Rail Freight Noise Abatement

A report on the state of the art

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Executive summary

The EU supports railways, because they are the most sustainable means of transportation. This, however, requires the railways to reduce noise, their most important environmental issue. Noise concern in the EU has led to the Environmental Noise Directive (END), which requires noise maps and actions plans for major railways as well as inside agglomerations. Railway noise emissions of new and upgraded vehicles have recently been limited by EU legislation.

Noise reduction in railways is influenced by the long life span of wagons and the large number of stakeholders involved. Basically rolling noise in railways is created by rough wheels and tracks. If both can be kept smooth, noise can be reduced significantly. Smooth wheels can be achieved by replacing cast-iron brake-blocks with composite brake blocks.

Currently two types of composite brake blocks are being discussed: K- and LL-blocks. K-blocks probably have a higher noise reduction than LL-blocks, but require adapting the braking system while wagons can be retrofitted with LL-blocks without adapting braking system.

Several economic studies show that railway noise reduction in retrofitting the freight wagon fleet with composite brake blocks has the highest cost-effectiveness. Also, if composite brake blocks are combined with other measures the overall cost-effectiveness is increased.

Life cycle costs are currently being investigated. It is expected that retrofitting with LL-blocks will be cost neutral in certain circumstances. With K-blocks costs for adapting the braking system must be added.

Due to the harsh competitive transport market, retrofitting is not possible without outside financial support for railway operators. Currently EU funding is only likely for pilot or demonstrator projects; investigations into additional sources of funding are therefore needed.

The UIC Action Programme for freight noise reduction aims to equip new freight wagons with composite brake blocks and to achieve the retrofitting of the existing fleet. This report is largely based on the UIC workshop on Rail Freight Noise Abatement in Europe of October 2005 as well as on the state of knowledge in Spring 2006. The report will be updated in regular intervals.

Introduction

The following pages report on the state of the art in railway noise control. The report is based on a UIC workshop on Rail Freight Noise Abatement in Europe, held in October 2005 in Paris. It is intended to inform a wider public on the issues involved.

1. The European framework

1.1 European traffic policy

European policy supports rail traffic: The European Commission is concerned about the impact of transportation on the environment. It realises that railways are the most environmentally friendly and sustainable means of transportation, both for freight and passenger traffic. In a white paper the European Commission therefore proposed to increase the market share of the railways. The stated aim is to attain the levels of 1998 by the year 2010.[1]

1.2 European noise policy

Noise is an important environmental problem: In a green paper[2] the EU considers noise one of the main local environmental problems, saying that noise abatement should therefore be given a high priority. As a consequence new and stricter noise legislation is being implemented considering both transport noise creation as well as ambient noise reception.

EU Working group proposes silent freight vehicles as part of the solution: Several working groups (WG) advise the Commission on noise questions. One of them was the WG Railway Noise, which concluded its work in 2004. This WG included participation of all major stakeholders, analysed many different noise abatement scenarios and produced a position paper[3] proposing retrofitting existing rolling stock with silent braking systems and noise limits for new rolling stock as the first priority. This position paper and its policy was largely supported by the participants of an EU organized workshop in October 2003[4].

1.3 Legal framework for railway noise

Noise creation (emission): With technical specifications for Interoperability (TSI) the EU enacts noise creation limits for railway vehicles, both for new rolling stock and for renewed or upgraded rolling stock. Different values are defined for the various types of rolling stock (e.g. freight wagons, locomotives, multiple units, coaches) as well as for different operation situations (e.g. pass by, stationary, starting and interior noise). For conventional railways the limit values for pass-by noise came into force on the 23.6.06. TSI regulations undergo a regular revision process every three years. This TSI acknowledges that retrofitting is desirable to accelerate rail freight traffic noise. [5]

Noise reception: In addition, all European countries as well as Norway and Switzerland have noise reception thresholds for new lines. Many countries also have limits for upgraded lines, while a few, such as Switzerland and Italy, also have reception thresholds for existing lines.

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[1] White Paper of the European Commission „European transport policy for 2012, time to decide“ (Com (2001) 370, 2001.
[2] Green Paper (Com(96)540), see: : http://ec.europa.eu/environment/noise/greenpap.htm
[3] see: http://ec.europa.eu/environment/noise/pdf/railway_noise_de.pdf
[4] see: http://ec.europa.eu/transport/rail/environment/noise_en.htm
[5] See Commission decision 2006/66/EC of 23 December 2005 (chapter 7.4)

1.4 Environmental Noise Directive (END)

Directive calls for environmental noise maps and action plans: The directive 2002/49/EC relating to the assessment and management of environmental noise[6] requires strategic noise maps and action plans for major railways (≥ 60'000 trains per year) and for large agglomerations (≥ 250'000 inhabitants) by 2007 (maps) and 2008 (action plans). Five years later strategic noise maps and action plans will have to be drawn up for railways with more than 30'000 trains per year and agglomerations with more than 100'000 inhabitants per year.

2. The railway framework

2.1 Relevance of railway noise

Noise abatement necessary for railway operation: Railway freight traffic is the main source of noise on existing railway networks. In order to maintain a sustainable transport system, the railways must reduce noise as their main environmental problem. If this is not done, the favourable view on railways may decline. In addition noise issues may prevent a traffic increase and therefore hinder the implementation of the European transport policy and its focus on increasing the railways' traffic share.

2.2 Railway particulars

Specific railway situation important for noise abatement: The particular circumstances in which railway operate must be taken into account when considering solutions for railway noise:

- The railways operate in a very tight competitive economic environment. Each investment influences competitiveness and must be considered very carefully.
- Normally freight wagons are only replaced after a very long life span. A satisfactory noise reduction therefore cannot be achieved merely through the normal replacement of existing wagons.
- Many stakeholders with different agendas are involved. These include operators, infrastructure owners, governments, regional authorities, and lineside inhabitants.
- Action planning will be the responsibility of infrastructure departments. These should include retrofitting in the currently ongoing action planning process in the framework of implementing the END.

3. The UIC Action Programme

A railway initiative to promote retrofitting: The railways recognize the need for noise reduction. Therefore the UIC (International Union of Railways), the CER (Community of European Railways and Infrastructure Companies) and the UIP (International Union of Private Car Owners) initiated the "Freight Traffic Noise Reduction Action Programme" in 1998. This project aims to equip new freight wagons with composite brake blocks and to achieve the retrofitting of the existing fleet.

Consensus building workshops: In October of 2005[7], the Action Programme organized a first workshop designed to build consensus and promote retrofitting the European freight fleet. Additional workshops are planned on a yearly basis.

[6] see: http://ec.europa.eu/environment/noise/#2
[7] see: www.uic.asso.fr/environment/Railways-Noise.html

4. The available technology

4.1 Basic noise control possibilities

Different possibilities exist for controlling traffic noise: Traffic noise, including railway noise, can be controlled with the following methods:

- *At the source:* This is usually achieved by either improving the rolling stock or the track.
- *Between source and inhabitant*: Noise barriers are the most common method of noise abatement between the railway lines and inhabitants.
- *Near the inhabitant:* Insulated windows can offer protection, where other methods fail.

4.2 Railway specific rail-wheel interaction

Smooth wheels on smooth tracks result in less noise: Railway rolling noise is the result of small irregularities or roughness on the wheel and on the track. When in motion, this causes both the wheel and the track to oscillate, thus creating noise. A significant portion of the noise can be eliminated, if the both the wheels and the track are smooth. Cast-iron braked wheels cause rough wheels. On the other hand, wheels remain smooth using composite brake blocks. Therefore, the choice of brake blocks has a large effect on rolling noise levels.

4.3 Composite brake blocks

Smooth wheels can be achieved using composite brake blocks: Currently there are two types of composite brake blocks in discussion: The K- and the LL-blocks. The two types are described in the following table:

	K-blocks	LL-blocks
Rolling noise reduction[8]	8 – 10 dB	Not yet sufficiently quantified, 2 dB less than K-blocks expected
Retrofitting possibilities	Requires adapting braking system	No adaptation required
Braking characteristics	Independent of velocity	Velocity dependent (similar to cast iron brake blocks)
Homologation	Definitive homologation of three types since 2003	Provisional homologation 2005 – 2007 for three types, definitive homologation scheduled for beginning 2007

Conclusions for UIC strategy: New wagons with K-blocks, existing wagons retrofitted with LL-blocks: In addition to braking performance, homologation requires safety and operating issues, such as performance under severe winter conditions and studying possible effects on track circuits.

[8] Pass by levels at 80 km/h at 7.5 m.

Figure 3.2. Picture of wagon retrofitted with k-blocks. Old wagons such as these are now as silent as modern passenger vehicles.

5. The economics

5.1 Studies undertaken

EU and UIC projects study cost-effectiveness of different measures: Anticipating the need to optimize noise control strategies on a European level, both the railways and the EU have undertaken cost-effectiveness analyses. The most comprehensive study was the STAIRRS (Strategies and Tools to Assess and Implement noise Reducing measures for Railway Systems) project, co-financed by the EU fifth framework programme and by the UIC. In this project the acoustically relevant geographic, traffic and track data were collected for 11'000 km of lines in seven European countries. Standard cost-benefit methodologies were adapted to fit the requirements of the project. An extrapolation mechanism allowed studies on Europe as a whole and, in an approximate manner, also on each individual country or region of interest.

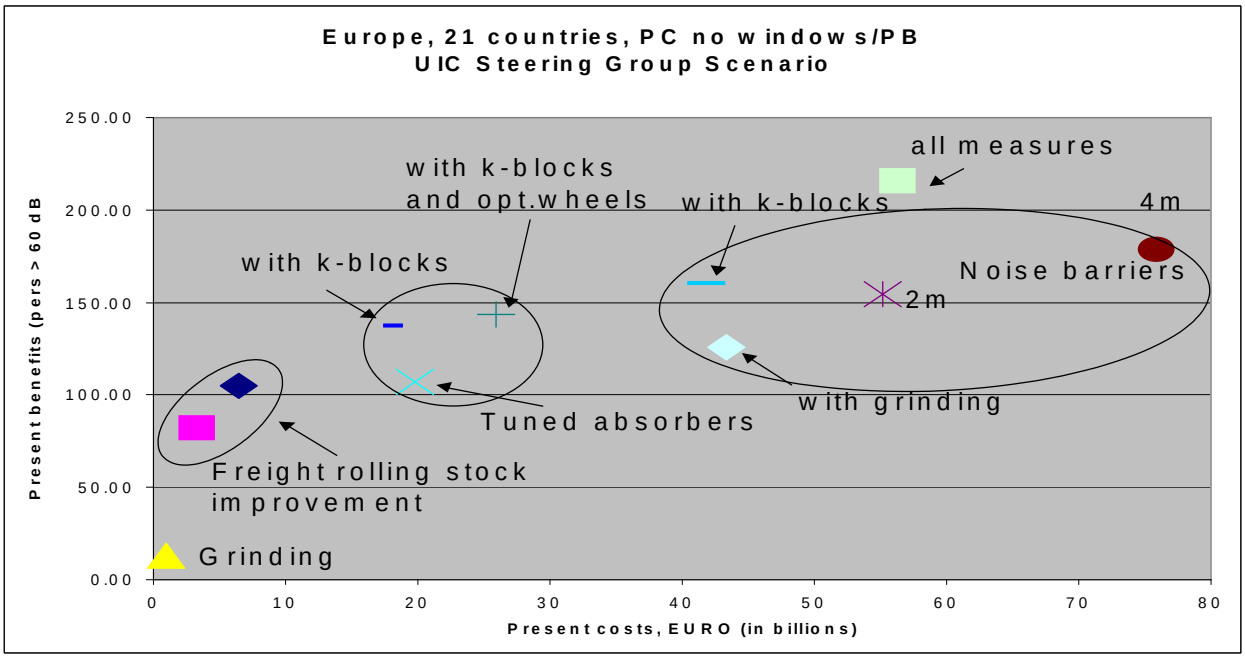


Figure 4.1: Main results of the STAIRRS project. The graph shows that solutions using composite brake blocks save considerable amounts of money in comparison to noise abatement with only noise barriers.

Conclusions: Major conclusions are:

- Good cost-effectiveness can be achieved by combining measures
- Freight rolling stock improvement has the highest cost-effectiveness both on its own and in combination with other measures.
- Noise barriers, in particular high ones, have a low cost-effectiveness.
- The conclusions for Europe as a whole are also true for individual countries.

In sum, STAIRRS shows that solutions using composite brake blocks save considerable amounts of money (billions of Euros in many European countries) in comparison to noise abatement with only noise barriers.

5.2 Overall cost estimates

New wagons cost neutral; retrofitting requires investment: Purchasing new wagons with K- or LL-blocks instead of cast iron blocks does not increase the overall costs of a vehicle. On the other hand, retrofitting existing wagons with k-blocks gives additional costs of € 4'000 to € 10'000 per vehicle[9], depending on the number of axles and wagon type. Retrofitting using LL-blocks is significantly less expensive and may even be cost-neutral. It must be noted that considerable costs occur for each wagon type in the homologation process. Wagon classes consisting of only few vehicles are therefore not the primary focus for retrofitting.

Extent of retrofitting: Retrofitting is most cost-effective if carried out during compulsory freight wagon inspection, which must be undertaken at least every 6 years. In total about 600'000 wagons must be retrofitted in all of Europe.

Maintenance costs: First studies indicate that maintenance costs are probably not affected when cast-iron blocks are replaced with composite brake blocks. Some studies indicate a small increase while others show a small decrease. The main cost drivers are wheel and brake shoe wear. These effects are in the process of being evaluated, in particular the cost effects of the wheel-sets. There is potential for optimization in maintenance cycles, so that an overall decrease in costs is expected.

5.3 Cost simulation tool

Calculating costs for a fleet: The UIC has developed a tool called FreightSimSilent, which allows precise calculation of Life Cycle Costs. This tool simulates the development of the costs in time and calculates profits or losses using K- or LL-blocks in new or retrofitted wagons in comparison to cast iron blocks. After being validated, this tool will be available to railways, the EU commission as well as other decision makers.

5.4 Regulations and possibilities for funding and financing

Railways require outside funding for retrofitting: Due to the harsh competitive transport market, railway freight companies currently do not have the financial possibilities for investments in composite brake blocks. Retrofitting the freight fleet will therefore require outside financial help, which might be supplemented by incentives for railway undertakings and wagon owners. Possibilities include:

- *EU funding:* Possible funding of pilot or demonstrator projects is being investigated. However EU funding or at least EU support for national funding should go beyond pilots and demonstrators and include the entire retrofitting process.
- *National funding:* The EU is in the process of developing state aid rules regulating subsidies by member states including retrofitting freight wagons.

[9] AEAT Technology, 2004, Status and options for the reduction of noise emissions from the existing European rail freight wagon fleet – including a third-party assessment of the UIC/UIP/CER Action Programme Noise reduction in Freight Traffic.

- *Incentives for retrofitting:* Reduced infrastructure charges might provide financial incentives to retrofit freight wagons.

6. Conclusions, next steps

Conclusions:

- ***Retrofitting saves money:*** Noise abatement solutions using freight wagons with composite brake blocks are cost-effective and save considerable amounts of money (billions of Euros in many European countries) in comparison to solutions including only noise barriers.
- ***Outside financial support necessary for railway operators:*** Due to the harsh competitive transportation market the railways are currently not in a position to finance retrofitting.
- ***UIC Action Programme is working on implementation:*** The UIC has put a project into place to support implementation of retrofitting freight wagons with composite brake blocks.

Next steps:

- ***Technical work:*** The K-blocks must be developed further and the LL-blocks must receive unlimited homologation by 2007.
- ***Economics:*** For both blocks life cycle cost studies should be completed.
- ***Funding:*** Funding possibilities for pilot and demonstrator projects as well as national subsidies should be investigated.
- ***Implementation Environmental Noise Directive (END):*** The possibility of retrofitting freight vehicles with composite brake blocks should be envisaged in the action plans of the END including funding modalities.
- ***Distribution:*** This report is distributed by UIC and CER to its members, who, in turn are requested to forward it to national and regional traffic, environmental and financial authorities.

Annex

Case studies

Switzerland

Noise legislation: Noise legislation has been in force in Switzerland since 1986. Additional legislation specifically for railways was enacted in 2000 and 2001.

Measure combination as a result of optimization: In order to obtain optimal noise control, costs and benefits of different measures and combinations of measures were calculated. The resulting measure combination includes retrofitting all Swiss rolling stock with k-blocks, building noise barriers with a cost-benefit constraint and installing insulated windows in all cases where thresholds cannot be achieved with either barriers or rolling stock improvement.

Road traffic pays for a large part of railway noise abatement: In 1998 the public voted on a public transportation financing bill including noise control. The finances come from taxes on trucks and gasoline as well as the value added tax.

Noise control completed by 2015: The retrofitting of all passenger vehicles was completed in 2005, freight wagons should be complete by 2009. Finally, by 2015 all noise barriers will have been built and all insulated windows installed. By then some 250'000 inhabitants will profit from reduced noise levels.

Noise creation is monitored by government: A maximum noise creation level for 2015 was defined for each line. These are monitored by the government at five locations.

Noise bonus as an additional incentive: Operators using silent vehicles on the Swiss railway network profit from reduced less track access charges, which currently amount to about 5 – 8 % of the total charges.

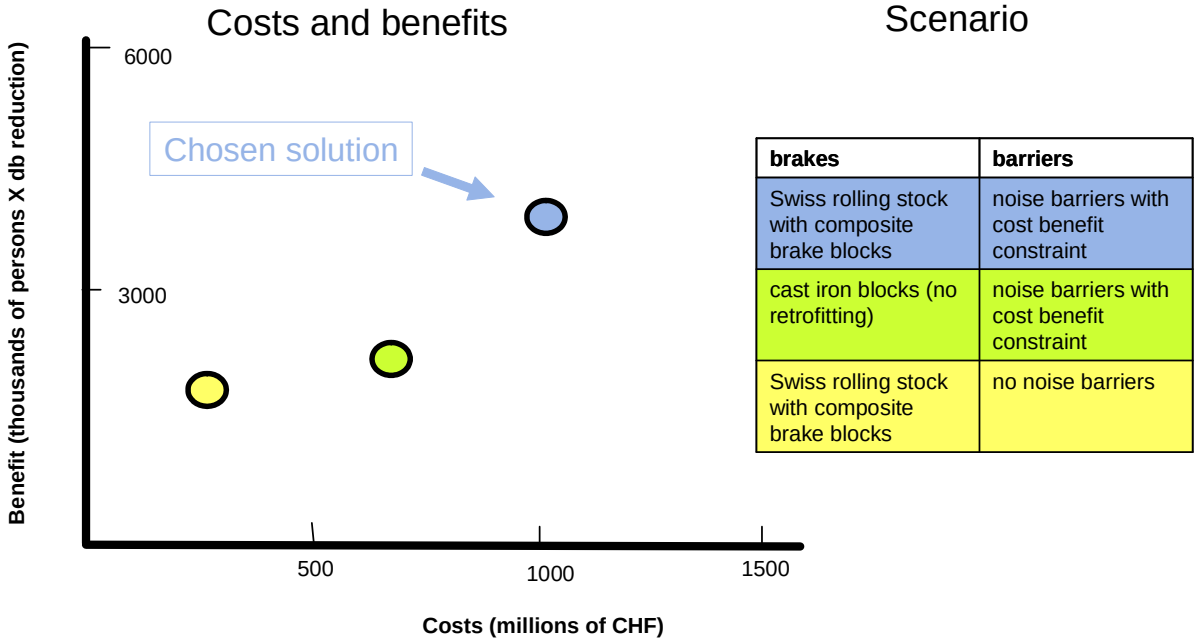


Fig. A-1: Railway noise abatement in Switzerland with and without composite brake blocks. Values are end cost estimates based on status of project in mid 2005. Combining rolling stock improvement with noise barriers increases cost-benefit ratio.

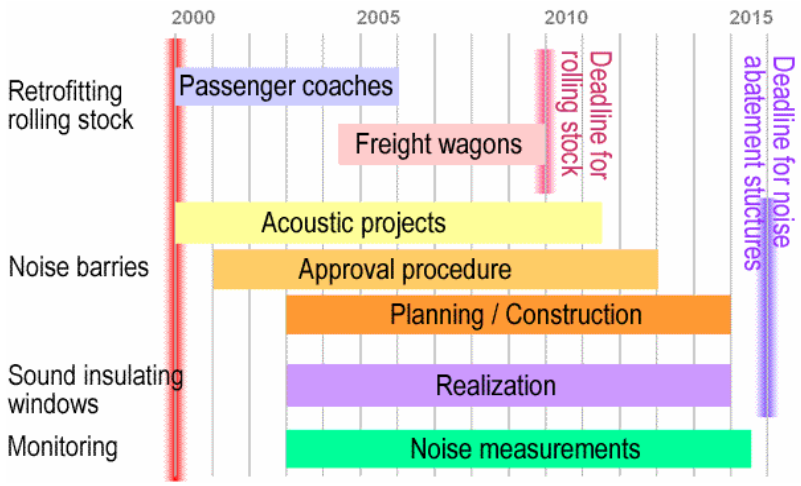


Fig. A-2: Time schedule of Swiss railway noise abatement plan. Noise barrier planning and implementation takes considerably longer than retrofitting wagons with composite brake blocks. This is because of the large number of individual projects.

The Netherlands

Noise innovation programme: Two government departments and railway infrastructure managers initiated the noise innovation programme in 2002. This programme, which will last until 2007 has a budget of € 110 million. It is designed to develop and implement cost-effective measure for road and railway noise.

Railway part: The innovation programme for the railways has a budget of € 25 million and is focussed on track and rolling stock. Large attention is given to implementing silent rolling stock.

Action to date: Some of the action to date include: fixed locations for noise measurement, practical tests with tuned rail dampers, acoustic grinding and retrofitting projects.

Whispering train: a k-block implementation project. For the whispering train project a block train was equipped with k-blocks and wheel dampers. The total noise reduction was 9 dB. The costs for retrofitting with K-blocks were given at € 6000 per wagon with four axles.

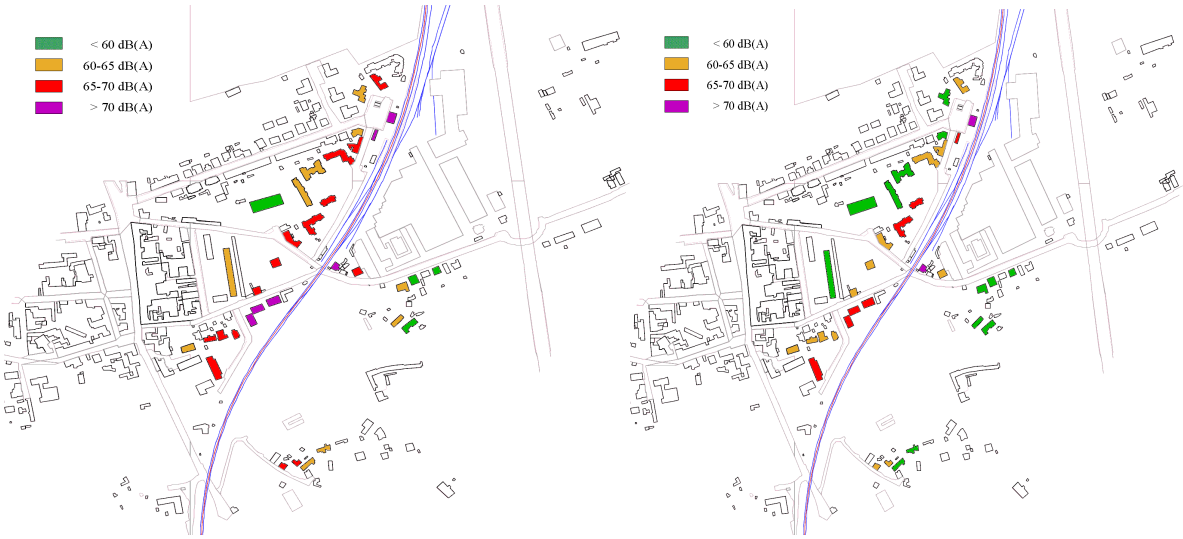
Fig. A-3: Test wagon of the noise innovation programme.

Italy

Complex legislation: Italian noise legislation is structured and complex. Starting from a framework law enacted in 1995 a large number of ordinances were issued. Railway noise legislation includes existing and new lines. The regions are responsible for controlling implementation of the legislation.

Extent of noise control: The railways are required to spend at least 7 % of the available finances for maintenance and development of the infrastructure on noise control measures.

Railway action plans: RFI (Rete Ferroviaria Italiana) presented a national action plan in 2004 setting noise abatement priorities based on number of inhabitants, noise levels and sensitivity of the area. This noise action plan requires costs of € 1'300 million over the next few years. Noise barriers are the most important measure. Improving existing freight rolling stock is not part of the action plan, although it is likely that this measure would increase the effectiveness. The Region Toscana is therefore promoting the idea.



Freight vehicles with cast iron brake blocks

Freight vehicles with composite brake blocks

Figure A-4: Effects of composite brake blocks in freight vehicles on first floor noise levels in a typical residential situation in Italy (railway line from Genova to Roma). It is estimated that noise barrier requirements can be reduced by 30 % in this particular situation. Note that the highest noise levels (>70 dB(A), violet) are almost entirely eliminated and the second highest (65 – 70 dB(A), red) are considerably reduced with the introduction of composite brake blocks. On the other hand, there is a significant increase in buildings with low noise levels (<60 dB(A), green).