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Developing noise control strategies for entire railway networks

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Abstract

The EU Environmental Noise Directive (2002/49) requires member states to deliver noise maps to the commission by 2007 and action plans by 2008 both for agglomerations as well as for major roads, railways and airports. Noise mitigation projects resulting from action plans are usually very expensive and therefore may threaten the economic viability of the railways in the current harsh competitive transport market, thus hindering sustainable transport policies. It is therefore of vital interest that the action plans and the resulting projects are designed in the most cost-effective way possible. The EU and Union of Railways (UIC) sponsored project Strategies and Tools to Assess and Implement noise Reducing measures for Railway Systems (STAIRRS) recognized this need and developed a tool, with which such optimal solutions can be obtained for entire railway networks. Since data collection is the most expensive part of the analysis, noise mapping data is ideally collected in such a way that it can be used for the calculation of the different scenarios, from which the most cost-effective action plans are chosen. The paper shows how the STAIRRS tool is used for this purpose and how cost-effectiveness considerations have led to optimal railway noise mitigation strategies in Switzerland and have given a basis for noise related decision making in Luxembourg.

1. Introduction

The EU Environmental Noise Directive (2002/49) requires member states to deliver noise maps to the commission by 2007 and action plans by 2008 both for agglomerations as well as for major roads, railways and airports. Noise mitigation projects resulting from action plans are usually very expensive. In those cases, where these costs must be carried by the railways, they may threaten their economic viability in the current harsh competitive transport market, thus hindering sustainable transport policies. It is therefore necessary to develop strategies which optimally balance noise reduction, European and national legislation as well as costs of the measures. Additionally, residents appreciate it and tend to accept strategies more readily, if the same criteria for noise control are used throughout a given network. Ideally, the strategy would be obtained through an iterative process, in which relevant legislative bodies work together with the railways both to develop options and to choose the most optimal ones. Usually, such mitigation options consist of different threshold levels, different types of measures and combinations thereof as well as a variety of constraints,

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e.g. cost-effectiveness limitations for noise barriers. Four case studies are presented, where such strategies have been developed and a suggested procedure is derived from these examples.

2. Case study Switzerland

The Swiss noise ordinance was enacted in 1986 and requires railways to attain defined threshold values, if this is economically feasible and operationally possible. An extensive noise mapping is additionally required as a basis for this mitigation. As a first step the Swiss Federal Railways undertook an approximate mapping of the entire network on a scale of 1:25,000. These maps indicated the location of noise problems necessitating a more extensive three-dimensional mapping. With the help of these detailed maps (1:2000) the costs and the amount of noise reduction of different combinations of measures were calculated. In cooperation with the authorities a strategy was found in which:

- all Swiss rolling stock is improved,
- noise barriers are built in all cases where a predefined cost-effectiveness index is attained. In most cases the height of the noise barrier is limited to 2 m above track [1],
- insulated windows are installed in all cases in which the thresholds are not attained with the first two measures.

With the first two elements of this strategy, almost 70% of the line side population can be protected at about 30% of the costs to attain threshold levels for all inhabitants [2]. The costs for the third element—insulated windows—is comparatively small and consists of about 5% of the total costs. This strategy was developed in close cooperation with the authorities and subsequently became part of an additional noise ordinance. The priorities where determined with an index called "noise mass" defined as the number of persons above threshold levels weighted by the number of decibels above the threshold. Based on this, priority was given to the main north–south freight corridors. The program is currently being implemented along in the entire system and is scheduled for completion by 2015. Currently, all noisy passenger cars have been retrofitted with composite brake blocks and the retrofitting of freight vehicles has started in early 2005.

To enable efficient noise barrier planning the noise mapping tool was upgraded into a sophisticated planning instrument (called APT "Akustikprojektierungstool"). This tool not only allows automated production of all reports and maps needed for the approval process but also allows on site determination of whether changes still fit the cost-effectiveness constraints. For the latter a laptop computer is directly connected to surveying instrumentation. This tool has greatly increased planning productivity and efficiency. In the past 4 years, some 122 noise barrier projects were sent to government authorities for approval.

3. Case study European freight corridors

In the years 1998–1999, the International Union of Railways (UIC) commissioned a study to determine the optimal noise control strategy along freight corridors (Cost Benefit Study) [3]. For this work costs and the effectiveness of different noise control strategies were calculated for a total of 1667 km of line length (Rotterdam-Basel-Milano) and (Bettembourg-Lyon). The study was based on annual costs, which were obtained by calculating a 5% long term average interest rate, a 1% cost for maintenance and a linear depreciation over the life cycle of the measure. The effectiveness was defined as the reduction in the number of persons exposed to A-weighted levels of more than 60 dB due to the measure.

Without noise control about 250 persons/km had noise values above 60 dB. The study showed that to reduce noise levels beneath 60 dB yearly costs of €20,000–100,000/km would be necessary. A maximum effectiveness was achieved at €60,000/km/year. Above this value there was no additional effectiveness in scenarios with higher costs. All solutions containing rolling stock proved to be optimal. Scenarios with high noise barriers were not cost-effective.

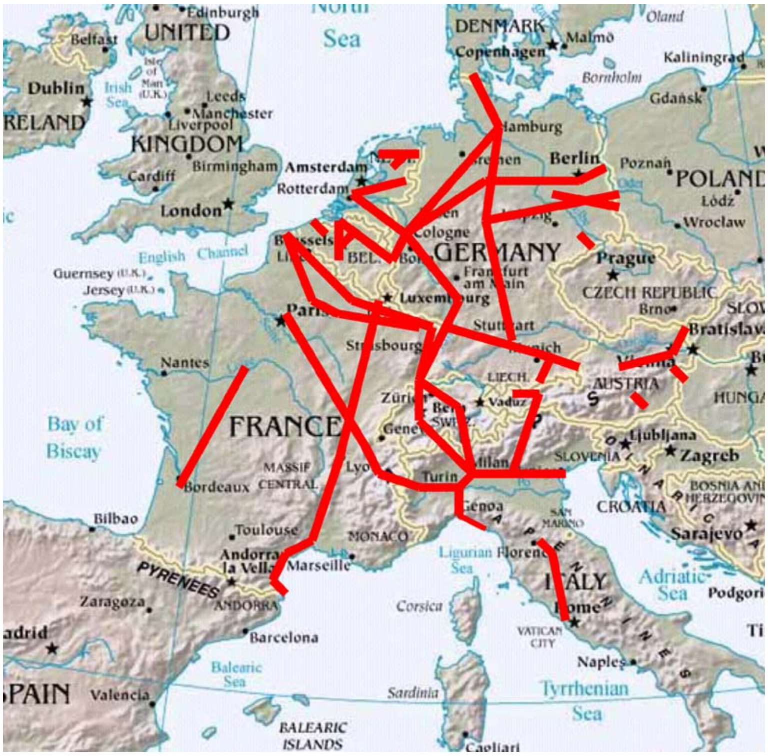

Fig. 1. Map showing lines chosen for acoustical data collection in the STAIRRS project.

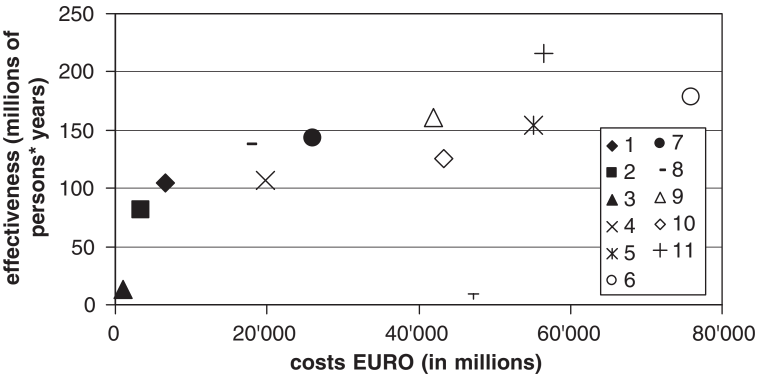

Fig. 2. Cost-effectiveness of programmes not including windows. Costs and effectiveness have been discounted. Scenario numbers are: 1: reducing freight wagons by 10 dB; 2: retrofitting freight wagons with K-blocks; 3: grinding the tracks; 4: adding tuned absorbers to the tracks; 5: 2 m high barriers; 6: a maximum of 4 m high barriers; 7: K-blocks, optimized wheels and tuned absorbers; 8: K-blocks and tuned absorbers; 9: K-blocks and 2 m high barriers; 10: grinding and 2 m high barriers; 11: K-blocks, optimized wheels, tuned absorbers, grinding and 2 m high barriers.

4. Case study STAIRRS

In the Strategies and Tools to Assess and Implement noise Reducing measures for Railway Systems (STAIRRS) project (WP1) the freight corridor analysis was enlarged to encompass all of Europe [4]. This project was co-financed by the EU and by the UIC. The acoustically relevant geographic, traffic and track data were collected for 11,000 km of line length in seven European countries shown in Fig. 1. Noise calculations were undertaken with the Eurano 2001 software program. Standard cost-effectiveness methodologies were adapted to fit the requirements of noise control projects. A specifically developed extrapolation mechanism allowed studies on Europe as a whole as well as in individual countries.

The results shown in Fig. 2 corresponded to those of the UIC study. The costs of noise control are high, the total extrapolated present costs ranging from €3.5 billion (K-blocks on freight wagons) to €76 billion (allowing a maximum of 4 m high barriers). Again freight rolling stock improvement had the best cost-effectiveness while noise barriers had a low efficiency. Also, track measures in combination with rolling stock measures were shown to be highly effective. The conclusions were true both for the 11,000 km for which detailed acoustical data was available as well as for an extrapolation to 21 countries. Exceptions only occurred in those countries which have an exceptionally high or low number of freight wagons.

5. Case study Luxembourg

In 2002, the Luxembourg Railways CFL commissioned the Swiss Federal Railways to undertake an approximate mapping as a first step in determining an optimal strategy for the network. Using the software program Eurano 2001 a two-dimensional noise map to the scale of 1:20,000 of the network was undertaken and different strategies and threshold levels were tested in close contact with government ministries. In addition critical hotspots were determined as well as areas without noise problems. The results for Luxembourg correspond to the STAIRRS results, with rolling stock measures again demonstrating the best cost-effectiveness ratio. These results form a basis for developing a noise control strategy for the CFL, which at the time of this writing (early 2005) was not yet complete.

6. Developing strategies: suggested procedure

The experience in the above case studies suggests it is worthwhile to follow the following procedure when developing a strategy for an entire network:

(1) Use approximate and inexpensive two-dimensional mapping to the scale of 1:25,000–1:50,000 to determine the extent of the problem. This mapping should be undertaken in such a way that the parameters necessary for step 2 have already been collected. These usually consist of geographic data (extent of urban areas, individual houses), traffic data (number, composition and speed of trains), track data (acoustically relevant elements) and demographic data (population density of urban areas).
(2) Calculate costs and effectiveness of different scenarios using the data obtained in step 1. This can be done with the tools developed in the STAIRRS project. Scenarios include individual measures, combinations thereof or variations in threshold levels. For this purpose it is useful to develop scenarios in close cooperation with the relevant authorities.
(3) Based on the results, the optimal balance between legislation, costs and noise protection can be determined and an optimal strategy developed. Ideally this strategy is determined in close contact with legislative bodies. Because the costs of each scenario are known, the often observed tendency to enact thresholds that are difficult to attain with reasonable financial commitment is greatly reduced.
(4) Based on the strategy and the approximate mapping results, those areas which require further attention can be determined. Here usually a detailed three-dimensional mapping is required, which will form the basis for planning the actual noise abatement measures. Three-dimensional mapping is usually expensive, however—following this procedure—it would be restricted to critical areas only.

7. Conclusion

An approach which integrates mapping and cost-effectiveness considerations allows adherence to the EU requirements while obtaining a network-wide noise control strategy at the same time. The procedure results in a strategy that finds a balance between legislation, railway competitiveness and environmental protection.

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