ForumAcusticum
2 0 0 5

Reducing railway noise, strategic challenges and state of the art

Peter Hübner, dipl. Ing. ETH/SIA
Environmental Director SBB Swiss Federal Railways (retired); Im Hölzli 25, CH 8706 Feldmeilen, Switzerland; **peter.huebner@bluewin.ch**

The paper will point first on the political challenge for each European State; to reduce noise in general as it is implied by the "EU Directive 2002/49/EC 'evaluation and control of environmental noise'". The paper will then demonstrate that the railway noise reduction as too a business challenge for the railways. Railways today's noise levels present a serious risk that increased operating restrictions will be introduced. Railway noise reduction is therefore a business question in retaining market advantage. The paper will recall that the technical prerequisites for noise reduction are available. It will focus on the main railway noise source, the existing freight rolling stock and present the status of 'UIC Action Program Noise Reduction Freight traffic', including the development of new low noise K- and LL-braking shoes. It will deal the context to EU Noise policy, pinpointing some important findings of "EU Working group railway noise". (P. Hübner was Co-Chairman of this WG). The paper will include the status of the railway noise creation limit values fixed in the "Technical Specifications for Interoperability" (TSI) and will then focus on the implementation of the EU's Environmental Noise Directive and its action plans. The paper concludes that in railway noise abatement with ~5 % of the total investments needed for noise abatement in theory 50 % of the potential benefits could be achieved, if the investments are done in an optimised matter

1 The political challenge

Railways are the most environmentally friendly form of transport when it comes to moving people and freight quickly over long distances. This observation is based on the fact that railways use the least energy per transported amount, for example, do the least damage to the atmosphere, and also place the least burden on cultivated land. However, railways must admit that their fine environmental record is somewhat tarnished by the noise pollution which rail traffic continues to cause today. And the fact that specific railway noise is less intrusive than specific road noise does not help their cause. Generally speaking, the issue of reducing traffic noise in Europe has become a matter for concern both in the European Community and in the rest of Europe: The *Directive 2002/49/EC of the European Parliament and Council dated 25 June 2002 on the evaluation and control of environmental noise* [1] came into force upon publication on 18 July 2002 in the European Community Gazette. The aim of the directive is to draw up noise charts by mid-2007 for all major agglomerations with populations in excess of 250,000 inhabitants. These charts should indicate which method of transport is causing what level of noise for what number of people. One year later, EU member states must have developed action plans which explain how the noise can be reduced to acceptable levels. Soon after this, European states will be required to specify the measures which can be adopted to reduce noise, and in particular whether these measures will be enforced

- at the source
- among affected populations
- at transport companies
- or through a defined combination of measures.

The aim should be to complete a noise protection in the most efficient manner. In such a demanding situation, railways will, of course, be expected to contribute to a lasting reduction in noise pollution, and that is the subject of this paper.

2 Noise reduction is a business challenge

People in the 21st century depend on efficient means of transport for their prosperity. The growth in prosperity - especially in Europe - has been accompanied and characterised over the past 50 years by unforeseen growth in global transport, both in terms of quantity and in distances covered. The growth in transport quantity has been most notably due to road traffic. This development has been accompanied by an enormous increase in environmental pollution caused by that traffic. Examples include energy consumption and the associated air pollution, land usage, the dissection of inhabited areas, and noise pollution. At the same time, the ever-increasing signs of climate change are causing concern to the general public and to politicians.

These concerns are also forming the basis for demands for a lasting transport policy in many states: the various means of transport are expected to develop in such a way that our Earth's resources will continue to be available for future generations.

In this context, good environmental performance will be *the* strategic success factor to enable railways to play a leading role in sustainable transport policy. However, railways will only be entitled to play this political role if they improve their environmental performance over that of their competitors or at least

maintain their head start. In fact, their good environmental performance is the reason railways currently do have the advantage over their competitors; there is no restriction on night-time or Sunday travel, for example. Ironically, it is during the night or at weekends when people want to take a break that the public and politicians are increasingly finding the current level of railway noise intolerable and unacceptable. This presents a serious risk that increased operating restrictions will be placed on the railways if they do not reduce their noise pollution within the foreseeable future. And operating restrictions means commercial restrictions. So, noise reduction for the railways is ultimately a business question whose resolution will result in retaining market advantage.

3 The technical prerequisites for noise reduction are already available

There are basically three causes of noise from land-based traffic:

- Wheel/surface rolling noise
- Engine noise
- Aerodynamic noise

In the case of railways, engine noise predominates between about 0 and 50 km/h, with rolling noise taking over from about 50 to 280 km)h. Noise caused by aerodynamic effects dominates at speeds above ~250 km/h.

There is a widespread view that smooth wheel surfaces on smooth track surfaces can successfully counter railway noise. The main cause of noise from the wheels can be traced back to the use of cast-iron brake blocks which rub directly on the wheel surface during braking, abrading it and leading to increased rolling noise. This explains why, when disk brakes were introduced on passenger coaches because of their superior braking performance, they had the pleasant side-effect of halving the noise from these coaches. Typical noise levels for wagons with disk brakes are less than 80 dBA at 80 km/h over a measured distance of 7.5 m, if the quality of the track is also very good at the measurement location. This noise performance is sufficient, and therefore there is no need for international action concerning noise reduction of disk-braked coaches.

The situation is quite different when it comes to freight traffic. Until now it has not been necessary, for technical and commercial reasons, to replace braking systems fitted with cast-iron blocks. In the mid-1990s, the railways recognized that synthetic brake blocks could deliver the required braking performance for freight rolling stock without roughening up the wheels surface during braking. In consequence such a solution could solve the noise problem with -under ideal circumstances- relatively minor additional costs. As a result, the UIC, CER and UIP initiated the 'Freight Traffic Noise Reduction Action Program'. This has the aim of equipping new freight wagons with synthetic brake blocks and also converting existing rolling stock, where this is achievable on a cost-neutral basis, with the new kind of brake blocks.

4 Freight traffic noise reduction action program status

The development of synthetic brake blocks for international freight traffic proved to be a very considerable technical challenge because, on the one hand, the new blocks had to provide comparable braking performance to the cast-iron variety and, on the other, they had to prove safe under all operating conditions in Europe. Aside from braking performance, the issues of operation under severe winter conditions in northern Europe and the possible effect on track circuits had to be resolved. In October 2003, the responsible CTR engineering research committee of the UIC was able to approve two kinds of "K-blocks" for international traffic. These blocks meet all the technical requirements; their use is cost-neutral on new freight rolling stock, compared to the traditional cast-iron blocks. The K-blocks are theoretically suitable for converting existing freight wagons but, because of their superior braking effectiveness, their use requires modifications to the braking systems. This, of course, leads to increased costs which the freight networks are not in a position to meet. One solution in progress is the so-called LL-block. It intends to develop of synthetic block offering identical braking effectiveness as cast-iron blocks and thus requiring no adoption of the braking equipment. Developments here are underway, so the EU sponsored ERS (Euro Rolling Silently) project will conclude by 2005. At present, a number of these blocks are undergoing operational testing; the previous operational test results have been mostly positive allowing a provisional homologation of 2 products of LL-blocks in February 2005. The noise reduction was measured on the Gotthard line and showed a reduction of approximately 8 – 10 dB, compared to cast-iron blocks. The question of the effect of the new brake block materials on track circuits is still open, but the same issue had to be resolved in the case of K-blocks. It is also not yet possible to report definitively on whether the LL-blocks will lead to the same reduction in noise as the K-blocks.

The reduction in noise using K-blocks is very encouraging; the measurements given in Fig. 1 show noise levels in the region of 80 - 84 dBA at 80 km/h over a measured distance of 7.5 m, under strict homologation conditions (defined (and very good) track surface condition; wagons with a kilometric performance below 1000 km). The noise reduction compared with cast-iron blocks [wagon Sggns (GG) in the figure] is more than 10 dBA, thus halving the perceptible noise level. [2]

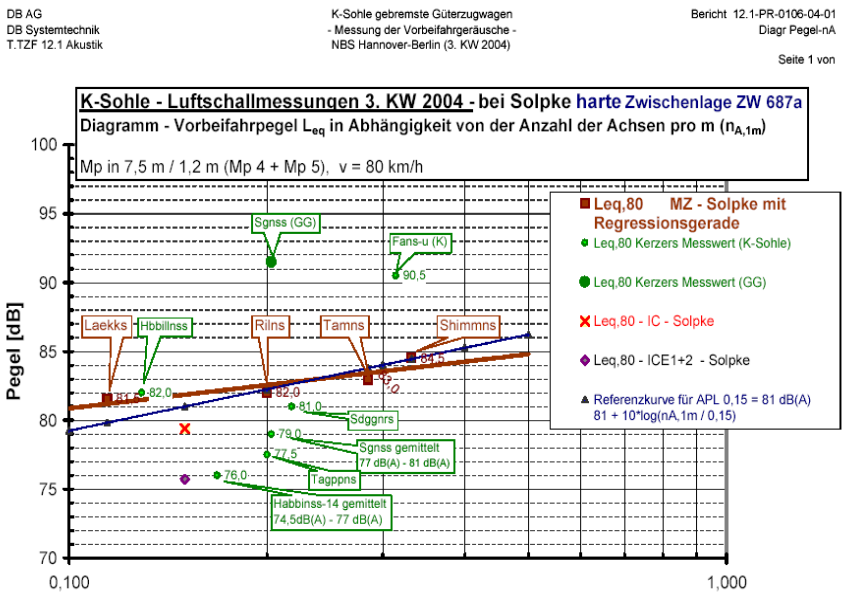

Fig 1: K-Block noise creation results

The planning for the conversion of existing freight rolling stock has basically been resolved as far as the procedure and the target wagons to be retrofitted are concerned: the conversion will be most cost-effective if it happens during the compulsory freight wagon inspection carried out at least every 6 years. There are about 600,000 wagons to be retrofitted in Europe. However, as indicated previously, it is a prerequisite for conversions that the railways can find sufficient funds. The data and predictions of the railways in the 'Freight Rolling Stock Noise Reduction Action Program' (quantity structures, conversion scenarios, costs) have been checked in an external study jointly commissioned by the UIC and CER in conjunction with the EU; in general, this study done by AEAT (NL) came up with the same results and recommendations as the UIC/CER.

5 Tools for developing a cost/benefit optimised noise reduction strategy already exist.

Traditionally, railways and researchers have been concerned with finding technical solutions to noise reduction. They investigated which technical methods could facilitate noise reduction. Of course, the implementation of any technical procedure involves costs but brings benefits which can be measured, for example, in terms of noise reduction. Unlike other technical developments which mostly bring commercial benefits for the railways, noise reduction cannot be sold directly on the market - rather, it brings political benefits. The question of an optimised cost/benefit noise elimination strategy for the railways was studied in detail in the STAIRRS[1] project in the 5th EU Framework Research Program. [3] Dedicated models were used in 7 countries and over 11,000 km of track to calculate the costs and benefits of the following noise reduction measures:

- rail grinding
- tuned absorbers, and
- converting freight rolling stock
- 2 m and 4 m noise barriers,

At the same time, the effects of both individual measures and their combined effect were calculated. The project also developed extrapolation methods which allow optimised noise elimination strategies to be determined for all of Europe as well as for individual countries. Fig. 2 shows the results for Europe. The first conclusion was that railway noise reduction in Europe would be expensive. Up to € 80 billions would have to be committed, depending on the scenario. The maximum benefit in Europe would derive from a combination of all measures (noise barriers, tuned absorbers and rolling stock conversion), with total costs of about € 60 billions. The conversion of rolling stock alone would cost some € 3-4 billions a sum which already accounts for about half the possible benefits. Worded another way, this means that 50 % of the benefit can be achieved with 5 % of the finance. This conclusion applies to all countries in Europe: the results are similar for each country, as Fig. 2 shows for the 21 countries studied.

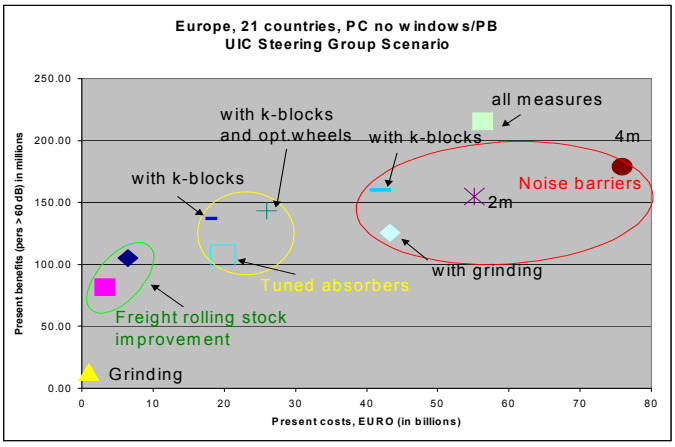

Fig2: Cost/benefits of different noise reduction strategies for Europe

[1] **S**trategies and **T**ools to **A**ssess and **I**mplement Noise **R**educing Measures for **R**ailway **S**ystems

6 The railway initiative is also gaining strategic political support.

Within the EU, various working groups have been given the task of advising the Commission on questions of noise policy. The working group on railway noise was formed in 1999 and concluded its work in summer 2004. The working group included representatives of the member states, the UNIFE railway industry, the UIC and CER railway organisations, as well as of the Commission. The chairman was Michael Jäcker from the German Federal Environment Office; the author of this paper was the co-chairman. Thorough discussions in the working group resulted in summer 2003 in the important result in form of a position paper on the strategies to be followed to reduce railway noise in Europe. [4] After analysing some 30 different noise reduction schemes, the working group came to the clear conclusion in this position paper that the first priority was:

- To introduce clear registration guidelines for noise for new rolling stock. This is provided for in the Technical specifications on interoperability (TSI) (see below);
- To convert existing freight wagons to synthetic blocks, and the question of financing this conversion had to be resolved for the railways.

In October 2003 at a workshop organised by the EU, the position paper earned broad support from representatives of traffic and environment ministries, as well as from railways. On the subject of financing, it was decided to look for solutions whereby funds which would otherwise be earmarked for the construction of noise barriers might be used for converting rolling stock. If this were possible, it would mean multiple benefits for infrastructure owners: noise reduction expenditure for the infrastructure would be lower than the expenditure for the rolling stock. Furthermore, the competitiveness of the operators in relation to the roads would not be adversely affected, meaning better business for the infrastructure owners through improved use of their routes.

The initiative the railways have pursued since 1999, to focus on noise reduction at the source and to tackle the current noise situation mainly from the point of view of converting existing freight wagons, has found definite political acceptance in the EU "Railway Noise Reduction" working group's position paper.

7 The legislative position in the EU

The following two actions form the basis at a legal level in the EU on the subject of noise abatement:

- The establishment of noise limits for new rail vehicles within the framework of the Technical Specifications for Interoperability in relation to noise reduction at the source, and
- The Environmental Noise Directive and its implementation in relation to noise control by affected parties.

8 The TSI position

The Technical Specifications for Interoperability have been developed for high-speed traffic (TSI HST) and for conventional rail traffic (TSI CR). The TSI HST was published some years ago, and work is currently under way on the TSI CR.

The TSI for high-speed traffic have been in force for a long time as have the maximum noise levels shown in table 1.

The TSI HST is currently undergoing revision - measurements taken as part of a measurement campaign organised jointly with the EU have shown that the limits proposed as a base line for 2004 are not realistic, given the current state of technology.

	Speed in km/h			
	250	**300**	**320**	**350**
New Rolling stock (1 dB(A) increase allowed due to measurement uncertainties)	**88**	**92**	**93**	
New Vehicles, ordered in existing design (during a transitional period of 24 months)	**90**	**93**	**94**	
Recommendations for new orders after 2004	**86**	**89**	**90**	**-3dB (A)**

Table 1: Noise creation levels for High Speed trains in existing TSI High Speed (TSI HST)

The TSI for conventional rail traffic (TSI CR) had to be developed new, as there was no regulation on force before. In November 2004 the draft, elaborated the technical experts of AEIF was accepted by the EU commission. The TSI noise for conventional rail rolling stock will come into force in summer 2005. It regulates for new rolling stock the admissible levels for pass-by noise, noise in stations, stationary noise and noise when starting off (see table 2). For retrofitted freight wagons, a 2 dB(A) increase of the pass-by noise levels is admissible.

In addition to the regulation of today's admissible noise levels of new rolling stock, the TSI also indicates, how the noise limits in the TSI should be modified for the future: This will be done in the revision process which will take place every 3 years. The TSI also includes a recommendation to lower all values by 5 dB for rolling stock to be ordered in 10 years and put in service in 12 years. However, it must always be remembered when discussing the TSI limits that the cur-

rent noise situation has been brought about by existing freight wagons. The low noise limits for new rolling stock are of only marginal help, and it will be decades before there are sufficient new (freight) vehicles in circulation which meet the low noise levels and result in a perceptible noise reduction. This is why the rail sector stresses that the conversion of existing freight wagons must be undertaken in parallel to the introduction of noise limits, and that this conversion must be cost-neutral for the railways.

Operating condition	Limits for Stationary Noise	Limits for Starting Noise	Limits for Pass-by Noise
Indicator: $L_{pAeq,T}$ 7.5 m from centre- line of the track in dB(A)			
Freight wagons with an average number of axles per length (apm) up to 0.15 m^{-1}	65		82
Freight wagons with an average number of axles per length (apm) above 0.15 m^{-1} up to 0.22 m^{-1}	65		83
Freight wagons with an average number of axles per length (apm) higher than 0.275 m^{-1}	65		85
Electric locomotives	75	82	85
Diesel locomotives	75	86	85
EMUs	68	82	81
DMUs < 500 kW / > 500 kW engine	73	83 / 85	82
Passenger coaches	65		80

Table 2: Noise creation levels for conventional railways

9 Implementing the Environmental Noise Directive

As established in the introduction, the EU's Environmental Noise Directive states that noise charts will be drawn up for larger agglomerations and for all kinds of traffic by mid-2007, and that noise reduction actions plans must be devised by mid-2008. Whether EU member states can hold to this plan is doubtfully, not least of all because there have been and are still unresolved questions regarding the calculation methods.

The railways must insist not only that the noise pollution is charted in dB, but, more importantly, that the different types of noise annoyance from different kinds of traffic are recorded. If equal noise annoyance were to be compared, in the noise maps would have to be considered as being comparable values:

- Rail noise of 65 dB
- Road noise of 60 dB
- Aircraft noise of 55 dB

The EU working group on 'Health and socio-economic Aspects' confirmed these conclusions in their report. It is even stated, that for night time the difference of noise annoyance between the noise of the rail and the other modes of transport is significantly higher.

Figure 3 shows that 10 % of the population feels highly disturbed by Air noise levels of 54 dB or road noise levels of 58 dB but there is a 'need' of 70 dB of railway noise to get the same effect. Or with 70 dB of noise, 25 % of the population are highly disturbed, if the source is air traffic, 20 %, in the case of road traffic and only 10 % in the case of rail traffic. [5]

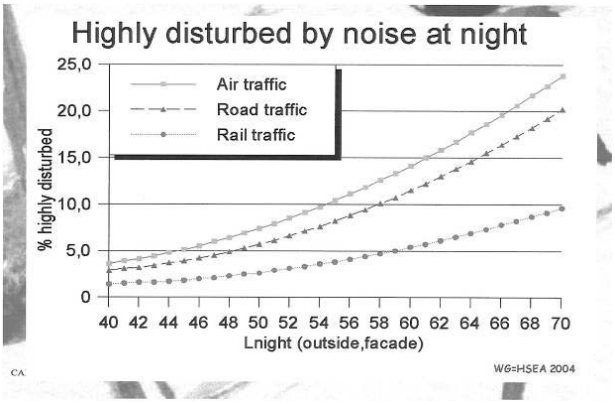

Fig 3 Noise disturbance at night by various traffic modes

10 The way to a railway noise-elimination strategy in Europe

The aim of any noise-elimination strategy for Europe must be to adopt the correct methodology, that is, to specify the measures to be undertaken to reduce noise for the whole area involved. It is especially important to decide whether these measures should be undertaken at the noise source or among those affected by the noise, or whether commercial strategies need to be devised for each means of transport. These clarifications must, in turn, be directed towards establishing which combinations of noise-reduction methods will provide the most efficient noise protection for the public.

In this context, efficiency means the way in which the greatest possible number of people can profit from the greatest possible reduction in noise at the lowest cost to the general public. By this definition, a noise-protection strategy is not simply the pursuance of a noise-protection program using by one single means, but the implementation of a whole range of measures which will differ according to circumstances, but which will together achieve the best result for the entire country.

The STAIRRS project has shown that a reduction in railway noise can best be achieved through a combination of the following measures:

- Converting rolling stock
- Tuned absorbers
- Noise barriers
- Rail grinding.

Financing must be sought for all of these measures, but in doing so it can be shown that the total savings in noise barriers brought about by converting rolling stock are many times greater than the money needed for the rolling stock conversion itself. Discussions at an international level have also drawn attention to the fact that quiet rolling stock will be quiet wherever it goes, thus proving that international co-operation can lead to a win-win situation where everyone benefits.

The optimum approach would be to achieve maximum noise reduction at minimal cost, going beyond transportation routes and perhaps even comprehensively tackling the more general issue of noise as an environmental pollutant. However, the real challenge for the future is to achieve maximum environmental protection at minimum overall cost. But this will take several decades...

11 Conclusions

In summary, the following facts are clear:

- The main cause of today's railway noise lies with the current generation of noisy freight wagons which are still fitted with cast-iron brake blocks.
- If all freight wagons were fitted with synthetic blocks, railway noise levels would almost be halved and would approach the acceptable level for modern passenger coaches.
- Synthetic brake blocks are available. However, the railways cannot afford the conversion on their own.
- The cost to the community would be lower if railway noise reduction concentrated on converting existing rolling stock.
- Financing the conversion is first of all a question of finance maximisation. As was shown above, about 5 % of the money used properly would realise about 50 % of the potential benefits.

If all these factors are evaluated correctly and ways and means found to implement conversion of the existing rolling stock, it would be technically achievable to halve railway noise pollution in no more than 10 years. All trains would then make no more noise than today's modern Intercity versions.

The author considers it likely that this reduction will prove sufficient for a long time to ensure an environmental leap forward for the railways over their competitors and in the market.

References:

[1] EU Environmental Noise Directive (2003): to be downloaded from: http://europa.eu.int/scadplus/leg/en/lvb/l21180.htm

[2] St. Bühler e.al., PROSE AG CH 8400 Winterthur: *Geräuschemissionen von Güterwagen* for Swiss Environmental Agency BUWAL: (11.11.2003), to be downloaded from : http://www.umwelt-schweiz.ch/imperia/md/content/laerm/14.pdf

[3] J. Oertli, '*The STAIRRS project, work package 1: a cost-effectiveness analysis of railway noise reduction on a European scale'*, pages 431 – 437, Journal of Sound and Vibration 267 (2003).

[4] Working Group Railway Noise of the European Commission: '*Position Paper on the European strategies and priorities for railway noise abatement'* (2003) to be downloaded from: http://europa.eu.int/comm/environment/noise/pdf/railway_noise_en.pdf

[5] Martin Van der Berg, *'Noise annoyance'* Presentation by given at CALM WS in October 2004. To be downloaded from: http://www.calm-network.com/calm1/cc04_02.pdf