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Cost-Benefit Analysis of Rail-Noise Mitigation Programmes at European Level: Methodological Innovations from EURANO to STAIRRS

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Abstract

The STAIRRS project (2000-2002) is a follow-up of EURANO [1] and a Swiss study [2], in which the authors evaluated the efficiency of noise reduction measures in two European freight corridors. STAIRRS includes a cost-benefit analysis based on about 10,000 km of track modelled in seven countries. The benefits are defined in terms of the dB(A) experienced by those living in the rail corridors modelled. They are to be weighted by the number of persons benefiting each year from a noise reduction as different measures provide different time profiles for the reductions. We assume people's preference for an early reduction in noise and will therefore experiment with a time weighting factor.

The problem of the different life spans of measures making up a noise mitigation programme will be approached in two ways: (i) The costs will be discounted over the lifespan of each measure in an investment programme, and the benefits will be weighted in function of the average lifespan of a programme. (ii) The costs will be modelled for each programme over a 50-year period, but assuming noise reduction on an indefinite basis.

The use of different discounting factors for both approaches should clarify the uncertainty implied by these two approaches.

1. Introduction

In order to reduce pollution and energy consumption, the European Commission should favour a modal transfer from road to rail in the coming years. However, this environmental gain cannot be supplanted by effects on the quality of life due to the increase of noise in the vicinity of railway lines.

The STAIRRS project, presented in greater detail in another paper in Internoise2001 [3] aims to evaluate the potential noise reduction level and the costs of a scenario involving a number of technical measures.

The first work package of the STAIRRS project is a follow-up of EURANO [1] and a Swiss study [2], in which the authors evaluated the efficiency of noise reduction measures in two European freight corridors. Task 1.7 of WP1 consists of the development of a cost-benefit software, based on about 10,000 km of track modelled in seven countries. This

software will be used in order to search for the optimal combinations of noise control measures (task 1.5 of the STAIRRS project).

At the time of writing, the study is still under way.

2. Methodology

The cost-benefit software will be based on an efficiency formula, which defines the efficiency of a scenario consisting of a set of measures. This efficiency is defined as the ratio between a physical Benefit function and a Cost function. The benefit is defined in terms of the reduction of dB(A) experienced by all peoples living in the rail corridors modelled.

The problem of the different life spans of the measures making up a noise mitigation programme will be approached in two ways: (i) an investment, or short-term, approach, where the investment can only take place during the first 10 years, and (ii) a long-term approach, where the costs will be modelled for each programme over a 50-year period.

The use of different discounting factors for both approaches should clarify the uncertainty implied by these two approaches.

2.1 Investment approach

2.1.1 Temporal aspects

The period allocated for a programme implementation is set at a maximum of ten years, *i.e.* between 2005 and 2015. A programme is composed of a number of measures to be implemented at various times during this period. The costs of implementation occur only once, but all these measures call for maintenance or repair costs, which occur periodically. Under maintenance, we consider simply the maintenance and repair that are necessary within the given lifespan of a measure to keep its noise reduction potential intact. For each measure it is necessary to specify the initial period after which maintenance and/or repair are required. It is also necessary to specify the rhythm at which this expenditure will occur.

Some measures, such as grinding, involve recurrent costs. These costs will be treated in the same manner as the maintenance and repair costs, and will not involve initial investment.

This short-term approach does not take into account the replacement of the equipment. Indeed, in 30/35 years, it can be assumed that the measures considered will be obsolete and that new technologies will have to be implemented. This approach enables also the most appropriate investment programme to be chosen in the case of an investor who has budgetary imperatives to be respected.

2.1.2 Cost Function

Costs will be discounted over the lifespan of each measure contained in an investment programme.

The cost function is the sum of all investment and maintenance costs. The investment costs are summed for each measure implemented during the 10-years investment programme. The maintenance costs are summed for each measure and each year since the end of the initial period (without maintenance costs) of the measure and to the end of its lifespan.

These costs are weighted by a function of the discount rate.

$$PC_x = \sum_{i=1}^{10} \frac{\sum_{j=1}^n I_{ji}}{(1+r)^{i-1}} + \sum_{i=i+s_j-1}^{i+a_j-1} \frac{\sum_{j=1}^n m_{ji}}{(1+r)^i} \quad (1)$$

Where:

PC_x = present costs for programme X

i = the year of investment ; $1 < i < 10$. Year 1 may be 2005 for instance.

j = measures (noise barriers, improvement of the rolling stock, brakes, etc). $1 < j < n$, where n is the number of different measures considered in programme X.

I_{ij} = investment costs for measure j in year i .

r = discount/interest rate.

s_j = number of years from the investment to the beginning of maintenance for the measure j .

a_j = lifespan of measure j .

m_{ji} = maintenance and repair costs for measure j in year i '.

2.1.3 Benefit Function

Benefits (P_i) corresponds to the number of persons living in the vicinity of railway lines who have experienced a noise reduction in terms of dB(A) thanks to the sum of the measures, weighted in function of the noise level before the introduction of the measures and the scale of the noise reduction.

Eurano2001 will provide data for this benefit calculation [3]. It is a software tool for large-scale noise strategy studies of railway lines on a European scale. It enables data input and noise calculation [1].

On the other hand, the benefits have to be weighted by a time factor (β) for the reduction of noise. Indeed, different measures provide different noise reduction time profiles and we assume people's preference for an early reduction in noise. ($0 < \beta < 4\%$)

We also assume that the benefits in terms of the reduction of noise are identical through the lifespan of the equipment. Thus, it can be supposed that the regular maintenance of the equipment may guarantee its maximum efficiency until the end of its useful life.

Finally, the last factor in weighting the benefit (ϖ_i) takes into account the difference of the average lifespan of the equipment between different scenarios.

The Present Benefit function (PB_x^{dB}) is the sum of this benefit, calculated and weighted by these three factors for each year of the investment programme.

$$PB_x^{dB} = \sum_{i=1}^{10} \frac{P_i}{(1 + \beta)^{i-1}} * \varpi_i \quad (2)$$

Where:

PB_x^{dB} = present benefits for program X (expressed in physical terms).

$$\varpi_i = \left[\left(\frac{a_i - A_{\min}}{A_{\max} - A_{\min}} \right) * \left(\frac{A_{\max}}{A_{\min}} - 1 \right) \right] + 1 \quad 1 \leq \varpi_i \leq \frac{A_{\max}}{A_{\min}} \quad (3)$$

a_i = average lifespan of the equipments corresponding to the different measures introduced

$$\text{in year } i.: \quad a_i = \sum_{j=1}^n \frac{a_j}{n} \quad A_{\min} \leq a_i \leq A_{\max} \quad (4)$$

A_{\min} = Minimum lifespan among the equipments corresponding to every measure j used in STAIRRS

A_{\max} = Maximum lifespan among the equipments corresponding to every measure j used in STAIRRS

A_{\min} and A_{\max} will be fixed from the beginning and will not depend on project X. They will therefore be common to each project X and for each year i .

2.2 Long-term target value approach

This approach assumes that noise target values must be attained over long periods of time. This requires replacement of noise measures at the end of their life spans so that these costs are included.

The costs will be modelled for each programme over a 50-year period, but assuming noise reduction on an indefinite basis.

Perspectives

This study is still under way. The cost-benefit analysis software has to be run to analyse the sensitivity of the different parameters to find which are the most influential items in the investment programmes.

The software has to run for the optimisation program, which permits to find an optimised investment programme. This subject is considered in greater details in another paper in *Internoise2001* (Guerrand *and* de Almeida).

We could later express the benefits in monetary terms rather than in physical units. This would enable us to go further than just a simple “cost-effectiveness” analysis.

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References

1. Elbers F. and Oertli J., “Eurano99: Policy tool for strategy of railway noise.” *Internoise2000*, Nice, France.
2. Oertli J., Elbers F.B.J., Beier M., Joncour S., Hemsworth B. “European Rail noise Abatement, Cost-Benefit Analysis. Final Report”, UIC Task Force Noise, 1999.
3. Oertli J., Elbers F., van der Stap P. “The STAIRRS Project: a cost-benefit analysis of different measures to reduce railway noise on a European scale”. *Internoise2001*, The Hague, Netherlands.