Long term monitoring site at Saint-Berthevin (France-53) : a tool for traffic noise characterization using space and time statistical variability of acoustical and meteorological events

Olivier Baume[1], Benoît Gauvreau[1], Michel Bérengier[1], Fabrice Junker[2], Francis Lauzin[3]

[1] *Laboratoire Central des Ponts et Chaussées, Rte de Bouaye, 44341 Bouguenais Cedex*

[2] *Electricité de France, Direction Etudes et Recherches, 1 av Général de Gaulle, 92140 Clamart*

[3] *Centre d'Etudes et de Construction de Prototypes, 2Bis av Général Foy, 49100 Angers*

Introduction

Propagation of acoustic waves above complex ground (impedance and topography) and medium (refraction and turbulence) involves several phenomena which have been studied separately in the literature [1]. Regarding a statistical approach, a qualitative method for estimating atmospheric influence on traffic noise level have been previously validated [2].

We introduce in this paper a new tool for experimental data which has been developed since 1998 by the Ponts et Chaussées laboratories network : the LCPC "monitoring station" in Saint-Berthevin (F). Thanks to the integrated time technology used and to the specifications of the site chosen, this monitoring tool will help to validate numerical models [3] : an acoustical model (PE) and a micro-meteorological model (SUBMESO). It will also support a new statistical tool. This latter is under development in the framework of a LCPC/EDF collaboration. It intends to classify the relative influence of various parameters on experimental results and to study time and space statistical structure of our database.

"Monitoring station" site

In order to determine how much representative a measurement can be, we need long term monitoring. Thus a great number of samples must be analysed. The aim of developing the "Station de Long Terme" at Saint-Berthevin (F) is to get available data of a 10-year-long period for atmospheric and acoustical variables and road traffic countdown.

The project was settled in 2001 by the Laboratoire Central de Ponts et Chaussées which was supported by the CECP (Centre d'Etudes et de Construction des Prototypes) from Angers (F) for designing technical solutions and the first stage in data processing.

The site was chosen for its great interest. Indeed, as simplified in Figure 1, five acoustical masts and four meteorological towers are spread out in a small valley with both highway (viaduct) and railway traffic sound sources. Atmospheric measurements include wind speed, wind direction, air temperature, hygrometry, pluviometry, sun exposure and ground temperature. In order to calculate vertical sound celerity gradients, the towers dispose sensors at 2 or 3 different heights. Microphones were implemented for sound pressure level measurement at 5 locations, with the "A1" mast being the acoustical reference for road traffic noise level. Moreover the traffic countdown station classifies every single vehicle detected (silhouette, lane and instantaneous speed).

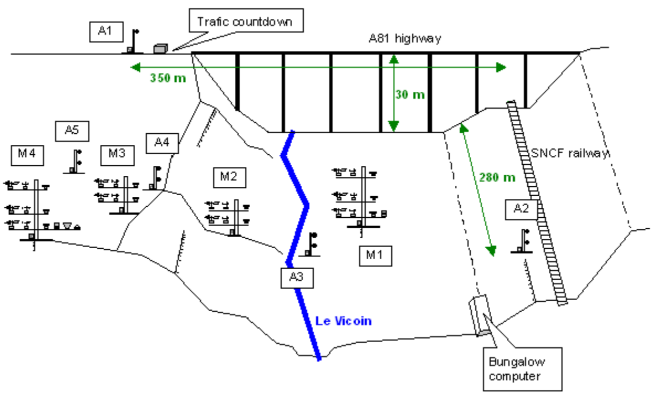

Figure 1: The monitoring site of Saint-Berthevin (F) – "A" stands for acoustical mast and "M" for meteorological mast.

Data processing

Monitoring holds efforts every single day from anyone involved in the project. The design of Saint-Berthevin site includes the data processing. The issue was to give time coherence to the database and to extract only validated measurement for future use and analyses.

Time coherence

In order to send results from the masts – each of them has a computer box to record data – to the computer supervisor, the CECP developed a software that dialogues from the bungalow computer with the masts computer boxes. Every other second it imports data from the masts and concatenates the information. Then the software creates a single file which contains :

- daily acoustical data in 10 second samples for global $L_{eq}(A)$ and every 1/1 octave L_{eq} from 125 Hz to 4 kHz;
- daily micro-meteorological data also in 10 second averaged samples;
- daily countdown of instant highway traffic spread in 5 different acoustical classes of vehicles with speed and lane number.

The supervisor computer in the bungalow gives time coherence to the data. Daily zipped files are then transferred on a web site from which data can be downloaded.

Validation

This second stage of data processing takes place in the laboratory. It consists in making various tests which purpose is to eliminate deviant values of variables. It discriminates figures showing that a sensor is not working properly and detects extraneous noise sources (pattern recognition method). These tests are led whether separately on each sensor or between several sensors of the same variable or even between different variables. The tests are carried out for straight values – 10 second samples – and for integrated values of 1 minute, 10 minutes and/or 1 hour, which gives information on mean values and standard deviations for both acoustical and micro-meteorological data.

This kind of test plays a major role for maintenance considering that this step in data analysis can inform on sensors dysfunction at a great distance from Saint-Berthevin. The result of this validation program is a matrix that indicates with a code whether a value is exploitable or not.

Data analysis

Though the study presented in [2] shows that it is possible to determine the qualitative influence of micro-meteorological conditions on sound pressure levels, a method for estimating the probability to exceed a noise level is still needed.

Classification

Ground impedance is bound to weather conditions and topography has a great influence on noise level and micro-meteorological conditions. Therefore, many parameters have to be taken into account in statistical classification of outdoor propagation situations. That's the reason why innovative works on statistical analysis are currently in progress. After checking systematically any influencing parameter, we will study data from several sites which have various topography and ground specifications : Saint-Berthevin monitoring site and former campaigns sites.

The purpose is to obtain a matrix of most general application which gives relative influence of parameters. The study will be held using different statistical tools. Correlation calculation will be helpful and so will be factorial analysis.

Space and time structure

For the classification issue and for further developments, we work on our parameters as regionalized variables. Geostatistics bring useful tools for such analyses. We bring a great bunch of complexity with the physical problem of outdoor sound propagation.

The variability of acoustical and micro-meteorological parameters has a structure that must be studied at several time scales. It is well known that the daytime and the season has a great influence on the SPL one can measure. Sound pressure level variability has both stochastic part and determinist part – in the physical modelling sense – but we need statistical identification of random effects of the physical phenomena to calculate probability. We dispose a great field of parameters for exploration. The experimental variogram [4] allows a clear and useful representation of data structure variability.

Space structure is more difficult to study because too numerous masts for measurement would have over-deviant impact on data. Nevertheless, studying correlations between Saint-Berthevin micro-meteorological figures and nearest Météo-France database from meteorological stations is a necessary stage for new explorations.

Conclusion

New statistical studies need a great variety of data. The new LCPC "monitoring station" site in Saint-Berthevin (F) is a very interesting tool for both classification and structure investigations. Considering that the design was done including data treatment, we have an opportunity to work on validated data only. Thanks to measurement from other sites, we will be able to study the influence of sites specifications and sound sources which is of special concern.

For the complete classification of relative influence parameters of the outdoor sound measurement and the calculation of the probability that SPL can exceed a limit, new statistical tools must be evaluated. In this context, a scientific cooperation with the "Centre de Géostatistique" of the Ecole des Mines de Paris is in progress.

Indeed geostatistics theories and tools are pragmatic and have been widely applied on distinctive physical issues. There are now applied to environmental acoustics. Because it deals with regionalized variables which include a physical interpretation, we will explore qualitative and quantitative modelling.

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