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COST–BENEFIT ANALYSIS IN RAILWAY NOISE CONTROL

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A method to calculate the network-wide costs of realizing different noise control possibilities and their benefits in terms of noise reduction for lineside inhabitants has been implemented in Switzerland. These studies have shown that an optimal cost distribution consists of spending 65% of the available finances on rolling stock improvement, 30% on noise control barriers and 5% on insulated windows. This mix protects 70% of the lineside population for 30% of the cost necessary to attain threshold levels for all inhabitants. This noise control strategy has been accepted by the federal traffic and environment agencies involved and will save billions of Swiss francs. The success of the calculation methodology has prompted development of a Europe-wide decision support system to the same effect. Along two freight freeways the relationship between rolling stock improvement, noise barriers, insulated windows, operational measures and track characteristics is being studied. The decision support system will allow determination of those combinations with the best cost–benefit ratios. The study is currently being undertaken as a joint venture by the railways of Switzerland, France, Germany and the Netherlands as well as the European Rail Research Institute. The results constitute part of the negotiating strategy of the railways with European and national legislators.

1. INTRODUCTION

Awareness of rail noise is increasing in most countries as the adverse effects on health and quality of life are being recognized. Several countries such as Italy, Switzerland and the Netherlands have enacted severe noise control legislation. Other countries are expected to follow suit and EU-wide legislation is being considered as well.

Those countries with existing noise control ordinances report tremendous costs to attain the regulatory threshold levels. Costs for railway noise control are threatening the economic viability of the railways, all of which must operate on very restricted budgets. The railways must therefore react quickly in an effort to negotiate feasible legislation. A method to calculate the network-wide costs of implementing different noise control possibilities is therefore of great importance.

This article reports on the results of an extensive cost–benefit study undertaken by the Swiss Federal Railways and on similar work being initiated on a European level.

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2. DEFINITION OF COST–BENEFIT RELATIONSHIP

First, three parameters must be defined:

Benefit of a noise control measure:

$$\text{benefit} = \text{attained noise reduction} \times \text{number of profiting persons}$$

In Switzerland the noise reduction is weighted, i.e., reductions at higher levels count more than at lower ones.

Cost–benefit relationship:

$$\text{Cost–benefit} = \frac{\text{yearly costs of noise measure}}{\text{benefit of measure}}$$

Yearly, rather than absolute costs, take differing amortization times into account. This relationship can be described with a number: the cost–benefit index. The lower the value, the better the cost–benefit ratio.

Goal-attainment level:
The goal-attainment level takes legislated threshold levels into account:

$$\text{goal-attainment level} = \frac{\text{number of persons with noise reception levels above threshold } \textbf{with} \text{ measure}}{\text{number of persons with noise reception levels above threshold } \textbf{without} \text{ measure}}$$

3. THE SWISS STUDY

3.1. NOISE CONTROL LEGISLATION IN SWITZERLAND

Swiss noise legislation, enacted in 1987, calls for noise control measures on existing railway lines by the year 2002, although a postponement until 2015, and on new lines as they are built. Different threshold levels are defined for existing and new lines. In addition, these levels vary with the noise sensitivity of the neighbouring areas and the time of day; i.e., threshold levels are higher for existing lines, in areas with low sensitivity, and during the daytime. The legislation allows the consideration of economic criteria when evaluating noise control measures; however, the federal agencies require a goal-attainment level of at least 66%.

3.2. RESEARCH CONCEPT

The aim of the research was to quantify the economic considerations allowed by the Swiss noise legislation and to determine the most economic combinations of measures. Rolling stock improvement, noise barriers and insulated windows were considered to be the most interesting noise possibilities to be examined. Using a computer simulation of a large part of the network, the overall costs and benefits of many different measure combinations were calculated.

3.3. METHODOLOGY

3.3.1. *Basic data*

The calculations were based on detailed noise cadastres of about 80% of the noisy lines. All the data were incorporated into a geographical information system. The topography was determined by aerial photography and analyzed photogrammatically. The noise creation values are based on operational statistics and predicted values for the year 2015. The number of inhabitants was based on the most recent population census.

3.3.2. *Measures*

Each measure was varied according to Table 1

3.3.3. *Calculation of costs and benefits*

For each noise creation scenario, i.e., for each type of rolling stock improvement, the necessary noise control barriers and the number of windows were automatically calculated for each variation. The costs and benefits for each measure combination were then determined. In all, over 100 different combinations were tested.

3.4. RESULTS

The results can be summarized as follows:

- The optimal combinations are dependent on the available financial resources. For example rolling stock improvement requires a certain minimal investment to be effective. In Switzerland this value is between 1 and 1·5 billion Swiss Francs.
- Above a certain value, virtually no added value can be gained from investing further, if only rolling stock and noise barriers are considered. In Switzerland, this value is reached at a goal-attainment level of about 80%.
- A consequence of the above statement is that the attainment of all threshold values is virtually impossible, if only rolling stock improvement and noise barriers are used.

TABLE 1

Noise control measure	Variation studied
Rolling stock improvement	Variation in number and type of rolling stock improvement (e.g., only passenger cars; passenger cars and freight cars; all Swiss and international rolling stock)
Noise control barriers	Different heights (2, 3 and 4 m) and different cost–benefit indices
Insulated windows	Integration of insulated windows at two different noise reception values

- For Switzerland, the optimal mix of noise control consists of spending 65% of the available finances on rolling stock improvement, 30% on noise control barriers and 5% on insulated windows. This combination requires improving all Swiss rolling stock, building noise control barriers with a maximum height of 2 m but with cost–benefit limitations (i.e., noise barriers only where economically sensible) and with insulated windows where the remaining noise reception levels are above the legislated threshold levels. This combination of measures results in a goal-attainment level of about 70%, at costs of about 30% of that needed to reach the legislated noise threshold levels.
- A considerable increase in the goal attainment levels (about 10%) can be achieved if there is European co-operation on rolling stock improvement.

3.5. ACCEPTANCE BY FEDERAL AGENCIES

The work was carried out with the participation of the Federal traffic and environmental agencies and therefore receives their support. As mentioned earlier, the Swiss noise ordinance allows economic criteria to be used when determining the amount of noise control necessary, although the extent of the emphasis on this element in the current study was not originally intended. Nonetheless, a good co-operation with the authorities has been achieved.

3.6. ACCEPTANCE BY LINESIDE POPULATION

Those persons not receiving any noise control due to economic criteria often have difficulty in understanding the procedure. The acceptance by the lineside population is therefore limited. However, the fact that the same criteria are being used throughout the network is appreciated. It is therefore important that no exceptions are made, even though many local governments perceive their particular area different from the rest of the country.

3.7. USING SYSTEM TO SET PRIORITIES

The results have allowed priorities to be determined. For this purpose, an “affliction level” was defined for each line. This level is defined as the number of persons above the threshold levels multiplied by the number of decibels exceeding the threshold divided by the length in kilometres along the line with noise reception levels over the threshold levels.

$$\text{Affliction level} = \frac{\text{number of lineside inhabitants} \times \text{their noise reception level above threshold value}}{\text{km of line length with noise reception levels above threshold values}}$$

Due to the major influence of rolling stock improvement, this measure will receive first priority. Next, mainly due to political reasons, the major transit lines will receive noise barriers and insulated windows. The remainder of the network will be treated following criteria based on affliction level. The priorities are summarized as in Table 2

TABLE 2

Priority	Action
1st priority	Rolling stock improvement
2nd priority	Noise control barriers and insulated windows along the two major north–south freight lines
3rd priority	Noise control barriers and insulated windows along the remaining track based on affliction level.

3.8. FINANCING

The required financial support is part of a government proposition to promote public transportation, including the transit lines across the Alps and a TGV connection to Lausanne. Swiss voters accepted the financing package in November 1998.

4. THE EUROPEAN STUDY

The success of the calculation methodology in Switzerland has prompted the development of a Europe-wide decision support system to the same effect. Along two freight freeways (Rotterdam–Venlo–Köln–Basel–Chiasso–Milano and the French section of Antwerpen–Luxembourg–Lyon) the relationship between rolling stock improvement, noise barriers, insulated windows, operational measures and track characteristics is currently being studied. For this purpose the Dutch Gerano software is being developed into a modified European version called Eurano. This will allow calculation of costs and benefits along the entire route. The basic idea behind the study is similar to the Swiss research described earlier; however, due to cost and time restriction, it is being undertaken in a more general form. The research is being led by the Swiss Federal Railways with the co-operation of the railways of Germany, France, the Netherlands as well as the European Rail Research Institute.

The basic data are based on topographic maps 1 : 25,000; other data such as train types and speeds or existing noise barriers are supplied by the railway companies involved. Population estimates are based on the extent of urbanized areas. The system will automatically calculate the remaining noise barriers necessary for different noise creation levels based on rolling stock or track improvement.

The results will provide optimal combinations of noise control measures for different financing levels. These results will be beneficial in the railways' negotiating efforts with the national and European legislature. First results are expected by mid-1999.