Automated monitoring station for railway noise

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Introduction

The Swiss Federal Office of Transport (Bundesamt für Verkehr - BAV) has to meet extensive legal requirements in the field of railway noise protection (see [1], [2] and [3]). In particular, a noise remediation programme is conducted. Part of this programme is to examine the effectiveness of reconstructing the rolling stock and to check the compliance with the emission plan by monitoring railway noise. The total emissions, which are caused by the system rolling stock and the railway track, are acquired.

On behalf of the BAV the measurements are made at six different locations throughout Switzerland. The measurement stations are operated day and night throughout the whole year in order to acquire the noise emission and complementary data of each passing train. The configuration of the monitoring stations, which are placed in containers, is illustrated in Figure 1. The sub-systems are described below:

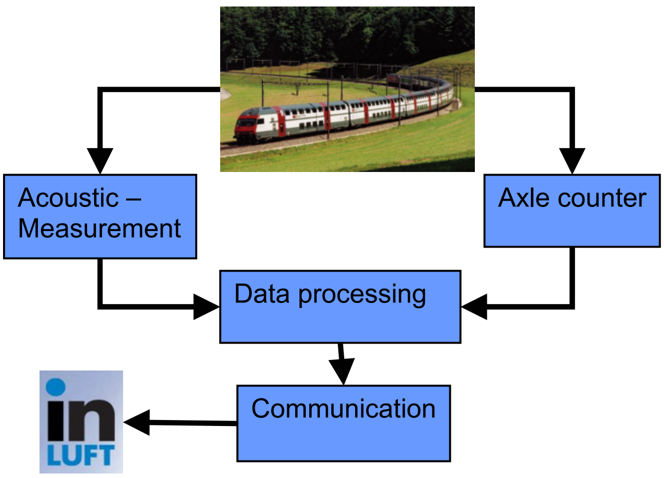

Figure 1: System configuration

Acoustic Measurement

The core unit of the acoustic measurement is a sound analyser (type Norsonic 121). Based on selectable conditions (trigger thresholds) this instrument is capable of detecting and measuring acoustic events. In particular, data before the actual trigger point can be acquired (pre-trigger). The analyser measures on two channels and is capable of measuring both level versus time history and also frequency spectra. Two weatherproof microphones (type Norsonic 1210) are used. Each microphone is placed at a distance of 7.5 m from the centre line of the track. The height above the track is 1.2 m. The measurement is made with the microphone on the opposite track.

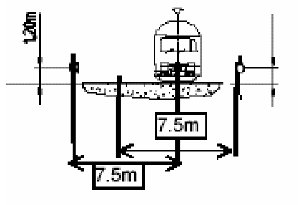

Figure 2: Position of measurement microphones

In principle the acoustic measurement proceeds as follows: when the trigger threshold is exceeded the instrument starts the measurement of the train. As the train passes the A, C and Lin weighted level versus time history is measured at a time resolution of one second. The quantities Leq(A,C,Lin), time of the day and duration of the event are computed automatically from the level versus time history. In principle the measurement is performed on both channels. Based on the axle-count data the choice of the right measurement channel is done in the central station computer. The trigger threshold has been set for each station individually. After a train has passed the measurement data is automatically read out from the analyser and then, after a plausibility check, stored into a database on the central station computer. The central station computer controls the entire process. All measurement parameters are managed on the computer and are communicated to the respective analyser. The outdoor microphones are checked daily by means of an actuator calibration system.

Axle Counter

The axle counter system for this monitoring system needed to be capable of measuring axle spacing at both a high temporal and geometrical precision. Furthermore this application demanded an operation at low maintenance cost, a low sensitivity to parasitic induction and a great robustness. Based on these requirements strain gauges were used for the acquisition of axle passages. Two gauges were affixed to the track in a distance of 30 m to each other. The signals from the gauges are connected to the A/D converter via a measurement amplifier decoupling the signals of the gauges, which work as full bridges. Based on the axle-count signals a programme, especially developed for this application, computes the following quantities for each train: number of axles, speed, train length, train type, direction of motion, trains passing one another and stopping. All quantities are acquired in real-time. This data is stored in a database on the measurement computer.

The identification of the train type (passenger train, freight train, single locomotive) is done based on the high precision measurement of the axle spacing and the knowledge of the possible roll material. With the algorithms in use a correct identification of the train type is possible for more than 95 % of all cases.

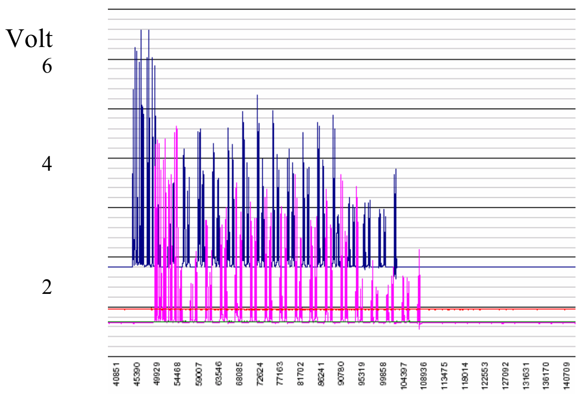

Figure 2: Typical signals of two strain gauges during a train passage (voltage as function of time)

At a train speed of 160 km/h the geometrical resolution of the axle spacing, when using a sampling rate of 5 kHz, is still 0.8 cm. However, in practice this theoretical value is reduced slightly due to temporary displacements of the axles.

Data Processing

The acquired data is processed periodically on the measurement computer. Acoustic events and axle-count data are combined by help of a time correlation method. Thus, acoustic events, which are not created by a train, are eliminated. Events with train crossings or not plausible acoustic data are marked and later substituted by other measurement data.

This procedure results in a complete dataset for each passing train:

Date	DD:MM:YY	Date begin of measurement
Time from	HH:SS	Drive-in measuring section
Time to	HH:SS	Drive-out measuring section
Leq A	[dBA]	
Leq C	[dBC]	
Leq lin	[dB]	
Speed beginning of train	[km/h]	Check Acceleration
Speed end of train	[km/h]	
Pass time	[s]	
Number of axles		
Train length	[m]	calculated
Transit Exposure Level (TEL)	[dBA]	calculated
Train type	Travel train Freight train Not defined	Calculation based on axle-data

Table 1: Dataset of each passing train

Communication

The finalised train data is transferred (via FTP) to a data processing centre several times a day. In the computer centre the data is imported into a large database. In cooperation with an engineering company the data is revised and analysed in a semi-automatic way. Thus, diverse reports and evaluations in both graphical and tabular form are generated.

Amount of Data

In total, approximately the following number of trains are measured by the six fully-automatic monitoring stations:

per day	2‘000
per month	60‘000
per year	730‘000
over 13 years	9.5 million

Table 2: Number of measured trains

Alarm- and Service System

An alarm system was implemented in order to detect system malfunctions as quick as possible. This system detects errors and not plausible results within the subsystems and communicates these to the service organisation via SMS. Service can be carried out via telephone line. Initially it is possible to switch on and off the subsystem by SMS commands. Due to this procedure the system features a very high availability.

References

[1] Rudolf Sperlich, Railway noise abatement; the implementation in Switzerland , DAGA 2004

[2] Robert Attinger, Railway Noise Monitoring in Switzerland, DAGA 2004

[3] Reference to the homepage of the Swiss Federal Office of Transport. URL: http://www.bav.admin.ch/ls