereby economical progress but to reduce transportation noise while and even though traffic density increases. Thus, the beneficiaries are the residents living in the vicinity of airports, on streets with high traffic density or along railway tracks as well as the industry which – through its involvement in the respective research – achieves specific knowledge in noise abatement technology and thereby a marketing advantage.

Noise abatement. Compared to noisy industrial devices the evaluation and the attenuation of transportation noise is a particular challenge. It is emitted by a great number of vehicles which move at various speeds into various directions (air traffic also at various levels) and which changes permanently its temporal and local composition. Thus, at any time and anywhere, effective noise reduction can be achieved only by the limitation of noise emission at its source. Suitable measures include technical alterations of vehicles, changes in traffic management and personal behavior of pilots and of drivers of ground vehicles.

Concerning technical measures, achievable improvements are indeed considerable. The potential reduction is 10 dBA for road noise, 10 to 15 dBA for rail noise and 12 dBA for aircraft noise. But full success is achieved only after many years due to the successive replacement of vehicles, concerning road traffic after about 8 to 10 years, concerning rail and air traffic after 20 to 40 years. Even technical alterations of vehicles in service such as the reequipment with new tires need at least 3 – 4 years, until the majority of tires are replaced.

Due to the long-term perspectives, the development and introduction of technical improvements for each individual vehicle must not be delayed any longer. But these measures should be supplemented by other source-oriented measures such as traffic management which is successful at short-term but is often of merely regional significance, and by behavioral changes of pilots and drivers of ground vehicles (cars, trucks, trains).

ORGANIZATION OF THE NETWORK *'QUIET TRAFFIC'*

The global attenuation of traffic noise is an ambitious goal, which requires the support of politicians, industry, carriers, administration, and researchers joining the network (Fig. 1) as well as a concerted interdisciplinary approach. The network is structured into 5 groups (Fig. 2). By combining their research efforts, the partners aim to increase their output and to optimize the use of resources.

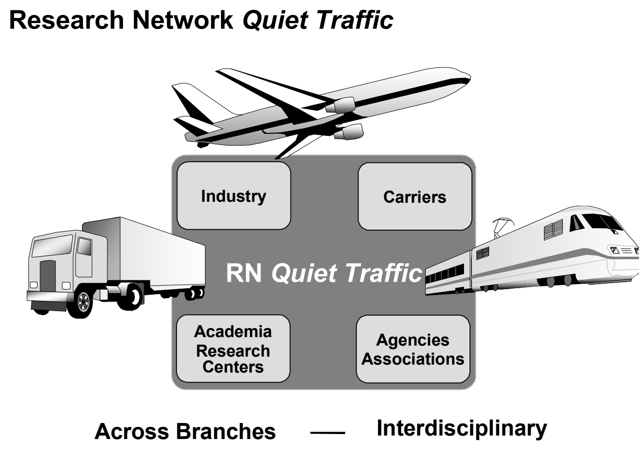

Figure 1: Research Network *'Quiet Traffic'*

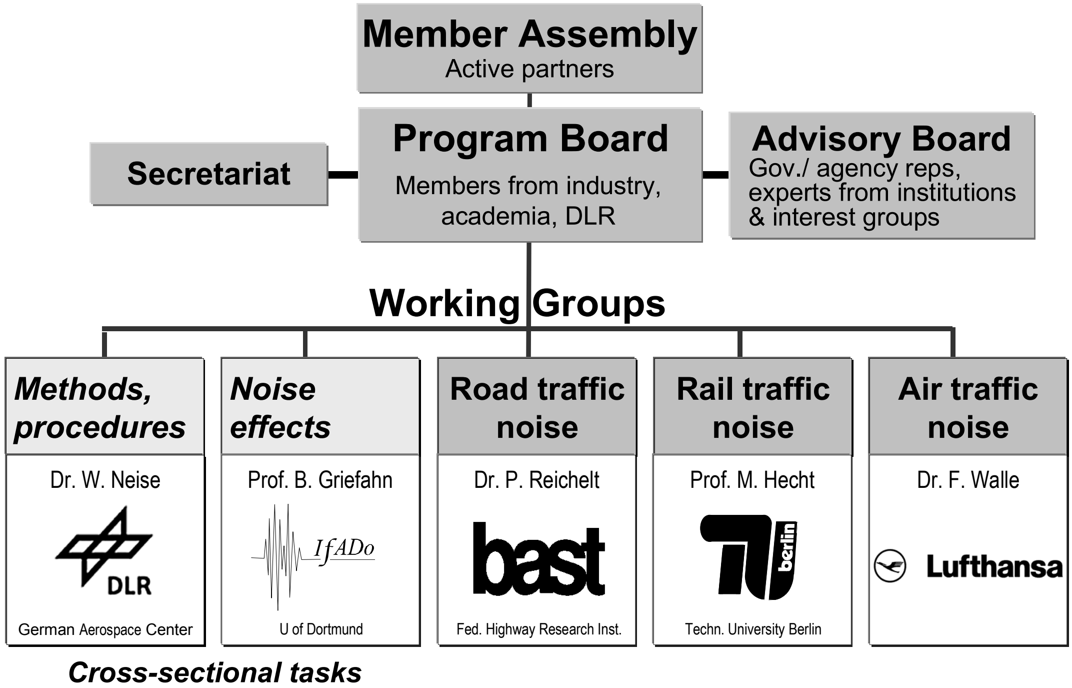

Figure 2: Organization of the Network

The respective groups and their goals are as follows:

Low-noise road traffic. Actual activities are directed toward reducing tire-road noise which 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 the efforts to reduce noise coming from the vehicle power train (fan, motor, driveline, exhaust).

Low-noise rail traffic. Concerning 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.

Low-noise air traffic. In air traffic objectionable noise comes from the engines and increasingly from the airframe. Actual activities concentrate on fan noise reduction, especially

- Optimized fan design,
- Suppression of disturbing discrete tones by active noise control.

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, modelling, and fly-over tests for data collection and verification.

Common technologies and methodologies concerning noise sources, propagation, and prognoses. Current activities concern

- Sound location methods,
- Sound immission prognosis,
- Acoustic simulation procedures,
- Traffic management,
- Broadband noise,
- Takeoff and landing procedures.

Noise effects

The researchers involved in studies on the effects of noise adhere strictly to the global concept of the network ***'Quiet Traffic'***. Their studies are designed to meet the requirements of the technically oriented groups *(Low-noise road traffic, Low-noise rail traffic, Low-noise air traffic)* and of the administration. They aim at the provision of immediately applicable scientific findings for directed and efficient noise attenuation. This excludes basic research as well as research on possible long-term effects on health. Within the network ***'Quiet***

Traffic' research on noise effects concerns instead the most important acute noise effects, whose reduction prevents consecutively the genesis and manifestation of health effects.

Research criteria

Within the network ***'Quiet Traffic'*** research on the effects of noise is therefore structured according to the following 3 effect levels (Fig. 3).

- **Psychosocial effects.** Annoyance is the most frequent noise effect which results mainly from disturbances of communication and performance, of recreation, and of sleep. It is felt as an impairment of the quality of life and causes the residents in the vicinity of (projected) airports, on streets with high traffic density or along rail tracks to protest and even to form pressure groups. It causes long-term alterations of the people concerned, who close their windows more often, use their balconies, terraces, and gardens less often, go out more seldom and have guests less frequently than residents living in quiet areas.
- **Speech intelligibility and cognitive performance.** Speech is the most important means of communication and essential for mental development and social behavior. Disturbances of acoustic communication impair in turn cognitive performance, mood, behavior, and eventually the quality of life.
  Cognitive performance. The masking of the communication sound impairs inevitably all those performances where acoustic communication is essential or at least helpful. These are in particular conversations and learning processes. Noise can also disturb those performances which are independent from acoustical signals as it may absorb processing capacity to some extent and/or interfere directly with cognitive processes, e.g. with short-term memory. Moreover, noise can distract from the actual task and can impair concentration via noise-induced sleep disturbances.
- **Noise-induced sleep disturbances.** Disturbances of sleep are assessed as the most deleterious effect of noise, as it does not only affect sleep but also impairs mood and performance the next day. Studies on noise-induced sleep disturbances are therefore extremely elaborate, as they require the recording of the physiological indicators of sleep (polysomnogram) as well as of subjective evaluation of the qualitative and quantitative parameters of sleep, and the recording of mood and performance. These studies are, however, a matter of priority, as traffic density will increase more during nighttime, then during the day, due to the prolongation of hours of machinery operation and deliveries 'just in time'.

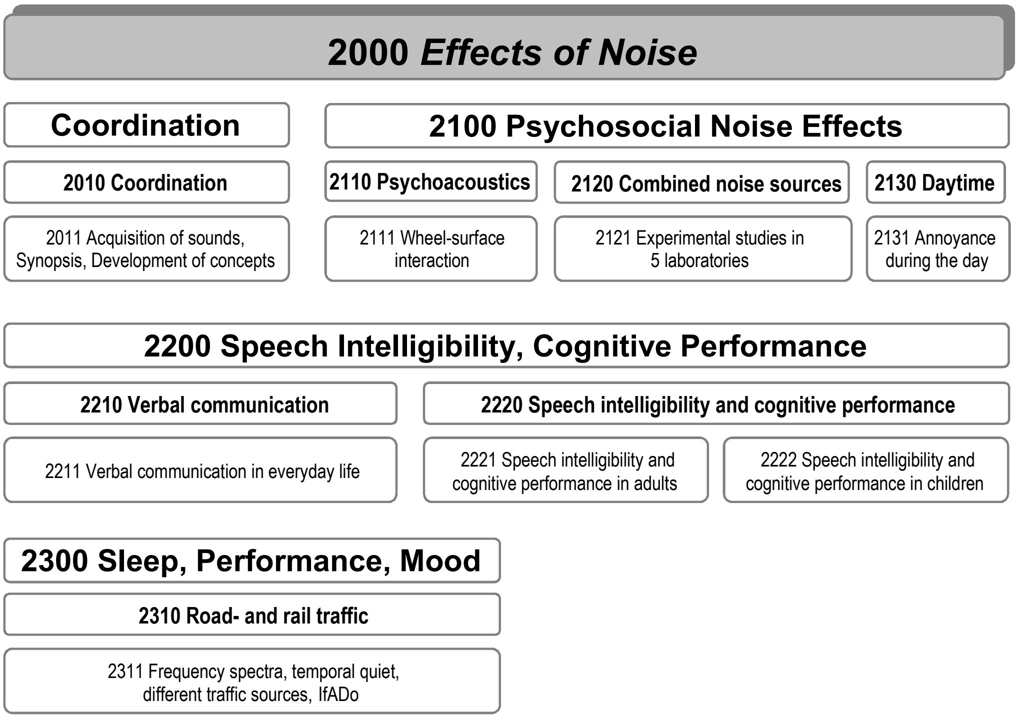

Figure 3: Organization of subject area 'Effects of noise'

Goals of research on noise effects

In consideration of the effects described, the attenuation of the level and the reduction of the impulsiveness of the noise emitted by the individual vehicle are a matter of course for the technically oriented groups *'Low-noise road traffic'*, *'Low-noise rail traffic'* and *'Low-noise air traffic'*. This alone, however, is insufficient as the extents of the effects depend on other acoustic parameters as well, particularly on the temporal structure and the type of traffic noise. It depends furthermore on noise sensitivity that varies during the day and during the night (during consciousness and during sleep). Thus, the equivalent noise level is only of limited value for the assessment of noise effects, particularly with respect to the simultaneous influence of noises emitted from different types of traffic.

Considering the need of the technically oriented groups, 4 main goals were defined which are solved by an interdisciplinary approach.

1 Assessment of various frequency compositions

The technical reduction of the A-weighted noise level is usually accompanied by an alteration of the frequency spectra, as the higher frequencies are much easier attenuated than the lower frequencies. As the effects on man often do not correspond to the extent of attenuation of the A-weighted level, it is concluded that lower frequencies are particularly harmful. This assumption is supported by the targeted careful study of the literature where numerous hints are found that the lower frequencies are more annoying and more disturbing even during deep sleep than noises where the higher frequencies prevail. Therefore, the guidelines published by the WHO [Berglund et al. 1999] recommend to lower the limits for low-frequency sounds.

A central goal of the research network is the determination of the most disturbing frequencies with psychoacoustic methods. Under consideration of technical possibilities, more pleasant sounds will be generated and their interference with verbal communication, cognitive performance and sleep will be compared to those of the original noises.

2 Quantification of diurnally varying noise effects/processing

Noise sensitivity during the day. Sensitivity against environmental noises changes concomitantly with the diurnally varying activities. A major goal is therefore to quantify the difference in terms of noise levels that must be added or subtracted to achieve the same effect as determined at another (reference) time in order to develop a measure similar to the DNL (day-night level) that considers an additional 10 dBA for the night, or the DENL (day-evening-night level) with a further 5 dBA for the evening.

Noise sensitivity during sleep. Studies with evenly distributed nocturnal traffic noise allow the conclusion that noise sensitivity increases toward the morning. The actual state of knowledge, however, does not allow definite recommendations for the introduction of a temporal prohibition of road traffic or a suitable design for itineraries for rail and for air traffic.

3 Effect-equivalent assessment of different traffic noises

The acoustical stress is usually assessed by the calculation of the equivalent sound level. This does not correspond to equivalent effects as shown by a meta-analysis, whereupon aircraft noise annoys more than road noise and the latter more than rail noise, and the differences increase with the equivalent sound pressure level. Whether the 5-dBA advantage (bonus) set for rail noise in several countries is true for communication, cognitive performance, and sleep will be studied.

4 Assessment of noise from different sources (prognosis)

Residents living along rail tracks and in the vicinity of airports are usually exposed to 2 or even 3 types of traffic noise. The assessment, however, concerns only the dominant or the most interesting noise source. This concept is at least debatable as noises from other sources contribute to the annoyance. The solution to that problem, however, is not trivial, as – see above – the different types of traffic are differently annoying and as these differences increase with noise level. Moreover, mutual effects are possible and prevent the prediction of noise effects on the basis of the equivalent sound pressure level only.

Summary

The research network *'Quiet Traffic'* which comprises industry, carriers, authorities, researchers, and universities and covers a wide-spread spectrum of various disciplines aims at the integrated abatement of noises emitted from ground and from air traffic by means of technical, operational and administrative measures.

The network consists of 5 subject areas. A general project is focused on common technologies and methodologies concerning noise sources, assessment, and prognoses and will also include take-off and landing procedures of transport aircraft.. Three technical projects in the fields of road, rail, and air traffic deal predominantly with road-tire noise, rail-wheel and fan noise and the reduction of aircraft propulsion and aerodynamic noise, as well as the development of active and passive noise reduction methods.

The 5th, cross-sectional project concerns the effects of noise. Its task is to support the other groups by elaborating basic knowledge that can be transferred into technical and operational measures. The criteria of evaluation are annoyance, communication and sleep disturbances as well as consequences on mood and performance.

Berglund B, Lindvall T, Schwela DH (eds): 1999: Guidelines for community noise. Geneva: World Health Organization.