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# Traffic noise modelling and measurement: Inter-laboratory comparison

Jurij Prezelj, Jure Murovec *

*Faculty of Mechanical Engineering, University of Ljubljana, Aškerčeva 6, 1000 Ljubljana, Slovenia*

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ABSTRACT

Traffic noise emission and its propagation can be effectively measured and modelled. Results of traffic noise modelling are very close to the results of measurement, typically within ±3 dB range in case of noise propagation around elementary situations. In a real complex environment, the deviation of results is larger. The procedure of gathering the information about the traffic attributes and the elements composing the propagation path is essential for traffic noise modelling, however it differs from laboratory to laboratory. The deviation of input data and consequently the deviation of modelling results occur, if different sources of information are used. Fourteen inspection bodies participated in the inter-laboratory comparison, which was organized in order to compare procedures of different laboratories with a purpose to identify key parameters influencing the deviation of noise modelling results. Presented inter-laboratory comparison (ILC) of traffic noise modelling is particularly reliable because it includes both, the comparison of modelling results and the comparison of measurement results. Assessment of noise level relative to the absolute reference value was not the primarily objective of the ILC, the main goal was the analysis of the risk of systematic errors. Conclusions of the study indicate that traffic noise models and noise propagation models can be regarded as an extrapolation of measurement results from one location to a wider surrounding area.



## 1. Introduction

Traffic is the dominant source of noise in living and working environment. It is eminent to assess its levels in order to be able to control it. However, there is always a residual risk of an incorrect assessment outcome. The variability of traffic noise, in both space and time, is often the major contributor to the overall risk [1]. Environmental noise levels can vary over a wide range, as a consequence of the environment diversity and different activities occurring during measurements. Inherent problem of traffic noise measurements and traffic noise modelling is nonexistence of the reference or true value of road noise level. Noise levels can only be described quantitatively by evaluation indices, as for example with the energy equivalent noise level $L_{Aeq}$ and with the percentile levels $L_{\%}$. A quantification of these parameters is the aim of the environmental noise assessment. Due to the stochastic nature of the environmental noise, a particular assessment can only lead to an estimate of evaluation indices, whose true values are known only to Mother Nature [2]. The closest approximation to their real value is a long term average. Variability of traffic noise is extremely important for a correct interpretation of assessment. It is often a source of disagreement when applying standards and regulations, as there is no consensus about how to estimate and present it [3].

An interested individual, who wants to determine the influence of traffic noise on the environment, usually commissions measurements and/or a modelling study in one selected laboratory. However, there are many different laboratories performing measurements and modelling of traffic noise and normally their results do not match perfectly. If an interested individual places a commission for traffic noise assessment to several laboratories, he will obtain several different results. Only an average approximate value of noise indicators can be obtained, even if the multitudes of estimations are given by different laboratories. If all the labs, for instance, adopt a wrong procedure, the estimation of noise is still wrong. The increasing number of labs can improve the statistical significance of the results, but cannot improve the results themselves. We can assume that with increasing number of results, values of averaged noise indicators are getting closer and closer to the real – reference value.

Traffic noise modelling and correlated calculations are performed according to Standard Operating Procedures (SOP), which are unique for each laboratory. Laboratory personnel shall follow SOPs to select measurement locations, to setup measurement equipment, to exclude residual noise, to acquire input data for modelling, to calibrate noise propagation models, etc. [4]. Different

* Corresponding author.
*E-mail address:* jure.murovec@fs.uni-lj.si (J. Murovec).

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laboratories have to prepare various SOPs, because they are using different equipment and different modelling software. Personnel differs in experience, and consequently, differences occur during choosing the microphone location, selections of measurement time, selecting the sampling duration, gathering the input data for models, simplification of models, etc. Incomplete instructions in SOPs, for simple calculation of noise level descriptors ($L_d$ and $L_{den}$) from measured $L_{Aeq}$, lead to dissipation of results, as noticed in the Inter-Laboratory Comparisons of environmental noise measurements [4].

An interested individual needs some criterion for selection of the laboratory. An assurance in the form of a certificate is generally required, before placing the commission. Such certificate is usually granted from national accreditation body to laboratories who established quality control in their procedures. Inter-laboratory comparison (ILC), (in some cases it could be referred as a Round Robin Test) is one of the most important tools in quality control, which is also used during accreditation process. Slovenian Acoustical Society organized ILC study in order to help laboratories provide proof of quality, to validate their SOPs and to identify key parameters, who influence the deviation of traffic noise modelling results the most. Presented inter-laboratory comparison of traffic noise modelling is particularly reliable, because includes comparison of modelling and measurements of traffic noise.

An inter-laboratory comparisons (ILC) is defined as an organization, performance and evaluation of the test on the same or similar test items by two or more laboratories in accordance with predetermined conditions [5]. ILC supplements laboratories' own internal quality control procedures, by providing an additional external measure of their testing capability. ILCs are conducted for a number of purposes and may be used by participating laboratories and other parties, For example, to:

- Determine the performance of individual laboratories for specific tests or measurements and to monitor laboratories' continuing performance. A participation in the ILC scheme provides an objective instrument for assessing and demonstrating the reliability of the data, produced by an individual laboratory.
- Identify problems in laboratories and initiate remedial actions, which may be related to individual staff performance or calibration of instruments.
- Develop and establish the effectiveness and comparability of a new test or measurement methods and similarly, to monitor already established methods.
- Provide additional confidence to laboratory clients. Confidence that a testing or calibration laboratory consistently obtains reliable results is of major importance to customers of laboratory services.
- Identify inter-laboratory differences in Standard Operating Procedure.
- Determine the performance characteristics of a method. Result of ILC can be also regarded as a validation of procedure, used in individual laboratory [4].
- Assign reference values and assess their suitability.
- Use ILC results in specific test or measurement procedures.

Useable comparison of results can be achieved, if equal conditions are guaranteed for all cooperating laboratories. Equal measurement conditions can be easily assured in laboratory condition. Measurement of the reference noise source from the same tripod in the anechoic chamber, under controlled environmental conditions would be the case. However, it is not the intention of the presented ILC to only compare measurement equipment. Laboratory procedures and personnel are under consideration too, especially gathering the necessary data about traffic attributes, traffic noise modelling, propagation modelling, sampling of the environmental noise, calculation of noise descriptors, etc.

## 2. Traffic noise

Traffic noise modelling and traffic noise measurement are complex tasks, because traffic is a stochastic noise source. A multitude of independent noise levels from different noise sources (light and heavy vehicles, slow and fast vehicles), generally in different places, contribute to form the traffic noise level which we observe. Noise generated by industry, inhabitants, animals, etc. is superimposed on the traffic noise which is under analysis. Moreover, all different types of noises generally occur in the form of continuous random levels [6]. Due to the uncorrelated nature of multitude of acoustic sources, a statistical description of environmental noise is appropriate [2]. A particular measurement can only lead to an estimate of these parameters, whose true values are not known [6]. A statistical interpretation of the traffic noise measurement is consistent with international standards.

Traffic noise analysis has been divided into four elements as shown in Fig. 1. Sound power of the traffic on the road is denoted with A, noise propagation from the road to the immission point is denoted with B, C denotes procedures for noise level assessment, (measurements and/or simulations), and D denotes administrative manipulation of measured and/or simulated noise levels presented in final reports. Such decomposition was used, because it conforms to standard approach Source-Propagation-Immission, used to solve noise control problems. Part D was added because it has been observed that inconsistent reporting is adding to the ineffectualness of results.

Attributes influencing the sound power $L_w$ of the traffic on the road are: traffic flow ($Q$), velocity of vehicles, traffic density, road surface type and its condition (asphalt, concrete, wetness...), vehicle mass, tires, road inclination, etc. These attributes of noise source in physical domain are constantly changing in time and space, therefore sound power of the traffic on the road is permanently fluctuating. If sound power $L_w$ is regarded as a cause, than the noise level $L_{Aeq}$ could be regarded as an effect. By accepting such an approach, the sound propagation path can be regarded as a transfer function presented in section B, Fig. 1. The distance between the road and the selected immission point and all the obstacles on the propagation path are the main attributes of this transfer function. Some attributes of the propagation path are fixed and do not change with time, but some of them fluctuate constantly. Such fluctuating attributes, which significantly affect the propagation path are weather, foliage and movable obstacles.

There are two available procedures for noise level assessment as shown in section C in Fig. 1: measurements in physical domain and calculations in numerical domain.

### 2.1. Traffic noise measurements

Results of measurements are inherently influenced by attributes of the propagation path and by the traffic attributes. Traffic is noise source with sound power $L_w$ in physical domain. Generated noise propagates to the measurement location where noise level $L_{Aeq}$ can be acquired. If values of traffic attributes are measured together with noise level, and attributes of propagation path are well known, a combined transfer function of traffic noise model, which includes propagation path, can be obtained. Such transfer function is valid for conditions under which the measurements were performed. Measurement results comprise influence of all attributes from both elements: noise source (A) and noise propagation (B).