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Options for reducing noise from roads and railway lines

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ABSTRACT

The fundamental noise generation mechanisms of road and rail vehicles are discussed with attention to noise abatement measures. Based on an evaluation of publicly available tire noise data and the European road traffic noise emission model CNOSSOS, it is shown that on the road side there is a significant noise reduction potential in the usage of low-noise tires. From a three months measurement campaign a noise model was derived to predict the maximal sound pressure level of heavy duty vehicles during a pass-by in 7.5 m distance with the parameters vehicle speed and number of axles. With help of recently published information about external costs caused by heavy duty vehicles and the noise prediction tool, a model was developed to derive a money equivalent that can be used as a bonus/malus in a heavy duty vehicle fee. As a measure at the infrastructure, the installation of low-noise pavements is an effective, durable and economically attractive measure. Recent experiences with different technologies from all over the world are compiled and evaluated. On the rail side, an overview of the possible noise reduction strategies is given, followed by a discussion of the current policy and legislation in the EU and on the national level of different European countries.

1. Introduction

Transport of goods, either on road or on rail, interferes with the environment. The parameters to describe the environmental footprint of a road and rail vehicle were identified in the Eureka project Footprint (2001–2008), see Mayer et al. (2012) and Poulikakos et al. (2013). Based on monitoring measurements and theoretical investigations it was found that the aspects.

- static and dynamic loading,
- audible noise,
- gaseous and solid pollutants,

are most relevant. In the ongoing Ecovehicle project, data analysis methods will be developed to identify vehicles with abnormal parameter values (Poulikakos et al., 2016). Strategies are developed to inform drivers and operators about the unusual condition of individual vehicles. Furthermore, appropriate criteria will be developed to characterize environmentally friendly road and rail vehicles. In a final step a relation between environmental impacts and costs will be established in order

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to determine an incentive (bonus) for vehicles with a low footprint and a penalty (malus) for vehicles with a large footprint. This would allow for the constitution of a *polluter pays principle* as aimed for in the EU Green Transport package of 2008.

This paper focuses on the noise aspects of the environmental footprint of road and rail vehicles. Many studies have shown, that environmental noise and especially transportation noise has very negative effects on health of humans. Noise can cause annoyance, cardiovascular problems, sleep disturbance and cognitive impairment of children. Due to the relevance of the problem, the European Council has enacted the Environmental Noise Directive (END) (Directive 2002/49/EC,) in 2002 for the reduction of environmental noise. On one hand END initiated the development of an EU-wide collection of noise maps, on the other hand the member states are obliged to design action plans to limit and lower traffic noise. In Ruiz-Padillo et al. (2016) a tool has been presented to support the evaluation and prioritization of possible technical measures.

Noise exposure of residents depends on the source strength and the propagation attenuation from source to receiver. Sound propagation attenuation is strongly influenced by obstacles that interrupt the sightline. The installation of artificial barriers is an effective method to significantly lower noise exposure. However, acceptance is generally limited due to disturbance of the visual impression. In urban environments only noise barriers of low height are an option, however under specific circumstances they prove to be surprisingly efficient (Ding et al., 2011; Van Renterghem et al., 2015). As the sound field in an urban situation is heavily influenced by reflections at building facades, the shape and form of the street canyons play an important role (Echevarria Sanchez et al., 2016).

The source strength of traffic noise emission can be lowered by measures taken at the infrastructure or at the individual vehicle. As will be shown later in the paper, great efforts have been made over the last twenty years to reduce road traffic noise by specifically designed pavements. Railway noise reduction on the side of the infrastructure can be achieved by rail grinding to smoothen the tracks and rail damping to absorb vibrational energy. Both on road and rail there is a pronounced spread of the emission of individual vehicles (De Coensel et al., 2016). From the view of the authorities, it seems therefore interesting to seek for incentives to motivate vehicle owners to reduce the emission of the individual vehicle. As will be shown later, this can be achieved by low noise tires on one hand and by low wheel roughness due to favorable braking systems on the other hand.

The paper is organized as follows: it starts with a discussion of the fundamental noise generation mechanisms and the consequences for noise control at the source. Section 2 is dedicated to road vehicles, Section 3 addresses rail vehicles. Finally in Section 4 conclusions are drawn with emphasis on possibilities on how politics can motivate for quieter vehicles with help of pricing systems.

2. Quieter roads

2.1. Noise emission of road vehicles

Noise emitted by road vehicles is broadband in its spectral contents with two peaks around 60 and 800 Hz (see Fig. 1). It can be split up into a contribution of the tire/pavement interaction (rolling noise) and a contribution of the engine and the exhaust system (propulsion noise). Rolling noise depends mainly on vehicle speed, the number of axles, the tire and

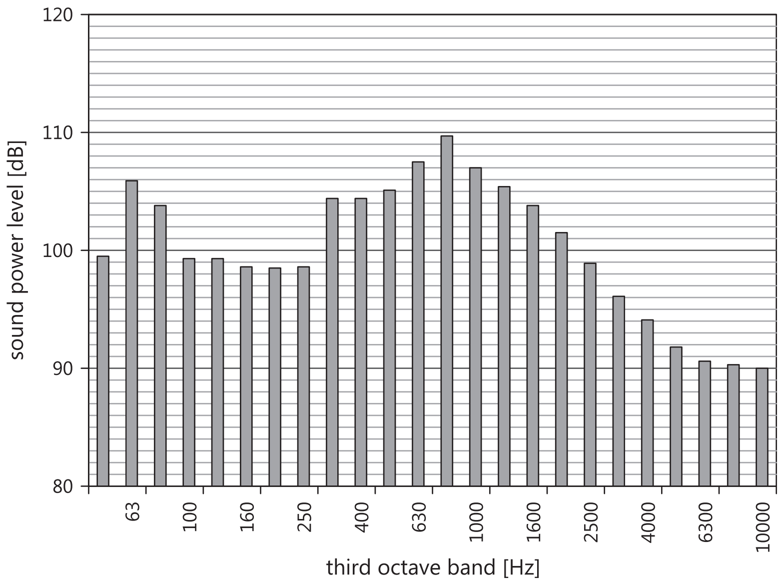

Fig. 1. Measured third octave band spectrum of sound power emitted by a heavy duty vehicle at 88 km/h.