inter.noise 2000
The 29th International Congress and Exhibition on Noise Control Engineering
27-30 August 2000, Nice, FRANCE

I-INCE Classification: 0.0

ECONOMIC STUDY ON RAILWAY NOISE: EFFECTIVENESS OF DIFFERENT SOURCE REDUCTION CONFIGURATIONS

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Keywords:
RAILWAY NOISE, COST BENEFIT, NOISE REDUCTION

ABSTRACT
Noise reducing products of the European projects Euro Sabot, Silent Freight and Silent Track have been assessed in an economic sense. Different combinations of promising noise reducing measures have been selected, based on estimated and validated acoustical effectiveness. In most configurations noise reducing measures to track and rolling stock are combined. Basic cost estimates for each of the products are based on estimates from industrial partners. The overall noise reducing effects of different configurations have been assessed, by using a geographical noise policy tool. The acoustical and economical effectiveness of each of the configurations is evaluated and compared to the performance of noise barriers and window insulation.

1 - INTRODUCTION
The European projects Euro Sabot, Silent Freight and Silent Track have resulted in a number of noise reducing measures [4]. In this paper the cost effectiveness of these measures will be evaluated, by applying them to a single European Freight Freeway. The evaluation will be based on a geographical noise calculation program.
The desired volume of expansion of freight and passenger traffic by rail causes an increase of noise emission. Enforced by environmental restrictions this increase should be limited near dwellings and urban areas. Reduction in noise immission reception can be achieved by a combination of measures at the source of train and track, noise barriers and facade wall insulation. The measures are combined in six scenarios. Each scenario should produce a specific total noise reduction to provide a wide range of noise reductions (5 to 18 dB(A)).
Based on noise calculations the costs and benefits of different combinations of noise reducing measures are assessed. The measures are quantified in length of track or number of wagons that will to be adapted, length of noise barriers and number of houses to insulate.
This paper presents calculated costs of achieving certain noise targets for a combination of different control measures. The costs of the measures are calculated in Euro and are based on average prices. The calculated benefits are expressed in terms of number of houses above certain noise levels.
The calculations have been carried out for a major freight traffic railway line: Rotterdam (NL) − Basel (CH) − Milan (I). It is expected that the results of this study are valid for the entire European network of major freight-traffic railway lines.

2 - SELECTION OF SCENARIOS
The source noise reduction scenarios are built from measures developed within the European projects. The measures are combined in six scenarios. Each scenario should produce a specific total noise reduction to provide a wide range of noise reductions, up to 18 dB(A). The selection of scenarios is based on numerically and lab testing determined noise reductions [3]. Additionally, limited results of field tests have been used.
In addition to the measures presented above, the effects of shielding and barriers will have to be handled. The effect of shields and barriers is based on pass-by levels measured at the Velim test site, [1]. The

measured combined result of shields and barriers is a reduction of 3 dB(A). For the calculations the total reduction is distributed in individual reductions of shields and barriers of 2 and 1 dB(A) respectively.
Measures delivered by the project EuroSabot consist of alternative types of brake blocks. Applying low noise brake blocks results in noise reductions of 5 or 7 dB(A) in addition to the reductions at the source. These reductions due to lower wheel roughness have not yet been achieved, however it is still believed that these reductions are within reach [5].
Measures suitable for retrofit and new wheel or new track solutions are applied in separate scenarios. Table 1 shows a description and noise reductions for the selected scenarios. Validation by measurements has shown these noise reduction are within 1 dB(A) accurate [1].

Scenario		*Description*	*Reduction*
1.	Reference situation	Wagon: ORE 920 wheel Track: UIC60/monoblock concrete sleeper/railpad 300 MN/m Tread braked wheels, smooth rail according to project references	**n.a.**
2.	Brake block solution	LL brake block EuroSabot	**5 dB(A)**)
3.	Low cost retrofit solution	Ring damper for the ORE 920 wheel Tuned rail absorber	**6 dB(A)**
4.	Advanced retrofit solution	860 wheel with tuned absorbers/860 with ringdamper, tuned rail absorber	**7 dB(A)**
5.	Maximised retrofit solution	860 wheel with tuned absorbers/860 with ringdamper, tuned rail absorber Including shields and low barriers	**10 dB(A)**
6.	New track solution	860 wheel with tuned absorbers/860 with ringdamper, optimised rail shape and tuned rail absorber	**8 dB(A)**
7.	Maximised new track solution	860 wheel with tuned absorbers/860 with ringdamper Optimised rail shape and tuned rail absorber K brake block EuroSabot Including shields and low barriers	**18 dB(A)**

Table 1: Description of the scenarios and estimated noise reductions.

3 - CALCULATION METHOD

The Eurano99 software is used for data management, calculation and analysis [2]. Based on the scenarios described above, reduction in the noise emission has been specified according to the calculation method of Eurano99. The noise reducing measures on rolling stock only apply to freight traffic wagons. Track solutions will only be applied near urban areas where in the reference situation noise barriers are needed. Additional noise barrier and facade wall insulation are applied in order to meet noise immission limits of 55 and 65 dB(A).
The following costs aspects are taken into account in the analysis:

- Reference costs of 1 meter of standard track and wheels for one 4 axle wagon.
- Purchase and installation costs of noise reducing measures
- Costs for additional barriers and windows insulation
- Costs of maintenance (including rail grinding), interest rate and depreciation

4 - CALCULATION RESULTS

Figure 1 shows yearly costs determined for a noise immission limit of 55 dB(A). The #.1 scenarios represent scenarios for which additional noise barriers and insulation measures are applied. Without any measures 155 houses per kilometre are above 55 dB(A). More expensive source reductions generally give a stronger decrease in number of houses. A maximum of source measures brings this number down to 22

houses per kilometre. However, scenario 6.0 is not conform to this trend. More expensive than 5, while the number of houses above 55 dB(A) is higher: 63 instead of 47.
Applying the noise barriers reduces the number of houses above 55 dB(A) to around 6 per kilometre. In all cases around 50% of the noise barriers are 4 meter high barriers. For scenarios with less source measures the amount of 4 m high barriers is significantly more. Without any source measures (scenario 1.1) requires 60% noise barriers of 4 meter. Scenario 6.1 requires 43% noise barriers of 4 meter.

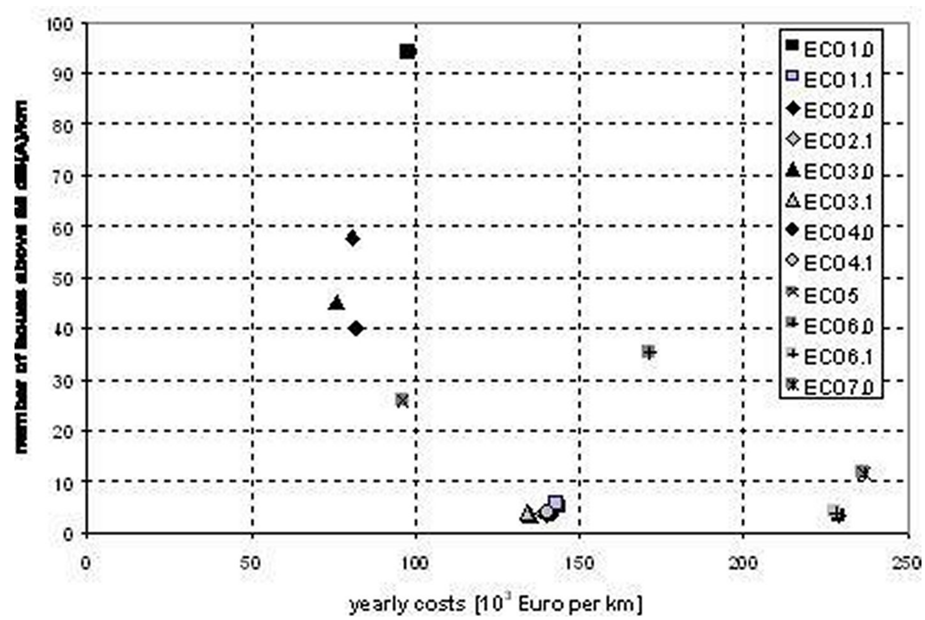

Figure 1: Number of houses above 55 dB(A) versus costs involved to meet a 55 dB(A) limit.

For the #.1 scenarios the number of houses above 55 dB(A) is comparable. With noise barriers applied scenario 3.1 is most cost effective. Figure 2 shows a break-down of the yearly cost for each of the 55 dB(A) scenarios. Costs of window insulation reduce strongly for increasing source measures. Track costs dominate for the new track scenarios 6.# and 7. Barrier costs dominate for all other #.1 scenarios.

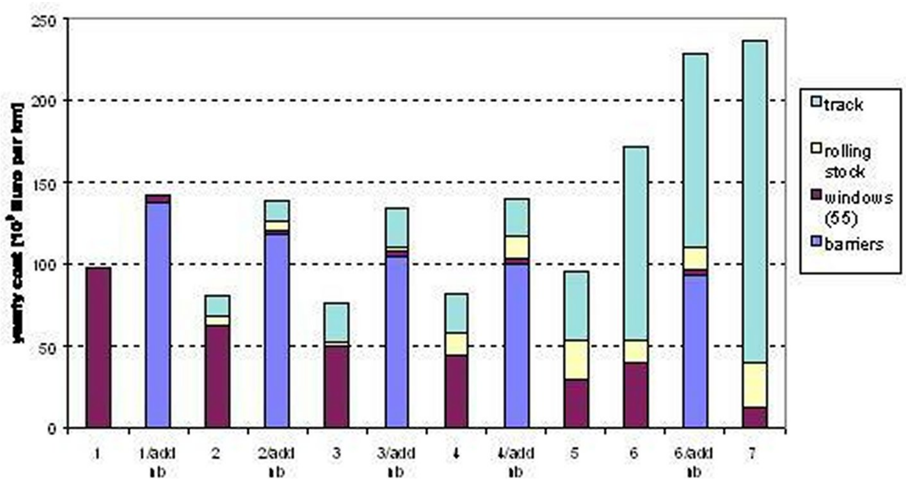

Figure 2: Yearly costs for different scenarios in order to meet the 55 dB(A) limit.

5 - CONCLUSIONS

Total reductions of up to 18 dB(A) are possible if a maximum off source measures is applied. Costs of track measures play a dominant role in the overall costs. Retro fit solutions, especially the low cost retrofit solution with 6 dB(A) reduction, are most cost effective to meet both the 55 dB(A) limits. The maximised scenarios, including noise barriers and shrouds, are able to limit the noise emission as good as barriers. A cheap solution is the application of low noise brake blocks, however additional rail grinding costs will have to be taken into account. Measures applied at the rolling stock are cheaper than measures to the track. However, based on the assumption of dominant track noise, these measures provide a low effort in total noise reduction.

ACKNOWLEDGEMENTS
This work was performed within the EU Brite Euram projects Silent Freight, Silent Track and Eurosabot, coordinated by ERRI.

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