Unobserved long-term measurements of railway noise

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Summary
The measurement of traffic noise is described in the German standard DIN 45642 "Measurement of Traffic Noise". Measurements for the certification process of trains are regulated in TSI Noise and ISO 3095. So far there is no standardization for unobserved long-term measurements of railway noise.
In Germany, several citizens' initiatives and environment agencies have installed long-term measurement stations beside railways.
As there is no definition of the exact measurement procedure or acoustical surroundings for unobserved long-term measurements, every measuring station carries out different results that are not comparable.
Meanwhile, the German Government decided that iron cast break-blocks used in freight-wagons must be replaced by composite break-blocks by the end of 2020. The Federal Ministry of Transport and Digital Infrastructure, BMVI, wants to evaluate the abatement effect of the measure by unobserved long-term measurements. Therefore the Federal Railway Authority, EBA, will soon start to install an extensive measurement system distributed all over Germany.
The expert report "Strategies for Effective Reduction of Rail Freight Noise", published by the German Environment Agency, UBA, shows how an effective measurement system can be implemented in Germany. Moreover, the German Institute for Standardization, DIN, works on the new standard DIN 38452 "Long-Term Measurements of Railway Noise".

1. Introduction

Noise is not only "annoying", it also leads to serious health issues and has an enormous negative economic impact. Railway noise is an important issue in Germany and within the EU and is often called the Achilles' heel of the otherwise energy-efficient transport system.
According to a representative survey "Environmental Awareness in Germany 2016" carried out by the German Environment Agency, about a third of the respondents complained of being annoyed by railway noise [1].
The most important sources for railway noise are freight trains operating day and night. For about 2 million Germans, the calculated night-time sound pressure level L_{night} exceeds 55 dB(A). This is far above the threshold of 40 dB(A) given by the World Health Organization (WHO) [2] for a precautious health protection.

2. German activities for railway noise abatement within the EU

To abate railway noise, the German Government decided that iron cast brake-blocks now used in freight-wagons must be exchanged by composite brake-blocks.
The German Government provides financial premium up to 50 % of the retrofitting costs therefor. The funding partially comes from the noise-depending track charges of the BMVI to companies that have not retrofitted their freight train stock yet.
As a result, the brake-block system will be fully removed for about 2/3 of the operation freight train stock until timetable change of 2020/21.

The government even promotes a ban of loud trains [3]. The operation of freight trains with iron cast brake blocks shall be prohibited.
The only permitted exceptions are the operation with reduced speed and the operation on the secondary tracks of the subnet, where the noise limits of the 16. BImSchV [4] are not exceeded.

3. Localization of measurement points

The rolling noise will be reduced by an abatement of the combined wheel and rail roughness.
The retrofitting of the freight wagons to alternative brake systems is expected to reduce the sound pressure of a passing train up to 10 dB.
To evaluate the abatement effect of the retrofitting, a system for unobserved long-term measurements is indispensable. Therefore, the Federal Railway Authority (EBA) on behalf of the BMVI installs measurement stations distributed all over Germany.
The expert report "Strategies for Effective Reduction of Rail Freight Noise" published by the German Environment Agency (UBA) [5], shows how an effective measurement system can be implemented in Germany.
The 15 measurement stations are able to record about 70 % of the German rail freight transport.

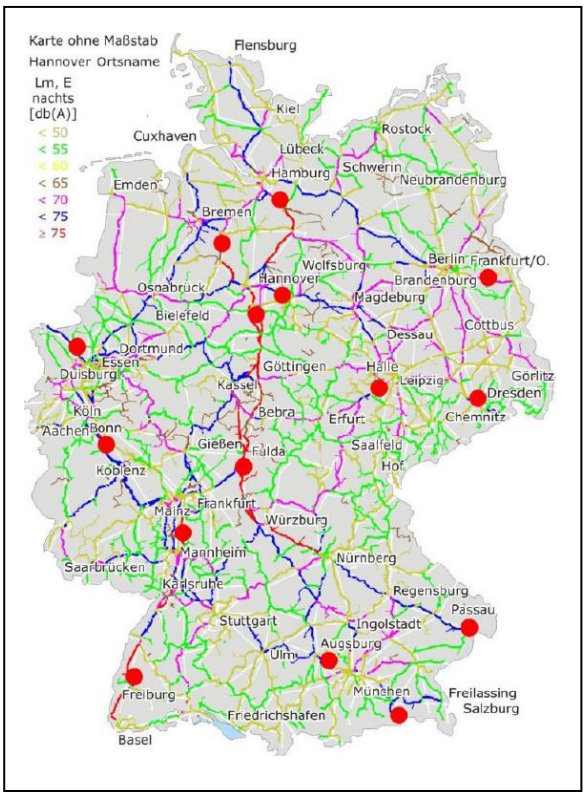

Figure 1: Proposed location of monitoring stations in Germany [5]

4. The new standard DIN 38452 -1

To enable the measurement for all interested groups, for example the Deutsche Bahn itself, the EBA, citizen' initiatives or even private persons, the DIN will release a standardized procedure for unobserved long-term measurement.
The DIN-standard is separated into two parts "Emission" and "Immission". While immission can be measured in any distance to the track and even close to or behind buildings or reflecting surfaces, the emission measurements are proceeded in a fixed distance of 7.5 m to the middle of the track with any reflecting surfaces within a radius of 15 m.
An immission measurement gives information of a locational exposure and can depend on sound propagation and weather issues, but the emission-measurement of railway noise puts out a maximum of information about the source and even allows a comparison of the results from different measurement locations.
Part 1 of DIN 38452, "Emission", consists of three grades of technical equipment and shows the expected quality of the results for each grade.
As intervention and trespassing of the rail tracks are subject to limited authorization, not every measurement system can reach all requirements.

Grade 1
Measurements can be done with a single microphone on one side of the track. On a double track route the trains pass in two different distances to the microphone. As no information about the guide track is provided, the effect of different distances to the microphone can't be excluded from the results.
The underestimation of the sound pressure level due to the unknown distance between microphone and guided track is estimated to be approximately 2 dB.
Grade 1 only gives the possibility to compare and assess local time shift differences.
It only can answer the simple question as to whether the numbers of sound events have changed and how the according noise levels have developed.

Grade 2
The measurement system Grade 2 contains a detection of the guide track of each passing, a speed recording and a train type detection additionally.

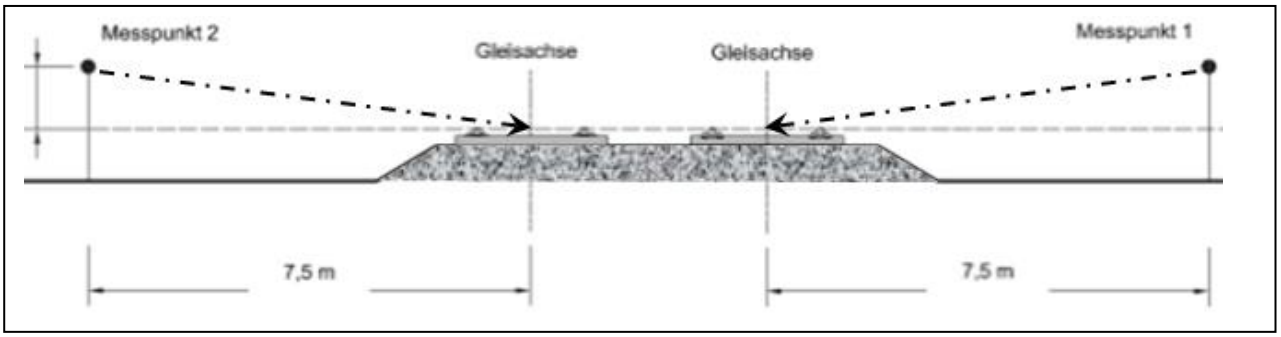

Figure 2: Example for microphone-positions beside a double-track route

If only one microphone is used on one side of a double-track route half of the data is invalid, because only the measurements of trains that pass in exactly 7.5 m distance to the microphone are declared as valid.
But with the detection of the guide track the invalid data can be excluded from the results properly. To avoid invalid data two microphones can be used, as figure 2 shows. Both microphones must be placed in distance of 7.5 m to a track.
With a measurement system of grade 2 the measurement results can be compared, normalized to speed value, and categorized to train types, such as freight trains.
The detection of the guide track can be done for example with a radar sensor or a camera. According to that the rail track doesn't need to be entered or changed in order to install a measurement system of grade 2.
As the state of the tracks and its influence to the sound production is unknown, a comparison of the data from different locations is difficult.

Grade 3

Additionally to the requirements of Grade 1 and 2, Grade 3 requires a detailed measurement of the state of the track within the microphone area.
Therefore, the Track Decay Rate (TDR) and the rail roughness need to be measured.
By knowing the influence of the track state on sound generation, different measurement locations can be compared with each other.
Of course, a measurement of rail parameters is not possible without entering the rail tracks and needs special authorization. Even closure of the track for the time of the measurements is needed.

5. Outlook

For the verification of effective noise abatement measures, a measurement system, which allows unobserved long-term measurements, is built up in Germany. Based on the acquired measurement results, it will be possible to display the long-term effects of rail noise abatement, such as retrofitting.
Therefore, the work on the German standard DIN 38452-1 has far advanced. A completion is expected in 2018.
With this standard, the results of different measurement systems become comparable. The standard shows technical requirements of the measurement to get the best out of the acquired data.
The standard will be translated into English, so that other countries can benefit of it as well.
In order to protect the people from railway noise, it will remain on the political agenda. Unobserved long-term measurements are a major step towards the right direction.

References

[1] Umweltbundesamt (German Environment Agency): Umweltbewusstsein in Deutschland 2016 (Environmental Awareness in Germany 2016), Dessau-Rosslau (2017).

[2] World Health Organization (WHO), Regional Office for Europe: Night noise guidelines for Europe, Copenhagen (2009).

[3] Gesetz zum Verbot des Betriebs lauter Güterwagen (GG-Wagen) in Deutschland (Schienenlärmschutzgesetz) vom 20. Juli 2017 (BGBl. I S. 2804)

[4] Sechzehnte Verordnung zur Durchführung des Bundes-Immissionsschutzgesetzes. (Verkehrslärmschutzverordnung) vom 12. Juni 1990 (BGBl. I S. 1036), die durch Artikel 1 der Verordnung vom 18. Dezember 2014 (BGBl. I S. 2269) geändert worden ist

[5] IGES Institut GmbH; Technische Universität Berlin, Fachgebiet Schienenfahrzeuge; IVE Ingenieurgesellschaft für Verkehrs- und Eisenbahnwesen mbH; Pache, E. Strategien zur effektiven Minderung des Schienengüterverkehrslärms (Strategies for effective reduction of rail freight noise) (2017)