Status and options for the reduction of noise emission from the existing European rail freight wagon fleet

– including a third-party assessment of the UIC/UIP/CER Action Program Noise reduction in Freight Traffic.

FINAL REPORT

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Abstract

This final report investigates the status and options for retrofitting of the existing European rail freight fleet based on a study commissioned by the European Commission and jointly funded together with the railways (UIC and CER), the wagon owners (UIP and UIRR), and the manufacturers (UNIFE). AEA Technology has been commissioned as consultant including the specific task of performing an independent third party assessment of the existing activities and results of the rail sector in the field of noise. The study has taken place from January to November 2003.

Chapter 1 outlines the background for the study with the development of the noise policy for the European Union and the role of rail in the view of the white paper on the European transport policy of September 2001. This chapter also summarises the historic efforts made by the railways in the field of noise.

Chapter 2 is an independent evaluation (by AEA Technology) of the "UIC/UIP/CER Action Program Noise reduction in freight traffic" and its three components: A technical, a (economically oriented) retrofit, and a political component. The overall conclusion of this third party assessment is that the conclusions of the action program are largely confirmed, namely: reducing the rolling noise of the EU-Railway-27 by retrofitting is the most cost effective solution.

The fleet size for EU-Railway-27 is estimated to be 825,000 freight wagons (2001) of which some 600,000 wagons would need to be retrofitted. The realistic retrofitting option is the homologated K-block, though still keeping track of the development of the less costly LL-blocks currently. Based on the available data the additional LCC costs of implementing K-blocks European wide would amount to 3.4 Billion €. However, the third party assessment also concludes that further investigations are needed in order to have more reliable LCC figures.

Chapter 3 then analyses and evaluates different scenarios for retrofitting. The study consortium recommends a basic scenario of a 10-year retrofitting period using the normal maintenance overhaul, which is taking place every 6-8 years as the basis for the exercise. The retrofitting exercise should take place all over Europe at appropriate workshops and should be controlled in some specified way.

Chapter 4 outlines and analyses various funding options for the retrofitting scenario. The most promising instruments are direct subsidies (from EU and member states), specific EIB loans in combination with early scrapping and tax exceptions as well as reduced track access charging. In addition, other instruments could become favourable, the task of this study has been merely to list and assess a variety of instruments.

Finally, chapter 5 provides the outlook and summarises the next steps for the rail sector as well as other involved parties. This final report constitutes the basis for future negotiations between the European Commission and the rail sector associations for possible solutions to reducing the predominant noise problem of European rail transport.

Acknowledgement

The authors wish to express their gratitude to all those who contributed to the study. In particular the members of the Consortium, and the parties who have agreed to provide information in writing or in the interviews have contributed significantly to the work.

Contents

Vocabulary

For the purpose of the present report, the following terms need general introduction and definition:

Consortium	The Consortium carrying out the project, consisting of representatives from the Railway Associations UIC and CER, the private wagon owner association UIP, the Union of Combined Transport organisations UIRR and the association of railway suppliers UNIFE, supported by the consultant AEA Technology Rail BV and AEA Technology Rail UK.
The UIC Noise Action Program	Official title is "UIC/UIP/CER Noise Action Program" it is the plan to retrofit existing freight wagons, replacing cast iron brake blocks by composite brake blocks, as first proposed by UIC and agreed to by CER and UIP.
The noise reduction steering group	The steering group of the UIC Noise Action Program
Noise Contact Officers	Representatives from the European railway companies assisting the noise reduction steering group

Executive summary

The growing societal opposition to excessive noise from transport in general is putting pressure on railway operations. Together with the environmental legislation coming into force, this pressure stands in the way of the growth of European rail freight traffic.

Rail transport is generally considered an environmentally friendly means of transport; the consumption of energy and space as well as the gaseous emissions are low compared to road and air transport. In the field of noise generation there is however a different balance: whereas lorries and aircraft have become quieter, at least with respect to engine noise, railway freight vehicles basically have an unchanged problem of rolling noise. With the growing capacity demand for passenger transport, freight trains run mainly at night. Existing lines run through densely inhabited, urban areas and the residents do no longer accept the noise levels produced by freight trains.

Legislators respond to the growing community reactions by setting restrictions to the noise from railway lines. There are two basic methods of noise control from transport systems:

- ✓ Control the noise reception at the receiver, by setting limits to the maximum allowable noise reception level.
- ✓ Control the noise creation at the source, by setting type test limits to the maximum allowable noise creation level [ref. **7**]. As many studies demonstrate, this is usually the more efficient way.

The latter method has been applied on a European Community level to e.g. new road vehicles, both passenger cars and lorries. The reason to maintain the European level is the objective to prevent member states from putting in force their own restrictions, which would inhibit the principle of a single European market.

For railway vehicles, noise creation limits are to be defined by the AEIF, which is mandated by the European Commission to set limits for accepting rolling stock with a view to interoperability. Limits have been set for high-speed passenger traffic and proposals have been submitted for new conventional speed rolling stock [ref. **6**]

This process would however not solve the rail freight noise problem in short term. Railway vehicles have a life span of 40 years, and due to economic circumstances the renewal rate is very low. Therefore a specific approach is required for existing vehicles.

It should be emphasised that railway noise for freight rolling stock is a product of wheel and track quality. Therefore any mitigation measure should preferably attack both sources. Any mitigation measure applied to the vehicle (i.e. the wheel) can only have the full effect if the track is maintained in good quality.

Rail freight transport: the challenge

The European economy envisages growing demand of mobility in the European Community, a growth that is particularly relevant now that 8 accession countries will join the Community. This in turn would bring serious obstructions from growing congestion on the roads and environmental and scarcity problems in air transport. Evidently, the railways have not been able to match this extreme growth. Rail freight transport has been in decline for several decades. The market share of railways in the freight transport within the European Community has decreased from 11% in 1990 to 8% in 1998 [ref. **11**].

Reasons for that position are both external and internal: road transport, the main competitor, has a benefit from the fact that many costs are external and are being carried by public sources. But the railways, certainly those that own large fleets of rolling stock, suffer from very low utilisation and productivity, partly due to the technology used, which forms a bottleneck in certain types of operation. In the wagonload operation, characterised by frequent remarshalling of the train, the frequent visual inspections required for safety check of the tread brake system consume a lot of time and costs.

It is a joint challenge of the next decade - for the enterprises involved and for the authorities and legislators on a European as well as a national level - to create conditions and to reshape the system such that the market share of the rail freight transport can grow from 8% in 1998 to 15% in 2020 [ref. **11**].

The railways' initiative: an Action Program

In 1998, the railway associations UIC and CER as well as the wagon owner association UIP approved of the "UIC/UIP/CER Action Program Noise reduction in freight traffic" [ref. **34**]. The key element of the plan is to create the conditions so that new wagons are fitted with composite brake blocks and existing wagons are retrofitted with composite brake blocks replacing the cast iron brake blocks. The retrofitting is aimed to reduce the noise levels by about 10 dB(A).

The Steering Group of the Action Program is assisted by so-called noise contact officers (NCO) from the main railway operators and three working groups to work out further the elements:

- ✓ Technical working group, with the task of creating the conditions for the introduction of composite brake blocks,
- ✓ Retrofitting working group, with the task to determine which wagons would need retrofitting and the costs involved,

- ✓ Policy working group, with the task to identify the strategic and political environment of the EU.

The final conclusions of this steering group have not been published yet, but main results have been discussed in several meetings. The main results are presented here:

> *"The best way to achieve a significant noise reduction compared to the present state of the art is to introduce composition brake blocks in rail freight vehicles. These brake blocks replace the conventional cast iron brake blocks. For new vehicles this has already been introduced in several operating companies. For existing vehicles, a retrofit operation would be required. The required investment for this retrofit depends strongly on the type of brake blocks: for LL-blocks the replacement can be virtually without additional cost, for K-blocks an adaptation of the wagon is required, costing between 6500 and 13,000 Euro per wagon (depending on the type of wagon). At present there are 1,200,000 freight wagons in Europe (date September 2002, [ref. 33]). Depending on the speed of retrofitting and on market developments, in fact only 650,000 wagons would need retrofitting. A clear incentive from the authorities is required to start off the retrofitting operation."*

Framework, scope and methodology of this study

This study is commissioned by the European Commission (DG Transport and Energy) and jointly funded together with the railways (UIC and CER), the wagon owners (UIP and UIRR), and the manufacturers (UNIFE). AEA Technology has been commissioned as consultant including the specific task of performing an independent third party assessment of the existing activities and results of the rail freight sector in the field of noise. The scope of the assessment has been the current EU15 countries, the 8 railway accession members, Norway and Switzerland, a total of 27 countries (EU-railway-27).

The objectives of this study have been to

- ✓ carry out a third party assessment with respect to the results and preliminary conclusions of the UIC Action Program,
- ✓ carry out a survey of possible implementation scenarios and funding options for the retrofitting operation,
- ✓ advice on the basis of the conclusions of the above.

The study has taken place from January till November 2003. It consisted of desk research and interviews with national contacts in railway operating companies, wagon owners, legislators and suppliers. Interviews have been carried out with the following parties:

- ✓ Trenitalia, economic experts,
- ✓ SNCF, technical expert,
- ✓ SBB, policy expert,
- ✓ DB Cargo, freight operator
- ✓ PKP Cargo, freight operator
- ✓ CP cargo, freight operator
- ✓ Railion Benelux, freight operator
- ✓ UIRR members, freight operators
- ✓ Nedtrain Consulting, engineering consultant
- ✓ EW&S, freight operator
- ✓ Freight Transport Association UK, operators association
- ✓ VTG, private wagon owner,
- ✓ SAB/Wabco, brake manufacturer
- ✓ Trinity Rail, wagon manufacturer
- ✓ Knorr Bremse, brake manufacturer
- ✓ DG TREN, policy makers,
- ✓ EU working group Rail, policy makers

In addition to the interviews, there were several contacts with the steering group of "UIC/UIP/CER Action Program Noise reduction in freight traffic".

Study Conclusions
The study came to the following conclusions:

a) Third party assessment:

The third party assessment confirms that replacement of cast iron brake blocks is indeed the preferred option for noise reduction, both in new and existing freight vehicles. Three basic options exist as alternative solutions: K-blocks, LL-blocks and disc brakes. K-blocks have been homologated, but only two suppliers dominate the market. LL-blocks have not yet been accepted for international use; the homologation process is still on its way and it cannot be reliably predicted when it will be finalised. Disc brakes are not suited for retrofitting, but may be represent an option for certain new vehicles under specific operational conditions. Each of the three solutions leads to a substantial but not exactly equal noise reduction. The full effect however is only achieved when track quality is good.

Each of the three solutions shows specific advantages and disadvantages and it may depend on the end user and his view to future rail freight transport, which solution is preferred.

Size of the fleet

There is evidence of about 825,000 wagons existing in Europe, of which approximately 600,000 would require retrofitting. This is based on an assessment using different assumptions:

- ✓ With respect to the fleet renewal and refurbishment it is assumed that the present rates will continue
- ✓ With respect to the age distribution of the present and future fleet it is assumed that never more than 1% of the fleet will be older than 40 years.
- ✓ With respect to the retrofitting program, it is assumed that it will start in 2005 and last 10 years and that no wagon will have cast iron brake blocks after 2015.
- ✓ With respect to the newly purchased and refurbished wagons it is assumed that from 2004 these will all be equipped with other than cast iron brake shoes. For the refurbished wagons the retrofitting is considered part of the Action Program.

The above assessment is based on the present commercial situation – the so-called "steady state" - in freight transport. Slightly different figures could be indicated for a growth and decline scenario. In the growth scenario, only slightly different figures would apply, as higher numbers of wagons would be purchased and refurbished. The increase would be mainly due to the fact that wagon life span would increase.

Cost of retrofitting

The cost assessment is divided into three elements:

- ✓ assessment of the investment costs for the retrofitting, expressed in Euro per wagon,
- ✓ assessment of the life cycle costs for the retrofitting, comparing different solutions to the basic LCC of operating cast iron block braked wagons,
- ✓ assessment of the total LCC for Europe, based on the wagon fleet.

The process of LCC-assessment is illustrated in figure A.

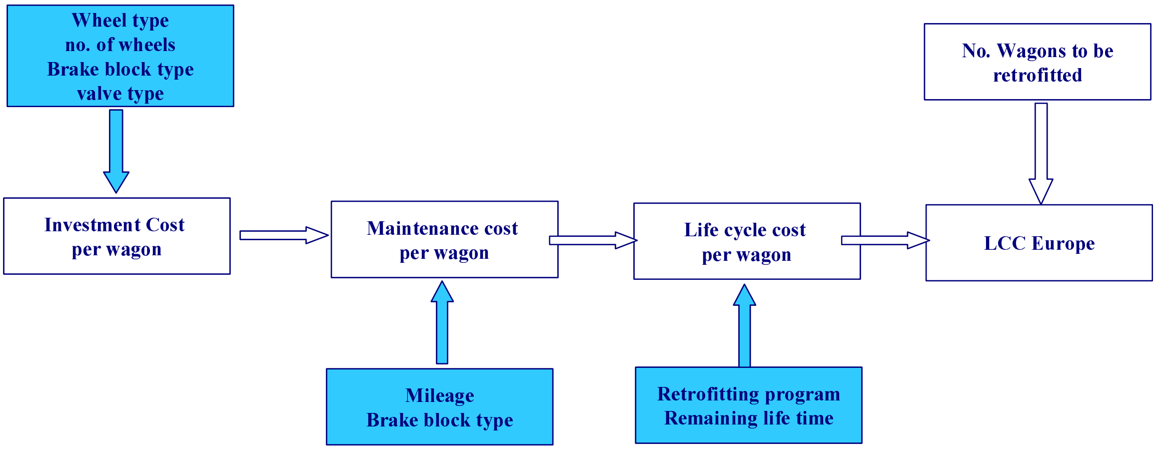

Figure A. The process of LCC-assessment.

The overall conclusion is that the retrofitting costs for the exchange of cast iron blocks to K-blocks would amount to 4500 to 13,000 Euro per wagon. The lower limit is somewhat lower than that within the assessment of the UIC Noise Action Program, whereas the higher limit is identical.
The investment cost assessment has taken into account real purchase cost from one experimental retrofitting of a series of 30 wagons, one pro-forma quotation from one supplier, several practical values on purchase costs of brake blocks and several practical values for workshop labour costs.

The costs do include a rough estimate of the costs for homologation of retrofitted wagons – which may be significant for some wagon types. It does however not include the transfer costs, which may be avoided if the retrofitting is combined with the regular overhaul of the wagon (which is called the "basic scenario" in the implementation scenarios).

The life cycle costs per wagon depend mainly on the life span of wheel and brake block. It has been suggested by different researchers that composition brake blocks would lead to higher wheel wear – in comparison to cast iron brake blocks – but would show lower block wear in similar operation conditions. The practical information which is available is however not sufficient to base firm conclusions upon it. A sensitivity analysis was made, using different assumptions for wheel and block wear, depending on two annual mileage scenarios.

A crucial element in the cost assessment is the decision whether or not to have to replace the wheels for an existing wagon. The wheel sets represent a significant cost element and if wheels need to be exchanged when K-blocks are installed, the LCC-costs for the retrofit turn out to be substantially higher. The study did not succeed in assessing an accurate answer with respect to the percentage of the total fleet that would need wheel exchange.

Using the best estimate for the different parameters, the analysis shows that the introduction of K-blocks on a European scale introduces additional life cycle costs to a total of 3.4 billion Euro (see table below). The variable cost for K-block operated vehicles is more or less equivalent to that of cast iron braked wagons.

The life cycle costs for 600,000 wagons to be retrofitted in the 27 countries were assessed to be:

- ✓ Basic scenario, cast iron (i.e. no retrofitting): € 526 mio Euro
- ✓ K-blocks, € 3957 mio Euro
    - o Additional cost: € 3431 mio Euro
- ✓ LL-blocks € 1412 mio Euro
    - o Additional cost: € 886 mio Euro

The assessment is based on the assumption that most wagons in the Eastern European networks will require wheels to be replaced.

b) <u>Implementation scenarios:</u>

Different scenarios emerge from different priorities. The conditions were defined such, that a reasonable time frame shall be applied (maximum 10 years) to the retrofitting and that the process should start within a reasonable delay (i.e. in 2005). The basic scenario is to combine the retrofit with the regular overhaul of the freight wagon, which takes place typically every 6-8 years (and increasing, mainly on the basis of curative maintenance steered by the actual status of the wagon). In the basic scenario, the costs for transfer of the wagon to a workshop can be avoided. As these costs are relatively large, the basic scenario is to be preferred from a cost point of view. In all other scenarios, there are logistics problems that are quite difficult and expensive to solve.

For the management of the retrofitting process, it is recommended that an overall strategic management and an internal operational management shall be put in place, in order to guarantee and monitor progress and reporting.

c) <u>Funding options:</u>

Without a clear incentive the retrofitting will not take place in the desired scale. Incentives may be of legislative or economic nature, the latter one being preferred by the sector. The most promising instruments are direct subsidies (from EU and member states), specific EIB loans in combination with early scrapping and tax exceptions as well as reduced track access charging.

The expected noise reduction is sufficient to avoid the use of noise barriers in many cases. This could lead to large savings for society in countries, which have noise legislation in place. State aid to infrastructure managers is allowed under European Directives, which leads to the application of differential track access charges as a feasible instrument. State aid could compensate for the loss of income of the infrastructure manager, due to the lower access charges received when more trains become quieter. Alternatively, the state aid could take the form of early scrapping subvention. A harmonised approach is required to achieve the full effect on a European scale.

1 Introduction

1.1 Historical background

Sustainable surface transport is considered a major element of Europe's economic development in the next decades. A modal shift from road to rail is a way to compensate some of the growing congestion on the roads. The EC White Paper 'European transport policy for 2010: time to decide' of September 2001 [ref. 11] reports the rail industry stakeholder objective for rail freight to achieve a 15% market share (of a bigger market) by 2020. This in effect would mean multiplying current business by three.

It is generally agreed that excessive noise generation by railway transport is one of the main elements in the way of the intended market share growth. Community opposition against new and existing railway lines through urban areas is growing. With the European Environmental Noise Directive (2002/49/EC [ref. 53]) coming into force, residents will be made even more aware of community noise from transport by the noise mapping exercise (due 2007).

Whereas it is the responsibility of national governments to set limits to the noise exposure of its citizens, the European Commission is responsible for the control of the noise generated by different sources. Type approval limits have been applied – and reduced several times - for road vehicles since the 1970-ies, aircraft noise is subject to worldwide limitations and European limits apply to a range of machinery such as lawn mowers and outboard motors.

For railways, an initiative was taken by the European Commission in the late 1970-ies to set common noise creation limits, but this was not implemented at the time. In the framework of guidelines for interoperability for railways, the Commission established the AEIF[*)], the Association Européènne pour l'Interopérabilité Ferroviaire, which engaged into defining the Technical Specifications for the Interoperability. One element of these Specifications is the noise created by railway vehicles. The TSI for high-speed train noise was adopted in 2002 and is presently being evaluated (the so-called Noemie project). A TSI for conventional speed train noise is in preparation to enter into force by 2004/2005 and has been published in a draft TSI. The draft specifies limits for new and existing rail freight vehicles.

The rail sector has followed the process with a lot of criticism. One element of that criticism refers to the TSI being used as an instrument to limit noise, whereas it is mainly intended to be used as an instrument to

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[*)] *AEIF (also see www.aeif.org) is the joint representative body mandated by the EU Commission to lay down the Technical Specifications for Interoperability (TSIs).*

prevent market restrictions. Also, the sector has stressed the fact that the implementation of any environmental restrictions would have to be economically viable, or else might jeopardise the sector's ability to contribute to sustainable transport in a growing European economy.

Here is the dilemma for the European policy makers: in order to achieve a modal shift from road to rail in a way that is acceptable to society, rail freight transport has to become quieter. On the other hand, if the noise reduction would lead to cost increases, rail freight transport may lose market share, so the noise reduction has to be close to cost neutral.

In June 1998, the UIC Board of Management approved the "UIC Action Plan for freight wagon noise reduction". The key element of this plan is the retrofitting of existing cast-iron braked wagons with composite brake blocks, cutting noise levels by about 10 dB(A). Three working groups were established, focusing on Technical Aspects (chaired by Mr. J. Raison of SNCF), Retrofitting Aspects (presently chaired by Mr. Casini of Trenitalia) and Political Aspects (chaired by Mr. P. Hübner of SBB) respectively. The working groups report to the Noise Reduction Steering Group chaired by Mr. J. Kettner of DB. Since 1998, collaboration has been found with all major associations, viz. CER, UNIFE, UIP and UIRR, who now fully support the Noise Action Plan.

Presently, the three working groups have reached a phase where results can be reported. This fits well with the agenda of the European Commission, which intends to evaluate the efficiency of its noise source policy by January 2004 (in conformity with the intentions set out in the Environmental Noise Directive 2002/49/EC).

1.2 Need for the study

1.2.1 Political aspects of transport policy

In the member states of the European Union, mobility has been the driver of economic development in the last half of the past century. With the new accession countries from Eastern Europe, a further demand for mobility, both for goods and for passengers, is expected. In the Western European countries, the traffic growth has caused major congestion around the large urbanised areas, with important economic effects.

The growing mobility leads to important adverse effects, not least environmental effects. In spite of important progress that has been made in exhaust gas emissions, air quality is still poor in many cities. The same holds for noise: although cars have become quieter, the traffic increase has more than compensated that effect, so that the number of people annoyed by road traffic noise in Europe shows an ever increasing tendency. Safety elements (casualties), land use and the costs required for infrastructure are other negative aspects of road traffic.

In view of these adverse effects, high expectations rest upon the railway operators and infrastructure managers. Short-range air transport for passengers in Europe is to be replaced by the high-speed train network. For freight, inland water transport and rail transport are challenged to increase their share of the market.

This challenge is addressed in the White Paper on Europe's future transport policy. Sustainable transport is considered an essential condition for the further development of Europe's economy.

Rail transport shows good performance when it comes to safety (both expressed in casualties of passengers and in external hazard), energy consumption and air quality. However, the noise performance of rail freight needs to be improved. Whereas high-speed trains show considerable noise reduction compared to conventional intercity trains, for freight trains there has been very little change for many years. Obvious reasons for that are:

- ✓ the long life span of freight vehicles (around 40 years) which reduces the incentive for and dissemination of innovative technologies,
- ✓ the high degree of standardisation which prevents innovations to be easily accepted,
- ✓ many of the former national railway companies were not used to managing their rolling stock as economic assets, as complete wagon fleets were involved in the privatisation into private enterprises,
- ✓ transport economics in the European Union lead to very low margins in rail freight transport which prevent investments for improvement. The sector considers the lack of internalisation of the external costs of road traffic to be one of the reasons for this.

It is stated in the White Paper that modal shift from road to rail can only be achieved if the rail sector is capable of improving its performance, not only in service and costs, but also in environmental performance, i.e. noise creation.

1.2.2 European noise policy

In June 2002, the European Commission adopted the Directive on the Assessment and Management of environmental noise [ref. 53]. This Directive contemplates the obligatory preparation of strategic noise maps of among others major railway lines, by the year 2007. UIC/UIP/CER Noise Action Programs will have to be prepared one year later. The responsibility for setting noise reception limits (i.e. perceived noise levels at the façades of sensible buildings) remains within the national authorities. However, the European Commission is responsible for setting noise creation limits to various sources such as railway systems.

There is a mixed strategy behind the setting of noise creation limits: first of all it is intended to avoid commercial barriers between member states and to defend the single European market. Noise sources such as machinery and vehicles, provided that they comply with the limits set by the EC, can be traded freely between all member states. Secondly, the EC intends to improve the environmental situation for its citizens. In Europe, approximately 6 million citizens [ref. 42] are exposed to high daytime noise levels (over 65 dB(A)) of railway noise in 1996). For road traffic, these are 72 million citizens. In 1996 an estimation of 78 million persons is annoyed by road traffic, around 10 million by rail traffic noise [ref. 41].

Thirdly, and probably most important, is the fact that the societal objections against increased railway traffic are often expressed in terms of concern about excessive noise. Therefore, noise reduction is an essential condition to the intended growth of rail traffic and is a key element in Europe's strategy towards sustainable surface transport.
The latter view is largely shared by the railway operators, as expressed in the Strategic Rail Research Agenda (September 2002) adopted by the European Rail Research Advisory Council ERRAC [ref. 2].

The European Commission considers that setting limits for noise exposure of citizens, regardless of the origin of the noise, is a responsibility of the national government. However, when a national noise regulation would lead to noisy products being expelled from that particular country because of its noise creation, this would jeopardise the free trade of products within the EU. Therefore, the Commission considers it its own responsibility to set environmental limits for products that are subject to international trade.

For road vehicles, such limits have existed for many years, and they have been reduced several times with the intention to improve the environmental performance. This has not been effective due to three main reasons:

- ✓ tyre/road noise (rolling noise), which is the predominant source of noise for the majority of motorways, has not been affected by the limits – as they refer to engine noise mainly,
- ✓ measurement standards were modified when a new limit value came into force, so that vehicles complying with the old limit under the old measurement standard would automatically comply to the new limit with the new standards,
- ✓ the steep increase in traffic volume affecting rolling noise has more than compensated the reduction of noise production from engines.

The European noise policy is supported by the EU Noise Steering Group, under which a series of dedicated working groups resides. One of these is the working group Railway Noise, under the chairmanship of Mr. Michael Jäcker-Cüppers and the co-chairmanship of Mr. Peter Hübner of SBB. The working group studies, among other things, the options for noise reduction [ref. 1]. The working group recently issued a position paper (May 2003), which assessed the advantages and disadvantages of a large number of different noise control options. Noise reduction of freight vehicles at source was considered the main priority item. The position paper expresses as the common view of the working group that "the main problem is the economically viable implementation" of the noise reduction measures.

1.3 Project overview

In January 2003, the European Commission, Directorate-General for Energy and Transport, commissioned the so-called Implementation Study, referring to the UIC/UIP/CER Noise Action Program. The study was commissioned to a consortium consisting of the railway associations UIC, CER, UNIFE, UIP and UIRR. AEA Technology Rail joined the consortium as a subcontractor.

The objectives of this study are to investigate and analyse implementation scenarios and funding mechanisms for the UIC/UIP/CER Noise Action Program. As a fundamental pre-condition the study includes a third party assessment in order to review the results acquired by the three working groups. AEA Technology Rail BV is responsible for this third party assessment.

More specific, the third party assessment has looked into the following basic questions:

- ✓ is the solution proposed in the UIC/UIP/CER Noise Action Program and worked out by the Technical working group the best solution (compared to available and conceivable alternatives)?
- ✓ are the consequences of implementation, as assessed by the Retrofitting working group, complete and correct?
- ✓ are the political consequences, as assessed by the EU work working group complete and correct?

In the context of the background of the study as described above and especially in view of the proposed dialogue between the European Commission and the industry, the study provides an evaluation of:

- ✓ the work done by the railway sector in finding technical solutions for retrofitting (the UIC/UIP/CER Noise Action Program for noise reduction),
- ✓ the information provided by the railways on quantities of wagons that would need retrofitting – including the retrofitting program and the resulting financial implications ("third-party assessment" of the UIC/UIP/CER Noise Action Program and related activities).

In addition to the evaluation of the work done by the railway sector, the study develops additional retrofitting scenarios based on the findings and in agreement with the Steering Group. The study analyses the financial implications and provides funding options taking into account future developments of the freight market.

To reach these objectives, the study contains the following elements:

- ✓ Investigation of the status of the existing fleet (covering the 15 EU countries, accession countries, Norway, Switzerland, Bulgaria and Romania) – its present age, use, adaptation to customer requirements, including a survey of existing plans to develop or renew the fleet through procurement, scrapping or upgrading (commercial data is used anonymously).
- ✓ Analysis of the different technical options for retrofitting: based on the characteristics of the K- and LL-blocks, by especially taking into account their availability and the life-cycle cost of the different options. The different cost elements (investment cost for retrofitting, maintenance etc.) will be shown independently in order to analyse the impact on operators, wagon owners and the effect on the whole system.
- ✓ Proposal of different retrofitting scenarios based on the findings in the previous elements. In particular, the different costs of each scenario are demonstrated.
- ✓ Assessment and proposal of funding schemes in the light of current EU and Member State legislation (e.g. state aid) and investigation of alternative financing instruments.

The approach to reach the above project objectives has been to collect information from whatever sources available, but at the same time make efficient use of the work that had been carried out already.

The objective of the third party assessment being to assess the quality of the work carried out by the UIC in collaboration with the Noise Contact Officers assembly, the approach to the study reported here has been not to repeat all that work, but to take so-called sample audits. The most relevant samples of the information already collected are identified. The sample audits involved a selection of a limited number of train operators, wagon owners and wagon leasers, who are considered representative for the full European freight market. Their selection was carried out on the basis of the total number of wagons operated (covering at least a certain percentage of the total European fleet), and the operators' share in both the main transport flows and in specialised goods transport.

The operators' position was investigated with respect to the technical and commercial lifetime of their fleets. Also the operators approach towards maintenance of their existing fleets and the cost associated with that maintenance was investigated.

The sample audit occurred in the form of personal visits (and phone calls) to the selected parties and personal interviews with the responsible staff. This approach enabled questioning the data provided by the operator and in doing so ensuring the reliability of the data.

2 Third party assessment

This chapter contains the independent so-called "third party assessment" of the UIC Noise Action program and is elaborated by AEA Technology. Data and communication presented is coming from a variety of sources mainly within the study consortium, but the conclusions are drawn exclusively by AEA Technology.

2.1 Scope of the Third party assessment

This paragraph gives the scope of the third party assessment in relation to the UIC/UIP/CER Noise Action Program.

2.1.1 Technical description

Summary of technical solutions, their noise reduction potential and their technical implication
A comprehensive overview of all technical aspects relevant to the introduction of composition brake blocks as a solution to noise control is presented in Annex 2. Here merely the main conclusions are summarised.

The findings of the UIC/UIP/CER Noise Action Program to be assessed in this part of the third party assessment are:

> The replacement of cast iron blocks by composition brake blocks represents the preferred option for noise reduction for existing freight vehicles.

Third party assessment: the noise sources
Freight trains represent the most important sources of railway noise in Europe. The reason is that freight trains often run during the night, where the exposure limits are generally 10 dB more tight that during the day. Another reason is that rail freight vehicles have not been through a technical development comparable to that of many passenger trains. In passenger traffic, technical (speed) and commercial (comfort) demands resulted in the need to introduce disc brakes, which have a positive side effect of considerable noise reduction. The wheel rail technology of freight vehicles is still basically the same as 50 years ago, whereas innovations have taken place in the wagon superstructure, mainly in the transport of hazardous goods.

Rolling noise is the predominant source of noise from freight vehicles. Traction noise from locomotives, although dominant when considered on a single vehicle basis, can be neglected when compared to a total train of typically 30 vehicles. Special noise types such as curve squeal, brake screech, level crossing bells etc. are dominant only on a local scale.

Rolling noise is generated by surface irregularities on the wheel tread and the railhead. These irregularities are indicated with the general term "roughness". For a freight train on a normally maintained track, the wheel roughness is predominant. The first and most effective way to reduce noise from freight train is to reduce rolling noise by controlling the roughness of the wheels. This wheel roughness is caused mainly because of the thermo-mechanical processes occurring at the interface between wheel tread and cast iron brake block.

Technical solutions: composition brake blocks

Technical solutions, which avoid these processes to occur are:

- ✓ Tread braking with a material different from cast iron, such as plastic or sinter metal,
- ✓ Non-wheel tread braking, such as disc brakes or rail brakes, or electro-dynamic braking (for locomotives only).

When changing to a different brake material, it is important to notice the braking performance of the material, which is indicated by some typical parameters such as:

- ✓ The friction coefficient of the brake block material, certainly in dependency of the vehicle speed and/or environmental factors such as temperature and humidity,
- ✓ The required force applied to the block in order to press the block to the wheel, required to stop the train within the required braking distance,
- ✓ The thermal conductivity and heat capacity of the material, which decides the amount of heat that is fed into the wheel as a consequence of the braking process.

With respect to the first parameter, the friction coefficient, different classes of characteristics are distinguished, which have been standardised within the International Union of Railways UIC, viz.

- ✓ The K-characteristic, which has a high friction coefficient compared to cast iron, at a level which is more or less independent of the vehicle speed, and which thus requires a lower braking force than cast iron,
- ✓ The L-characteristic, which is similar to the of K-blocks, but with a lower friction coefficient,
- ✓ The LL-characteristic, which has a friction coefficient comparable to that of cast iron in the higher speed range, but which is independent of the vehicle speed.

Typical characteristics are presented in Annex 2 in figure A2.3.

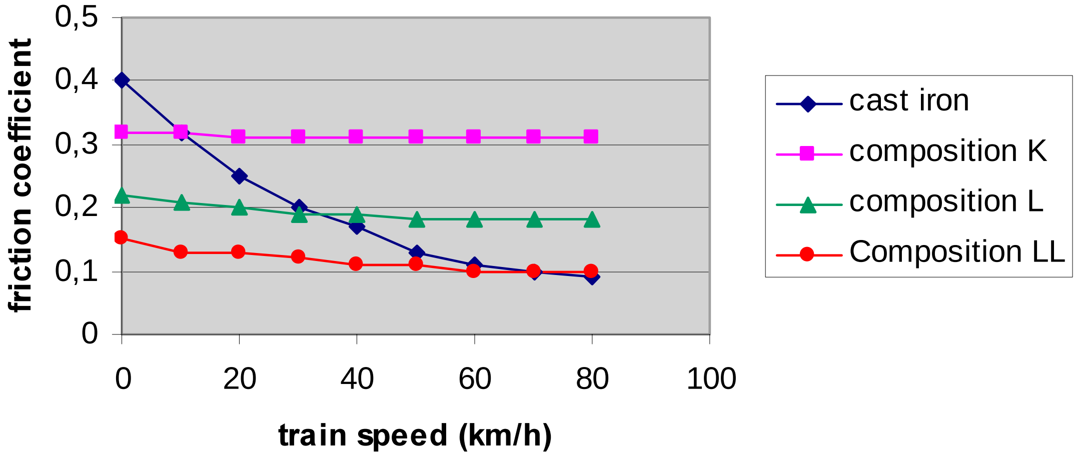

Figure A2.3. Typical friction coefficient for different types of brake blocks.

It is important to notice, in the above figure, that the composition material is "better suited" to be used as a braking material, as it requires lower force to achieve the similar braking power as the cast iron. The LL-block is basically an anomality, as it is intended to simulate the "poor" braking performance of cast iron.

Technical solutions: disc brakes

Disc brakes have been used for a long time in passenger rolling stock, and are known to show a noise reduction of approximately 8 – 12 dB with respect to cast iron braked wheels. Disc brakes are used in freight rolling stock only in the United Kingdom (10,000 wagons) and in very limited series on the continent of Europe. Disc brakes are not suited for retrofitting: replacement of cast iron brakes by disc brakes requires replacing the complete running gear.

Disc brakes show advantages in terms of high braking performance, which is desirable in high speed and high axle load operation. They also show very good behaviour in terms of life span, control and maintenance procedures, which are presently affecting the productivity of tread braked vehicles [ref. 38, 39]. A disadvantage is that the visual inspection of the brake functioning, which is required after every composition or decomposition of a train, has to take place from under the train, so that an inspection pit is required leading to drastic loss of productivity. This could be avoided when introducing disc brakes with automatic brake pad control, which would require the presence of electronics in every wagon. It has been suggested that in high mileage operation, there would be an opportunity of a drastic productivity increase by introduction of disc brakes. For some applications it could show a break-even point after 3 years of operation.

Therefore one conclusion is, that if rail freight transport should indeed achieve the revival that is intended by some policy options, the large-scale introduction of disc brakes could be a better option than the modification of tread brakes. It is mainly the high investment costs that make this option unlikely to happen. It is also clear that this measure requires high investments for existing vehicles. This option is therefore only realistic under specific assumptions/scenarios for the future development of freight transport, respectively for certain operation conditions in market niches.

Experience with composition brake blocks

Up to now, K-blocks, L-blocks and LL-blocks have been used in passenger stock and locomotives, but only seldom in freight vehicles. The Portuguese railway CP have retrofitted their entire fleet (4000 wagons) to LL-blocks in 1999 and run these without problems since. EW&S operates 3,000 wagons with composite brake blocks.

K-blocks are applied by Hungarian railways MAV (20 wagons), Transwaggon (850 wagons), Swiss railways SBB (1608 wagons) and German railways DB (1388 wagons). Also SNCF operates 10,000 wagons equipped with K-blocks.

It has to be noted that these examples of composite brake-blocks applications are neither useable in a general way for environmental reasons (e.g. Pb-content in some older K-blocks) nor homologated for international freight traffic due to operational and/or topographic conditions (slopes, train loads etc).

Apart from these examples, some pilots have been linked to research projects. In most cases a noise reduction similar to that of disc brakes was found, although results show large spreads, possibly due to differences in track quality and measurement methods.

Some adverse effects are reported with respect to the use of composition blocks. The loss of shunt represents the most serious of these problems, but so far it appears to has been noticed in very few networks and for particular signalling systems only. These adverse effects have now been quantified and overcome, and the temporary homologation of K-blocks have recently been transferred into a definitive homologation by the Technical and Research Commission (CTR) of the UIC (October 2003). This definitive homologation is effective as from the 1st January 2004. From then on, when larger series of new wagons are purchased they will all be equipped with K-blocks.

For LL-blocks, the availability is questionable. Even though Portuguese railways have purchased these blocks and apply them without problem, the homologation is still on its way. The behaviour of LL-blocks for the long term, as well as their behaviour under severe winter conditions and

steep Alpine slopes is questioned by the experts. Here the present situation may be rather like a self-fulfilling prophecy: since the K-blocks have received general homologation, there is no commercial challenge for the suppliers to further develop an LL-block. In that situation it is unlikely that new, more performing LL-blocks will be developed or even offered for homologation purposes.
Nevertheless the ERS-project has defined some products that are submitted to homologation tests, but it cannot reliably be predicted when this process will be finalised. See chapter 5 for further information.

Noise reduction with composition brake blocks
The reported noise reduction to be achieved with K-blocks shows large inconsistencies between different reporters, which may affect the credibility of the UIC/UIP/CER Noise Action Program. Therefore, there is an urgent need to formalise and document the exact expected noise reduction potential for this solution. However, this inconsistency does not affect the choice for the optimal solution, which would still be to modify the brake system. The conclusion presumes a normal well-maintained track (low rail roughness in all cases).

Alternative noise control solutions may leave the brake system intact, trying to reduce the radiated noise without changing the wheel roughness. All these solutions are known to show fairly limited efficiency - in the order of 1 to 3 dB – and with distinct practical disadvantages. This applies to wheel absorbers (low efficiency), wheel screens and shrouds (obstruct visual inspection of the wheel) and bogie shrouds (conflicts with the loading gauge and obstructs visual inspection).

The first conclusion from the above reads, that changing the brake system in order to reduce wheel roughness (or to prevent the wheel from getting rough) is indeed the preferred option for noise control.

The impact of standardisation
In the present situation, RIV wagons are allowed throughout Europe without any necessary adaptation (except for the track gauge, which differs in Spain, Portugal and Finland). Obviously this is a major achievement in terms of the desired interoperability. Therefore it is also obvious that the search for the most appropriate solution starts again from the presumption that one single best solution has to be identified. This presumption is discussed here.

First of all, the process of standardisation is lengthy and costly. The responsible bodies within UIC have defined the process of homologation of K-blocks in document 4.04.501, Design rules for composite (K) brake blocks [ref. **30**]. The document describes three specific makes of K-blocks and the complete specifications against which compliance has to be tested for each wagon (type) equipped with one of these blocks, before it is allowed to run in international traffic. Braking performance and reliability are the most serious safety provisions and it is obvious that compliance to these specifications deserves the highest priority.

Nevertheless, the conclusion is obvious that this high degree of standardisation leads to very little flexibility in terms of diversity of options. This statement can be confirmed by the examples presented above: disc brakes on 10,000 wagons in the United Kingdom, K-blocks on 3,000 wagons in the United Kingdom, and LL-blocks on 4,000 wagons in Portugal – as well as 10,000 wagons with K-blocks in France. These modifications can only exist thanks to the fact that there is no full exchange of traffic on a European scale, so there is no need for homologation. The statement could not hold that the operators do not run a safe and reliable system, but apparently the requirements for European homologation assume more extreme operation conditions (such as low temperature behaviour, Alpine crossings and shorter brake distances).

Technical and general standardisation will grow under the influence of the interoperability specifications coming into force. These may affect safety regulations and others, particularly in international freight traffic. However, the traffic that runs under RIV regulations is already standardised to a very high degree. The point was raised in the interviews with both operators and manufacturers. No evidence had been found yet that the TSI coming into force will affect whatsoever the size and composition of the fleet, nor the rate at which wagons are scrapped or refurbished.

Intermediate remarks

In view of the above, it is conceivable that certain solutions are to be preferred for certain types of traffic or types of operation, whereas other solutions may be better suited for others. The following is intended to serve as an example:

Example 1

The members of the UIRR, the International Union of combined Road-Rail transport companies, operate or own dedicated freight vehicles, which run mainly in shuttle services. The wagons show high utilisation and high annual mileage when compared to conventional wagons in wagonload traffic. High speed (i.e. over 120 km/h) could be a preferred option for this kind of traffic. Faced with the problem of noise reduction, the introduction of disc brakes would, for the UIRR members, be a very realistic option for these wagon owners. Aluminium discs have been reported to show very good behaviour in terms of life cycle costs for high mileage operation [ref. **38**].

Example 2

A large freight operator (PKP) operates around 80,000 vehicles in international and national service. Most of the wagons are equipped with tyred wheels. The use of tyred wheels in combination with composition K-blocks is not permitted by the UIC and it is not to be expected that it will be, due to the high thermal constraints on the wheels resulting from the use of K-blocks. In case the use of tyred wheels is permitted in combination with LL-blocks, the operator under concern would be strongly in favour of LL-blocks and opposed to K-blocks.

The retrofitting process for the above solutions

In the previous sections, the main solutions for noise control at the source have been discussed. They all consist of a change of the braking system, starting from the present standard, which is an air pressure brake with cast iron brake blocks.
A clear distinction should be made between:

- ✓ equipping new wagons with either of the above solutions, and
- ✓ retrofitting existing wagons with either of the above solutions.

For new wagons, the composition block with K-characteristics tends to become the new standard, certainly now that the Technical Committee of UIC has decided that the homologation is definitive. Nevertheless some operators or vehicle owners might choose to install disc brakes, as these are homologated as well for freight operation. Only in rare cases operators might choose to install e.g. LL-blocks, which would prevent them from using the wagons in RIV-regime because of the lacking homologation.

For existing wagons, most likely equipped with cast iron brake blocks, a retrofit adaptation is required, which is described in more detail below. Reference is made to Annex 3 for further detail on the technology of rail vehicle brakes.

Retrofitting from Cast Iron to K-blocks involves:

- ✓ The wagon has to be withdrawn from operation (taken out of service) and has to be transported to a qualified workshop. There is a cost involved both in the wagon withdrawal (loss of turnover) and in the transport.
- ✓ If the wagon is equipped with tyred wheels, the wheels have to be replaced by solid wheels of an accepted make,
- ✓ If the wagon is to run in SS-service (high speed), it is recommended that the wheels be replaced with low residual stress wheels (for wagons in S-service only, this is optional)
- ✓ If the wagon is equipped with an automatic load relay valve, this valve has to be replaced (the valve controls the brake pressure in dependence of the wagon load); in some cases it may be possible to modify the existing valve instead of replacing it (man hour costs versus hardware costs).

- ✓ If the wagon is not equipped with the automatic valve, there is a manual switch (loaded/unloaded) which has to be replaced or modified
- ✓ The brake cylinder (usually 1 per wagon) has to be replaced by a smaller one, because the K-block requires less brake pressure than the cast iron brake block. Alternatively, the cylinder might be modified (man hour cost and safety aspect, versus material costs)
- ✓ Some of the rigging between brake cylinder and block holder may need adaptation (length), particularly the horizontal levers between cylinder and joint
- ✓ The brake block holder needs to be changed, so that it will no longer be possible to mount a cast iron brake block,
- ✓ The wagon receives a mark, indicating that it is equipped with K-blocks
- ✓ Per wagon type (complete series) a type test of the braking performance has to be carried out,
- ✓ After delivery, the wagon can resume service

Retrofitting from Cast Iron to LL-blocks involves:
For LL-blocks, the development towards homologation has not been finalised yet. The following process is based on expected results of that homologation only.

- ✓ The wagon has to be withdrawn from operation (taken out of service) and has to be transported to a qualified workshop. There is a cost involved both in the wagon withdrawal (loss of turnover) and in the transport.
- ✓ If the wagon is equipped with tyred wheels, the wheels have to be replaced by solid wheels of an accepted make (this is a conservative estimate, as there is no information available yet on the necessity to replace tyred wheels for LL-blocks. Based on the low heat capacity of any composition block, it is expected that a change of wheels will be compulsory or recommended),
- ✓ If the wagon is to run in SS-service (high speed), it is recommended that the wheels be replaced with low residual stress wheels (for wagons in S-service only, this is optional)
- ✓ Valves, switches, cylinders and rigging can remain unchanged,
- ✓ The brake block holder needs to be changed, so that it will no longer be possible to mount a cast iron brake block,
- ✓ The wagon receives a mark, indicating that it is equipped with LL-blocks

- ✓ Per wagon type (complete series) a type test of the braking performance has to be carried out,
- ✓ After delivery, the wagon can resume service

Retrofitting from Cast Iron to Disc Brakes:
In general it is not feasible to mount disc brakes into an existing bogie or axle. As most of the bogies in freight service are Y-25 bogies, both from a space point of view and a mass point of view the bogie does not allow installation of disc brakes. This means that the retrofit can only be carried out by a complete replacement of the bogie, or in other words: the vehicle superstructure is put onto new bogies. In order to operate the disc brakes, in principle that could be done by air pressure.

Technical conclusions
Reduction and control of the roughness of the running surface of the wheels represents the most straightforward solution to rolling noise of freight trains. This reduction and control can be achieved by an adaptation of the braking system. Alternative options for noise control, other than noise barriers, will not achieve the necessary noise reduction.

It is important to note however, that the full reduction of this measure can only be achieved under the condition that the track is well maintained and without heavy corrugation. Due to the fact that rolling noise is generated by the combined roughness of wheel and track, the latter may destroy the complete effect of the measure in cases where significant rail corrugation is found. Under the PROMAIN network a study is currently carried out by ODS in co-operation with UIC to investigate grinding operations. First results show that only very few networks have engaged into grinding for acoustic purposes.

An evaluation of the different options to reduce wheel roughness is not as straightforward. Preferences may depend on ambition and view with respect to rail freight transport in Europe, on the age and remaining life span of the fleet, on the wagon type, on the type of operation, e.g. annual mileage, the wagon is engaged in, as well as on the required maintenance. In the following table the qualitative merits and demerits of the different solutions are presented in a summarised way. For reasons of comparison, cast iron brake blocks are included. Because of the relevance of the type of operation, a description of several types of operation is presented in Annex 2.

Table 2.1. The qualitative advantages and disadvantages of the different solutions.

<table>
<tr><th colspan="2">Cast iron brake blocks</th></tr>
<tr><td>Advantages
• Well known concept, available everywhere, well defined properties,
• Easy to recycle,
• Low purchase cost,
• Generally low wheel wear, low thermal load of the wheel,
• Well developed market.</td><td>Disadvantages
• No noise reduction with respect to present situation,
• Generates high levels of wheel roughness,
• Heavy mass; hazard to occupational health in work shops
• Low friction coefficient, high brake force required,
• Braking performance not sufficient for high speeds ad/or high axle loads,
• High wear of the brake blocks.</td></tr>
<tr><th colspan="2">Composition K-blocks</th></tr>
<tr><td>Advantages
• Demonstrated noise reduction of 6 to 12 dB with respect to present situation,
• Is installed in new wagons as a standard, so will develop to be the standard in 40 years from now,
• Definitive homologation agreed 14th October 2003,
• High friction coefficient, low brake force required,
• Light mass, slight increase in payload,
• Easy and safe to handle,
• Lower block wear, therefore longer life span of brake block,
• May be suitable to somewhat higher axle loads and speeds than cast iron.</td><td>Disadvantages
• High purchase costs,
• Suppliers market (to date few suppliers, difficult process to enter market for new ones),
• Comments about braking performance at low temperatures due to ice forming,
• Comments about interference with signalling (loss of shunt),
• Comments about recyclability, waste disposal,
• Composition and performance are not tightly defined: large spreads within series of same supplier and even more between suppliers,
• Not suitable for slide protection,
• Higher wheel wear due to abrasive character.</td></tr>
<tr><th colspan="2">Composition LL-blocks</th></tr>
<tr><td>Advantages
• Expected noise reduction or at least 5 dB with respect to present situation,
• Simple exchange of existing cast iron brake blocks,
• Better performance at low temperatures is likely to occur,
• Light mass, slight increase in payload,
• Easy and safe to handle,
• Composition and performance are defined tighter than for K-blocks.</td><td>Disadvantages
• Ongoing developments, no results for homologation available (yet),
• Suppliers market,
• Serves as a temporary alternative to cast iron only, will be replaced by K-blocks in time,
• High purchase costs,
• Comments about interference with signalling (loss of shunt),
• Not suitable for high speeds and high axle loads,
• Comments about recyclability, waste disposal,
• Not suitable for slide protection,
• Little practical experience with LL-blocks in freight traffic.</td></tr>
</table>

Table 2.1 Continued

Sinter metal blocks	
Advantages • Demonstrated noise reduction of 5 – 8 dB with respect to present situation, • No problems expected with signalling (loss of shunt), • Known to have resulted in very smooth wheels.	**Disadvantages** • Very high purchase cost, • Very high wheel wear, • Noise reduction potential as yet unclear, • Suppliers market, • Comments about recyclability, waste disposal, • Not suitable for slide protection, • No practical experience with sinter metal blocks in freight traffic, • Risk of "hollow wear" of the wheels.
Disc brakes	
Advantages • Demonstrated noise reduction of 6 – 12 dB with respect to present situation, • Well known performance in passenger traffic, • Suitable to slide protection, • Very long wheel and brake pad life, • Suitable to high speed and high axle loads, • Reduces stand still times for inspection to almost zero (for automatic brake control), • Solutions for low temperature available, • No fear for loss of shunt.	**Disadvantages** • Hardly any experience in freight traffic in Europe, • High purchase cost, • Would represent a new standard: difficult to introduce in wagon load transport, • Not suitable for retrofit.

The third party assessment of the technical aspect of the UIC/UIP/CER Noise Action Program can be summarised as follows:

> Modification of the brake system, whereby cast iron brake blocks are avoided, is the most straightforward way to reduce rolling noise from rail freight wagons.
> K-blocks may tend to represent the new standard for new freight wagons, certainly with the general UIC-homologation being available. For new wagons, disc brakes may be the preferred solution in the further future or in niche markets.
> Although K-blocks are suited for existing wagons they require a substantial modification of the wagon. LL-blocks, if they receive homologation, could be a more economic alternative to K-blocks for the short term. The time scale for this development to take place is as yet unclear. Sinter blocks are an alternative to composition blocks, as they are available either as K- or LL-blocks. They represent a risk with respect to the achievable noise reduction, due to hollow wear. Also, they tend to lead to high wheel wear.
>
> All these options will achieve a considerable noise reduction(5 dB or more) , but more consistency in the expected reduction levels has to be achieved.

2.1.2 Fleet description

Estimation of the current European freight wagon fleet by the UIC/UIP/CER Action Program.

A detailed survey of the European rail freight fleet has been made by Trenitalia. The results were presented on several occasions and were regularly updated. The study was based on information supplied by the most important networks and operators in 2000. The main conclusion of that survey was, that 650,000 of the total 1,2 million wagons would need retrofitting, assuming that the operation would start in 2005.

So:

> The UIC/UIP/CER Noise Action Program has estimated that around 1,2 million freight vehicles exist in the EU-Railway-25, of which 650,000 will need to be retrofitted (Status report April 2003).

Third party assessment

Assessing the size of the fleet across Europe is a vital and indispensable part of the third party analysis. Producing a representative and accurate assessment of the number of wagons per country will enable to produce a clear evaluation of the total cost - both investment and life cycle cost - of retrofitting these wagons across Europe.

In identifying the number of wagons across Europe different sources were used:

- ✓ the disclosed figures from NCO (Noise Contact Officers) workshops [ref. **29**].
- ✓ the UIC statistical book [ref. **10**] that includes historical figures on the rail freight transport stock across Europe.
- ✓ assessments made on behalf of AEIF (European Association for Rail Interoperability) [ref. **12**, **13**, **14**, **15**].

The data contained in the above sources was cross-checked with information that was collected during the interviews with wagon owners and operators across Europe.

The retrofitting refers to basically every wagon that could be operated on the tracks of the European Union. It means that wagons coming in from neighbour countries would have to be included. Various definitions of the area of concern have been used, taking into account the above condition. The definitions are as follows:

- ✓ EU 15: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain, Sweden, United Kingdom

- ✓ EU 15+2: EU 15 and Switzerland and Norway
- ✓ EU-Railway-25: EU 15+2 plus eight accession countries: Estonia, Hungary, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Slovenia
- ✓ EU-Railway-27: EU-railway-25 plus Romania and Bulgaria

The number of freight wagons across Europe has dramatically declined over the past 30 years. Notably, over the last 10 years there has been a 47% decrease in that period [1989-2000]. The figure below provides a good illustration of this trend.

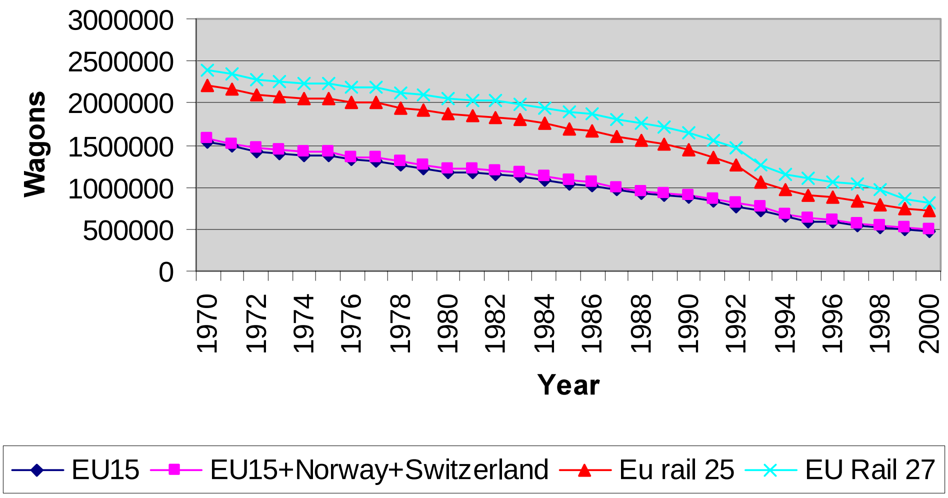

Figure 2.1. Evolution of freight wagons (fleet size) across Europe [ref. 10, 12, 13, 14, 15]

Figure 2.1 represents the evolution of the wagon fleet across Europe from 1970 to date. In the subsequent analysis the year 2000 data are used as an estimate of the current fleet size.

For the countries where the year 2000 observations were missing it was assumed that the number of wagons remained unchanged from 1999 and that years' data were used instead. The figure includes wagons owned and operated by UIC-member companies and privately owned wagons. Per 2003, the number of privately owned wagons (UIP members) was 162,301 for EU 15. There are no data for EU-Railway-27, but it is safe to assume that very few privately owned wagons exist in the remaining countries. The total number of wagons owned by UIRR members as per 2003 was estimated by AEA Technology to be smaller than 10,000.

Summarising: Based on a thorough assessment of the available statistics and information, AEA Technology has reached the following conclusion:

Total current European freight fleet size:
825,000 wagons in EU-Railway-27 (year 2000)

The above information was cross-checked in the sample test, which is made in this study. The results are presented in table 2.2.

Table 2.2. Information gathered during interviews.

	Existing fleet by 2003	
	cf. UIC statistics [ref. 10]	Cf. own indication
Poland (PKP)	88,988	88,000
Germany (DB Cargo)	188,752	120,000 DB + 60,000 private
Netherlands (Railion)	3331	2500 own + 1500 lease
Portugal (CP)	3,931	4,381
England (EW&S)	18,500	23,000
Switzerland (SBB)	19,894	20,000

There is generally a good agreement between the numbers from the UIC statistics and the numbers collected in interviews. Therefore it is fair to assume that the UIC statistics are correct.

Composition of actually existing fleet

For the composition of the fleet reference is made to the exact same source of information, i.e. the UIC statistics. The following table provides a distinction between 2-axle and 4-axle (bogie) wagons, a distinction that is most relevant with respect to the retrofitting cost.

Table 2.3. Total number of wagons (UIC/UIP/UIRR-wagons) in EU-Railway-27 in year 2000. (Source: International Railway Statistics 2001, UIC)

Country	Country Status	2-Axled	4-Axled	Total
Austria	EU 15	9,291	14,679	23970
Belgium	EU 15	5,825	12,965	18790
Denmark	EU 15	693	1,543	2236
Finland	EU 15	5,312	6,492	11804
France	EU 15	25,058	69,731	94789
Germany	EU 15	66,858	121,894	188752
Greece	EU 15	1,093	2,433	3526
Ireland	EU 15	703	1,564	2267
Italy	EU 15	14,882	50,101	64983
Luxembourg	EU 15	791	1,626	2417
Netherlands	EU 15	1,033	2,298	3331
Portugal	EU 15	1,219	2,712	3931
Spain	EU 15	11,372	15,080	26452
Sweden	EU 15	5,455	12,141	17596
UK	EU 15	5,735	12,765	18500
Czech Republic	Accession in 2004	18,132	40,358	58490
Estonia	Accession in 2004	2,253	5,014	7267
Lithuania	Accession in 2004	4,078	9,077	13155
Hungary	Accession in 2004	6,633	14,764	21397
Latvia	Accession in 2004	276	9,144	9420
Poland	Accession in 2004	11,726	77,262	88988
Slovenia	Accession in 2004	1,207	4,848	6055
Slovakia	Accession in 2004	8,780	19,543	28323
Norway	EEA	780	1,737	2517
Switzerland	EFTA	12,909	6,985	19894
Romania	Europe	16,028	45,620	61648
Bulgaria	Europe	9,476	21,092	30568
	Total	**247,598**	**583,468**	**831,066**

Table 2.3 shows, that 30% of all the existing wagons are 2-axled. The majority of wagons from private wagon owners are 4-axled (81%), whereas for non-privately owned wagons this is 58%. This last inventory covers only the countries participating in the Noise Contact Officers meetings.

<u>NOTE</u>: table 2.3 shows a total number of 831,066 wagons. As there is an uncertainty of at least a few % in the numbers, in the present report it is preferred to use the rounded number of 825,000 as has been mentioned before.

Other parameters can be used to subdivide the complete fleet, which are also relevant to the cost assessment of the UIC/UIP/CER Noise Action Program. Such parameters are:

- ✓ The annual mileage distribution,
- ✓ The wagon type.

With respect to the mileage, the following information was collected:
An assessment was made by the noise contact officers, showing the annual mileage of wagons owned by UIC operators, as presented in figure 2.2. The data covers 530,000 wagons and is applicable for 2005 and beyond. It is shown that a large percentage of all the wagons (in Europe) runs only around 30,000 km per year. Privately owned wagons show somewhat better performance, as around 30% run more than 40,0000 km per year. For UIRR most wagons cover more than 50,000 km and some even more than 100,000 km per year.

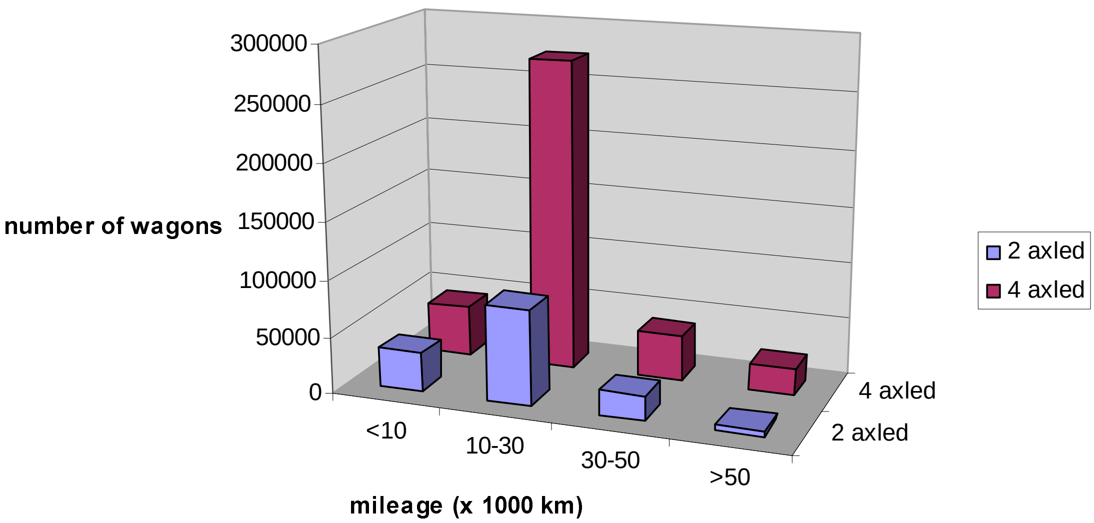

Figure 2.2. Annual mileage UIC wagons.

Detailed information has been received from one large operator, who indicated the following distribution (2003):

- ✓ > 50,000 km 14%
- ✓ between 10, 000 and 50,000 km 71%
- ✓ < 10,000 km 15%

This appears to be in line with figure 2.2.

With respect to the wagon types, the information is fairly confidential. One large operator (DB) mentions the following rough distribution (2003):

- ✓ sliding wall 19%
- ✓ automobile carrier 7%
- ✓ flat bogie wagon 19%
- ✓ tilting wagons 5%
- ✓ open wagons 20%
- ✓ flat wagons 29%

This distribution is representative for the Western European freight fleet. The wagon type is not particularly relevant for the cost assessment.

For privately owned wagons, around 80% of the 160,000 wagons are tank wagons, most of them 4 axled.

Finally, an assessment has been made of the age of wagons. Figures received from AEIF, covering the EC fleet only, indicate the following distribution (by 2000):

- ✓ built before 1970: 10%
- ✓ built between 1970 and 1980 46%
- ✓ built between 1980 and 1990 22%
- ✓ built after 1990 10%

The distribution is illustrated in figure 2.3.

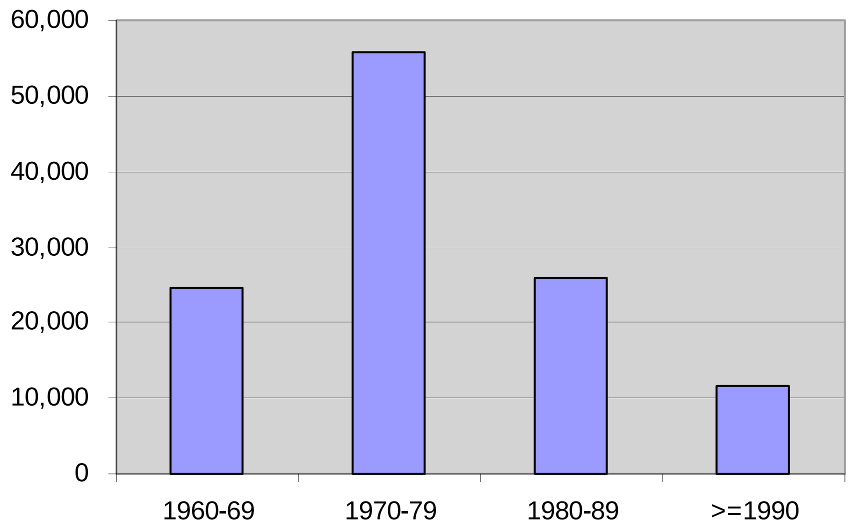

Figure 2.3. Age distribution of freight wagons

Summary existing fleet

The present fleet in EU-railway-27 consists of 825,000 vehicles. Around 30% of these are 2 axled wagons. The vast majority of these vehicles have an annual mileage between 10,000 and 30,000 km. Almost half of the fleet consist of flat wagons. There are about 10% of the wagons older than 30 years. Most of the wagons are between 10 and 20 years old.

Future developments in rail freight transport: tendencies

Freight transport in the EU has expanded considerably in the last decades without a similar trend for the rail share, thus rail's share of the significantly growing freight market in Europe has been in decline for many years. From 1970 till 1999 in the EU15 the amount of goods transported by rail reduced from 282 billion tonnes km to 237 billion tonnes km (i.e. a reduction by 17%). The modal share of rail in total land transport reduced from 33% to 13%, in total freight transport from 21% to 8% [ref. **11**].

The size of the total fleet of freight wagons in Europe has more than kept pace with this decline. As shown in figure 2.1, in thirty years, the overall capacity of rail freight has been reduced by about 2/3 or 66%. The comparison between these two figures – 17% reduction in tonnes km, 66% reduction in fleet capacity – demonstrates the large improvement in utilisation that the freight operators have gone through. For this reason it is not to be expected that there is still a large over-capacity.

Table 2.4. Goods transported by rail, in absolute market share for the total goods transport market and in relative market share compared to other goods transported by rail only.
(Source: White Paper, European transport policy for 2010: time to decide, European Commission, September 2001,[ref. 11])

Goods	% rail absolute	% rail relative
agricultural	3.5	12
coal and other solid mineral fuels	0.3	10
petroleum etc	0.6	10
ore/waste/steel	0.2	8
metal products	0.8	12
cement and building mat.	2.4	12
chemicals and fertilizers	0.8	10
machinery, articles	6.2	24

Growth is reported in the field of coal, ore and other solids, and chemicals, whereas agricultural, building materials and automotive are rather stable. This leads to a tendency to keep the number of tank wagons and flat wagons stable or growing, whereas covered wagons are being reduced.

Other significant trends and issues identified as important for future development are the following:

- ✓ There is a difference of opinion with respect to the tendency towards 4-axled (bogie) vehicles or 2-axled wagons. Some report on a growing demand for smaller wagonloads and thus an increase in 2-axled wagons, others – mainly private wagon owners – say that the future is to the bogie wagons.
- ✓ To a large extent, newly constructed wagons are flat container carriers. The high flexibility and low price of this wagon type makes it the preferred choice for many operators.
- ✓ There is not so much a need for higher maximum speeds, but for better synchronisation of speeds between freight traffic and passenger traffic. This synchronisation should allow freight traffic to be mixed with passenger traffic on the same line more smoothly and would thus avoid many interferences of the freight traffic scheduling.
- ✓ The average speed of a freight train in international traffic is around 20 km/h (including long stops), due to capacity restrictions (priority to passenger traffic), formalities at interfaces, and particularly due to inspection whenever the composition of the train changes. This average speed can be increased significantly without having to increase the maximum speed above the present typical speed of 100 km/h.

- ✓ Most of the EU infrastructure is not equipped to take more than 22.5 tonnes per axle. UIRR members report their intention to increase wagonloads from 22.5 tonnes per axle upwards, if the infrastructure could bear it.
- ✓ The efficiency of rail wagon use is, on the average, very diverse. The actual productivity of approximately 232 billion tonnes km per year in EU15 can be expressed in utilisation figures: Assuming approximately 500,000 wagons in EU15, 68% 4-axled and 32% 2-axled, maximum axle load of 22.5 tonnes, and annual mileage of 12000 km (scenario 1) to 30,000 km (scenario 2), the utilisation is between 11% and 25%. This means that still a drastic improvement of the present market share can be made in the EU15 countries, before needing to expand the present fleet at all. It is reasonable to assume that this conclusion holds also for the EU-Railway-27. On the other hand, private wagon owners report a far better productivity for their part of the market.
- ✓ At present, the total European market for new wagons is indicated to be approximately 8,000 wagons per year. In parallel, a similar number of wagons are refurbished by the operators. In the AEA Technology analysis these refurbished wagons were counted as new.

Future developments in rail freight transport: 3 scenarios

The basic assumption is that the retrofitting operation starts in 2005. The market view adopted in the present report however reflects the longer term, up to the year 2020. The figures below have been assessed for the assumed end of the retrofitting operation, i.e. 2015.

It is possible to adopt differing views about the prospects for rail freight in Europe. The EC White Paper 'European transport policy for 2010:time to decide' reports the rail industry stakeholders' objective for rail freight to achieve a 15% market share (of a bigger market) by 2020. This in effect would mean multiplying current business by three times. On the other hand many European freight train operators, exposed to strong economic pressures, are saying that they may need to further reduce volume to maintain profitability or mere survival, by abandoning unremunerative traffic. Between these two positions there is the middle ground, defined as the 'steady state' position.

Based on these three basic options 'growth', 'steady state' and 'decline' have different consequences for the overall number of wagons required, and for the volumes of wagons in the retrofit program. The three scenarios have been presented in figure 2.4 below.

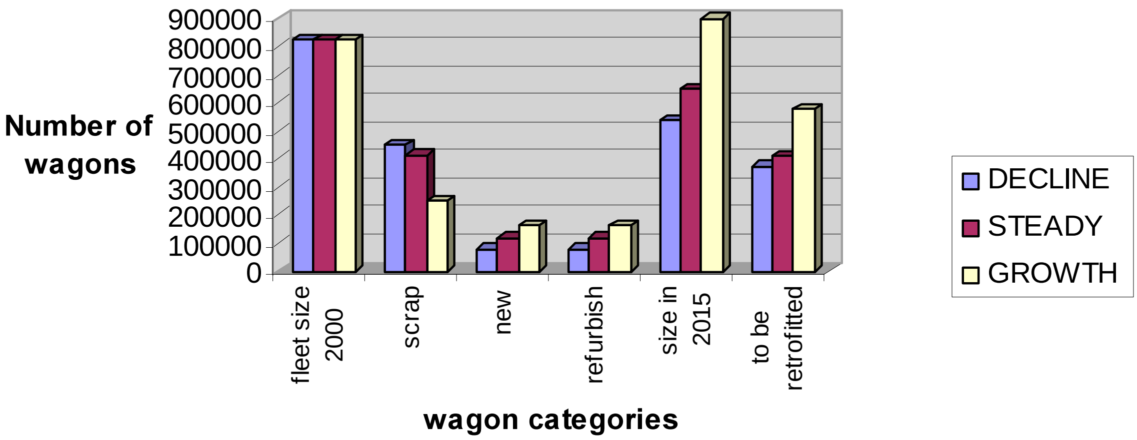

Figure 2.4. Fleet size in 2003 and 2015, under three different future scenarios

Under the 'growth' option there would be an increase in the total wagon numbers, but of course all new wagons would have K-blocks fitted at build. Existing wagons (and new wagons) would be utilised better. The current scrapping rate would reduce, in order to extend wagon life to cope with demand. However, there would be a gradual replacement of older and less efficient wagons with modern higher capacity wagons. The total vehicle fleet would increase from 825,000 to about 900,000 by 2015 (assumes doubling of productivity by 2020). There would be pressure on accession states to adopt more modern wagons, although the availability of finance would be a limiting factor.

Under the 'steady state' option there would be a limited reduction in the total wagon numbers. This reflects the balance between several factors - the substitution rate, the extension of wagon life beyond the traditional 30 years towards 40 years, better fleet utilisation and a high proportion of scrapping from the older and less efficient parts of the fleet. Scrapping rates would be higher in the accession states. The overall effect would be a reduction of wagon numbers by 175,000 to give a fleet size of 650,000.

Under the 'decline' option there would be a more significant reduction in the wagon fleet. Wagons would be renewed on a more selective basis for profitable business, and there would be a higher scrapping rate than under the other options as inefficiency and poor utilisation of wagons are squeezed out faster. The overall effect would be a reduction of wagon numbers by 290,000 to give a fleet size of 535,000.

Quantitative assessment of the fleet to be retrofitted

Following the three future scenarios as described in the previous section, the estimated numbers of wagons to be retrofitted have been assessed as:

- ✓ Decline scenario: 375,000
- ✓ Steady state scenario: 410,000

✓ Growth scenario: 575,000

The above assessment is quite speculative. The only conclusion can be that the number of vehicles to be retrofitted is between 375,000 and 575,000.

A more quantitative approach has been chosen, based on the following assumptions:

✓ The present market for new vehicles in Europe (27 countries) is around 8000 vehicles per year. It was assumed that this market will remain unchanged for the years until 2015.

✓ At present, an annual number of 8000 vehicles are refurbished and used as new vehicles. It was assumed that this figure will remain unchanged until 2015.

✓ It was assumed that only the new vehicles will be equipped with composite brake blocks (K or LL type) as a default from 2004 or 2005, based on the UIC homologation decision. This assumption is the most critical one in this analysis. For existing wagons to be refurbished, it has been assumed that, as a default, they would keep their cast iron brake blocks. In the case of refurbishing and retrofitting the blocks it would have to be considered part of the UIC/UIP/CER Noise Action Program.

✓ The age distribution as indicated in table 2.5 below per 2000 was adopted for the complete EU-railway-27 fleet.

✓ It was assumed that never more than 1% of the total fleet will be older than 40 years.

From the above assumptions the total size of the EU-Railway-27-fleet between 2000 and 2020 was assessed. Results are presented in the figure 2.5.

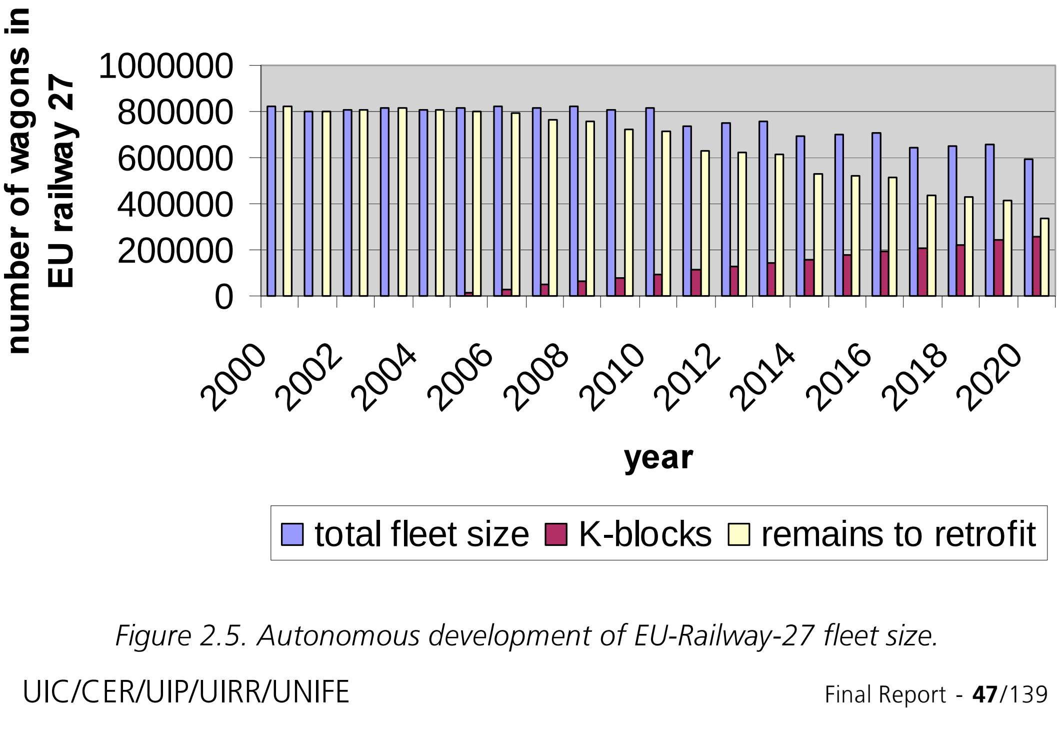

Figure 2.5. Autonomous development of EU-Railway-27 fleet size.

The above development would imply an autonomous scrapping of vehicles whenever their age would be above 40 years and they would not be required for refurbishing.

It can be concluded from the above picture, that, if the present market situation for new vehicles and refurbishment does not change, the size of the EU-Railway-27-fleet will autonomously decrease by up to 28% down to 600,000 until 2020 (or 700,000 by 2015).

The renewed part of that fleet would be equipped with K-blocks from 2004. If the retrofitting were to be finished by 2015, **520,000** wagons would have to be retrofitted. If the refurbished wagons would be considered part of the retrofitting program, the total number would be **604,000** wagons.

Table 2.5. Age of freight transport stock in 2005 for various types of wagons [Sources: AEIF, UIC Supplementary Railway Statistics, table A27, years 1990-1995-2000].

Country	Operator	Wagon type	1960-69	1970-79	1980-89	>=1990	Total	Average Age	Residual Age
Austria	ÖBB	Other wagons	0	183	350	0	533	23.43	16.6
	ÖBB	Covered wagons	1394	2714	2239	1608	7988	24.79	15.2
	ÖBB	Flat wagons	279	2075	2321	1156	5957	22.06	17.9
	ÖBB	High-sided wagons	223	186	2158	701	3293	19.64	20.4
Belgium	SNCB/NMBS	Other wagons	5	41	0	0	46	31.09	8.9
	SNCB/NMBS	Covered wagons	117	660	767	74	1618	25.07	14.9
	SNCB/NMBS	Flat wagons	1585	5098	773	1486	8942	27.58	12.4
	SNCB/NMBS	High-sided wagons	531	893	1355	0	2779	27.03	13.0
Spain	RENFE	Other wagons	92	100	230	895	1317	15.36	24.6
	RENFE	Covered wagons	740	1798	603	955	4096	25.67	14.3
	RENFE	Flat wagons	1831	2413	3400	746	8560	25.83	14.2
	RENFE	High-sided wagons	481	1443	1747	669	4590	22.69	17.3
Finland	VR	Other wagons	191	559	28	0	781	31.97	8.0
	VR	Covered wagons	1166	853	372	1964	4355	22.80	17.2
	VR	Flat wagons	2271	1878	1498	564	6211	29.43	10.6
	VR	High-sided wagons	112	547	246	40	945	27.74	12.3
France	SNCF	Other wagons	20	258	1	4	284	30.28	9.7
	SNCF	Covered wagons	2265	5244	1929	511	9949	29.31	10.7
	SNCF	Flat wagons	6161	17976	3476	457	28190	30.50	9.5
	SNCF	High-sided wagons	1860	5508	566	0	7936	31.62	8.4
United Kingdo	EUROTUNNEL	Covered wagons	0	0	0	411	411	10.00	30.0
Ireland	CIE	Other wagons	0	249	0	0	249	30.00	10.0
	CIE	Covered wagons	0	216	0	0	216	30.00	10.0
	CIE	Flat wagons	142	708	57	0	907	30.94	9.1
	CIE	High-sided wagons	0	282	165	0	447	26.31	13.7
Luxemburg	CFL	Other wagons	0	0	0	0	0		
	CFL	Covered wagons	48	177	0	0	225	32.13	7.9
	CFL	Flat wagons	393	729	254	487	1863	25.52	14.5
	CFL	High-sided wagons	102	231	60	10	403	30.55	9.5
Norway	NSB BA	Other wagons	23	599	22	0	647	29.88	10.1
	NSB BA	Covered wagons	49	229	325	0	603	25.42	14.6
	NSB BA	Flat wagons	318	297	438	81	1134	27.51	12.5
	NSB BA	High-sided wagons	4	58	0	0	62	30.65	9.4
Portugal	CP	Other wagons	133	0	266	13	412	26.14	13.9
	CP	Covered wagons	550	665	0	133	1348	32.11	7.9
	CP	Flat wagons	163	466	287	315	1531	19.20	20.8
	CP	High-sided wagons	200	381	0	30	640	30.83	9.2
		Grand Total	**23449**	**55714**	**25933**	**13310**	**119468**	**27**	**13**

Fleet to be retrofitted: the corrected NCO information approach

The Retrofitting Working group of the UIC/UIP/CER Noise Action Program has evaluated the number of vehicles to be retrofitted. The participating railways were asked to provide numbers.

The numbers provided by the different Noise Contact Officers have been analysed. Inconsistencies have been removed, such as:

- ✓ In the cases where it was indicated that less than 10% of the existing fleet would have to be retrofitted, it has been assumed that there must be some misunderstanding and that particular country or operator was ignored.
- ✓ In the cases where the number of vehicles to be retrofitted by 2005 was higher than the number of vehicles present in 2000 according to UIC statistics [ref. 10], the indication has been suppressed in the first approach
- ✓ For the remaining railways, it was found that the overall reduction of wagons was 20%. This figure has then been taken as the high estimate.

With these corrections, the remaining operators/networks cover 48% of the total vehicle fleet existing in EU-Railway-27 in 2000. They indicate that 73% of their fleet would need retrofitting. This can then be extrapolated to a figure of **602,000** wagons, which is well in line with the above assessment.

For private wagon owners the situation may be somewhat different. Their 170,000 wagons are younger and cover higher mileages than the non-privately owned wagons. However, UIP's own estimate is that 78% of their fleet would require retrofitting (based on a 6 year retrofitting program starting in 2005). If the program would be extended to 10 years, it would be down to 74% of the fleet.

Table 2.6. Estimation of the percentage of wagons that will need retrofitting if the program would start in 2005, according to Noise Contact Officers.

		To be retrofitted	Total existing fleet	Not requiring retrofit	Corrected number to be retrofit	Corrected total existing	Not requiring retrofit	From interview
SBB	Switzerland	21850	19894	-10%				20000
HZ	Croatia	6555	9986	34%	6555	9986	34%	
BDZ	Bulgaria	2800	30568	91%				
NSB	Norway	2065	2517	18%	2065	2517	18%	
DB	Germany	97400	188752	48%	**137400**	188752	27%	83092+ 40000 P
SZ	Slovenia	3069	6055	49%	3069	6055	49%	
LDZ	Lettonia	8035	9420	15%	8035	9420	15%	
VRCARGO	Finland	11973	11804	-1%				
MAV	Hungary	22411	20604	-9%				
CFL	Luxembourg	2172	2417	10%	2172	2417	10%	
PKP	Poland	104580	88988	-18%	**65000**	**88988**	27%	65000
SNCF	France	107473	94789	-13%				
CFR	Rumania	68480	61648	-11%				
FS	Italy	50000	64983	23%	50000	64983	23%	
OeBB	Austria	16426	23970	31%	16426	23970	31%	
Renfe	Spain	26326	26452	0%				
		551615	662847	17%	290722	397088	27%	

Future fleet size: Discussion and conclusion

Summarising the above approaches, the following numbers were identified as number of wagons to be retrofitted until 2015:

- ✓ 3 growth scenarios approach: between 375,000 and 575,000

- ✓ quantitative approach 604,000

  (refurbished wagons count as "to be retrofitted")
- ✓ corrected NCO approach 602,000

The quantitative approach is estimated to give the highest reliability.
It is as expected that the Noise Contact Officers' estimate is conservative. The 3 scenario approach is highly speculative. For this reason, a total number of 604,000 is applied in the further assessment.

2.1.3 Economic evaluation for retrofitting

One off cost elements <u>per wagon</u>

The one off cost of retrofitting a vehicle consists of four elements:

A. The purchase of the components to be replaced (reduced by the potential rest value of the components that are to be replaced or increased by the cost to dispose of these components, the latter element has not been taken into account in the assessment),

B. The labour cost for the replacement,

C. The cost for withdrawal of the vehicle from commercial operation, and possibly the transport of the vehicle to a workshop,

D. The cost for testing and accepting the retrofitted vehicle (expensive certification tests are required for every series of a particular vehicle type after retrofitting).

All of these costs have been assessed, mainly by the Technical working group of the UIC/UIP/CER Noise Action Program. The conclusions from the Technical working group have then been integrated and used by the Retrofitting working group. They form the basis for the UIC assessment of the Life Cycle Cost.

The different costs elements are described in detail in Annex 3. Here the main conclusions from the UIC Noise Action Program are summarised. The conclusions to be assessed by AEA Technology are:

> The investment cost for retrofitting one wagon depends on wagon type and time of retrofitting. Depending on these parameters the cost are between € 6,000.- and € 13,000.- per wagon.

The price difference was assessed by the Technical working group of the UIC/UIP/CER Noise Action Program as follows (for Bg or Bgu – see Annex 2 for technical details):

- ✓ € 5,700.- Euro in the cheapest case, i.e. a 2 axled wagon with Bg type brake blocks and manual empty/load switch,

- ✓ € 13,000.- Euro in the most expensive case, i.e. a 4 axled wagon with Bgu type brake blocks and automatic load relay valve.

A. Discussion of purchase price elements

The purchase price of the brake block is the first cost element. For composition brake blocks the market in Europe is still very small; only two suppliers have been acknowledged to supply blocks with characteristics that allow international admission.

The purchase price of K-blocks has been assessed by the Technical working group. For the purpose of the third party assessment, this price has been compared with indications from different other sources. The results, presented in Annex 2 and 3, are summarised in table A3.2. Other sources are currently investigated to have a comprehensive view on the price level. The price depends on the type of brake block (Bg or Bgu).

Table A3.2. Comparison of the purchase price of brake blocks.

Shoe material	**Supplier base**	**UIC Noise Action Program**	**Source A**	**Source B**	**Source C**	**Source D**
Cast iron brake shoe (Bg size)	EU	€ 6	€ 10 – 11		€ 10 – 12	
Cast iron brake shoe (Bgu size)	EU	€ 5				
Composition brake shoe K-type (Bg size)	EU	€ 28	€ 14-21	€ 31 (500 ordered)	€ 50 – 70	€ 23 – 30 (K-type)
Composition brake shoe K-type (Bgu size)	EU	€ 23				
Composition brake shoe K-type (Bg size)	USA		€ 11			
Composition brake shoe LL-type (Bgu size)	EU					€ 40 – 50
Sinter brake shoe (Bg size)	EU	€ 50	€ 115 (present)			
Sinter brake shoe (Bg size)			€ 63 (future)			
Sinter brake shoe (Bgu size)	EU	€ 40				

Obviously, in a fully developed market the price of the block will be lower than present prices with only two suppliers – this can be seen clearly from the difference between EU market and USA market as presented by source A.

It is expected by AEA Technology, that the price of a brake block in a fully developed market could be € 20 for Bg and € 18 for Bgu type blocks.

In general from the above table the first conclusion indicates that the UIC/UIP/CER Noise Action Program underestimates the cost for cast iron, overestimates that of composition blocks and underestimates the cost for sinter blocks.

Other components represent cost elements as well:

- ✓ the wheels, which have been indicated by the UIC/UIP/CER Noise Action Program as € 500,- a piece, which is probably a fair price (a different source which was consulted for the third party assessment quoted a price of € 1660,- to € 2300,- for a complete wheel set, yet another source quoted € 520,- per wheel),
- ✓ the empty/load valve, which may require replacement when the cylinder is replaced, at € 1343,- by UIC and at € 1260,- by a single other source, the order of magnitude being confirmed by yet a third source,
- ✓ the brake cylinder, at € 1059,- by UIC and at € 245,- by a single independent source. There is apparently a scope for different interpretation here, as some parties say that the cylinder would need replacing and others claim that it could be modified.

B. Discussion of labour costs

The labour cost, indicated at 27 hours at an hourly rate of € 41,- for a 2 axle wagon, lead to a total of € 1107,- for the complete retrofit. During the interviews prices of € 3000,- to € 3500,- were quoted for the complete retrofit of one wagon (this is in a workshop in Western Europe). It has been pointed out by others that the man hour rate of € 41,- may be too low. It includes marginal personnel cost, not effective workshop cost. In some Western European workshop the charge is at € 55,- per man hour. A detailed discussion of the effects of different assumptions for labour costs is made at the end of the present chapter.

C. Cost for withdrawal of the vehicle

These costs have not been taken into account by the UIC assessment. The rental costs for a replacing vehicle, if the vehicle is withdrawn from commercial operation, are reported to amount to € 21 per day.

D. Testing and acceptance cost

The estimated homologation (approval) costs can only be estimated in the AEA Technology analysis. An estimation of the order of magnitude may read as follows:

- ✓ number of different wagon types in Europe: at least 100, not more than 1000,
- ✓ homologation cost per type: € 200,000 ,
- ✓ Average number of wagons per type: 800 to 8000 (note: in some cases very small series of maybe only 20 wagons may exist),
- ✓ Average homologation cost per wagon: € 30 to € 300, in some exceptional cases much more!

Conclusion: on the average, it is fair to neglect this amount.

It should be stressed that, in the case of small series of wagons, the homologation costs per wagon can be dramatically larger than the amount indicated. VTG operates 50,000 wagons, which represent 100 different wagon types. If each of the wagon types requires the full acceptance testing for homologation, the testing cost per wagon is 400 Euro.

Discussion of investment cost

The main uncertainties in the above analysis are:

- ✓ in the replacement of the brake cylinder, which is not necessary in all cases. In some cases the existing cylinder can be kept, while changing the brake pressure and leverage by changing a valve setting.
- ✓ In the labour cost which may depend both on the hourly rates and on the amount of time estimated for the job. A single axle replacement has been reported to consume 12 man-hours, which could affect the overall price.

Taking the above uncertainties into account for the different wagon types under concern, the following conclusions can be drawn (all in Euros and rounded to the nearest 100):

Table 2.7. Costs estimation (sensitivity analysis) third party assessment (source: AEA Technology).

		2 axles				**4 axles**			
		Bg		Bgu		Bg		Bgu	
		No cylinder change	Cylinder high estimate	No cylinder change	Cylinder high estimate	No cylinder change	Cylinder high estimate	No cylinder change	Cylinder high estimate
Labour high esti-mate	**K-blocks**	5000	6400	4900	6300	8100	9500	8000	9400
	Sinter blocks	5200	6600	5100	6500	8500	9900	8300	9700
	Disc brakes	15000				25000			
Labour low esti-mate	**K-blocks**	4500	6000	4500	5900	7400	8800	7300	8700
	Sinter blocks	4700	6200	4700	6100	7800	9200	7700	9100
	Disc brakes	13000				22000			

In table 2.7, the lowest and highest estimates have been indicated. The costs mentioned in this table need to be increased by the cost for a replacement of an automatic load relay valve for vehicles equipped with such a device, which would cost € 900,- for a 2 axle vehicle and
€ 3200,- for a 4 axle vehicle.

In addition to the above sensitivity analysis, two examples of wagon retrofitting costs are presented in the following table 2.8.

Table 2.8. Two examples of retrofitting cost per wagon, based on AEA Technology cost assessment.

Example 1

4-axled, tyred wheels, 2Bg type blocks, Oerlikon valve

Component	Number	Price/piece	total	SUM
Wheel	8	500	4000	
Blocks	16	20	320	
Cilinder	2	300	600	
Valve	1	1300	1300	
clamps	16	30	480	
rigging	100	1	100	
				6800
Labour				
wheel exchange	48	40	1920	
other	20	40	800	
				2720
	units	Price per unit		
Replacing wagon	3	21	63	
Homologation	100	200000	2000	
				2063
TOTAL				**11583**

Example 2

2-axled, SS type, already equipped with LRS wheels and Knorr valve, 2Bgu

Component	Number	Price/piece	total	SUM
Wheel	0	500	0	
Blocks	16	18	288	
Cilinder	2	300	600	
Valve	0	1300	0	
clamps	16	30	480	
rigging	100	1	100	
				1468
Labour				
wheel exchange	0	40	0	
other	20	40	800	
				800
	units	Price per unit		
Replacing wagon	3	21	63	
Homologation	100	200000	2000	
				2063
TOTAL				**4331**

The conclusion from the above analysis reads as follows:

The investment cost for the retrofitting of a freight wagon with K- or Sinter blocks is roughly between € 4500 and € 13,000 depending on the wagon type and on the assumptions regarding labour cost. When "retrofitting" with disc brakes, the investment cost will be between € 13,000 and € 22,000.

It should be emphasized that the cost for wagon withdrawal and type testing are included in this estimate, but may lead to large differences per wagon. Wagon transfer is not included, it may cost up to € 1 Euro per wagon per kilometer.

Life Cycle Cost (LCC) elements per wagon

The Life Cycle Cost of a freight vehicle is composed of the annual net value of the purchase price, depending on the total life span. The life span of some components may be less than that of the complete vehicle; this is certainly the case for the brake blocks and possibly also for the wheels. The life span of wheel and brake blocks depends on the annual mileage and on the operation conditions.

In the AEA Technology analysis an assumption was made about the total typical life span of a freight vehicle. An estimate is based on the figures received from AEIF/EEG [ref. 12, 13, 14, 15], which are summarised in the following figure 2.6 and 2.7.

Figure 2.6 suggests, that the life span of freight wagons increases over time, as there were only 10% older than 30 years in 1990, and 20% in 2000.

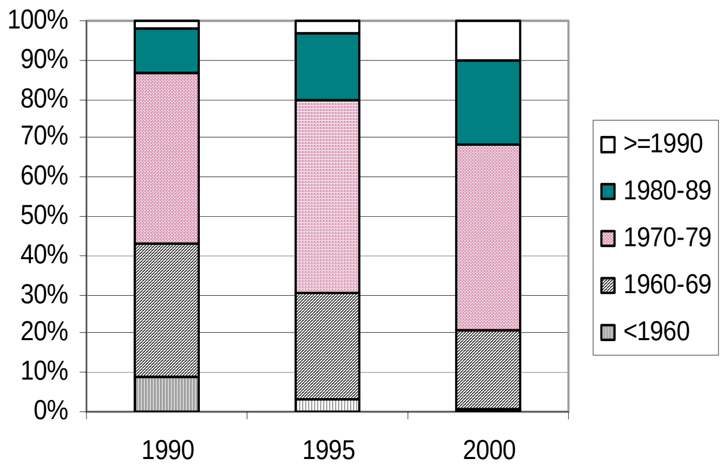

Figure 2.6. Fleet structure in % at end of years 1990, 1995, 2000 divided according to year of manufacture. [Source: AEIF]

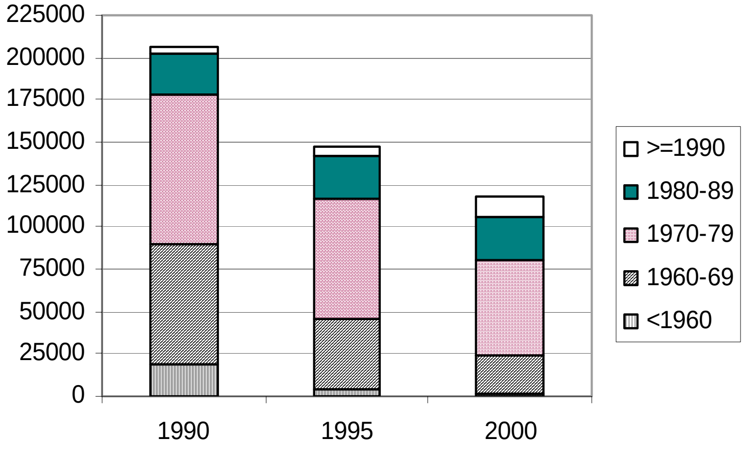

Figure 2.7. Fleet size at end of years 1990, 1995, 2000 divided according to year of manufacture- Note: part of the EU fleet only. [Source: AEIF]

However, the figure 2.7 shows, that the increase is not that dramatic: thanks to the fact that many vehicles have been scrapped, the absolute number of vehicles older than 30 years remains more or less the same. From the 85,000 vehicles that were older than 20 years in 1990, in 2000 only 25,000 were left. From the 115,000 vehicles that were younger than 20 years in 1990, 80,000 were left in 2000.

This analysis was made by AEIF/EEG [ref. 12, 13, 14, 15], including the companies CFL, CIE, CP, Eurotunnel, NSB, ÖBB, RENFE, SNCB/NMBS, SNCF and VR. Some information is also available on the vehicle types that were present in the fleet, presented in figures 2.8.

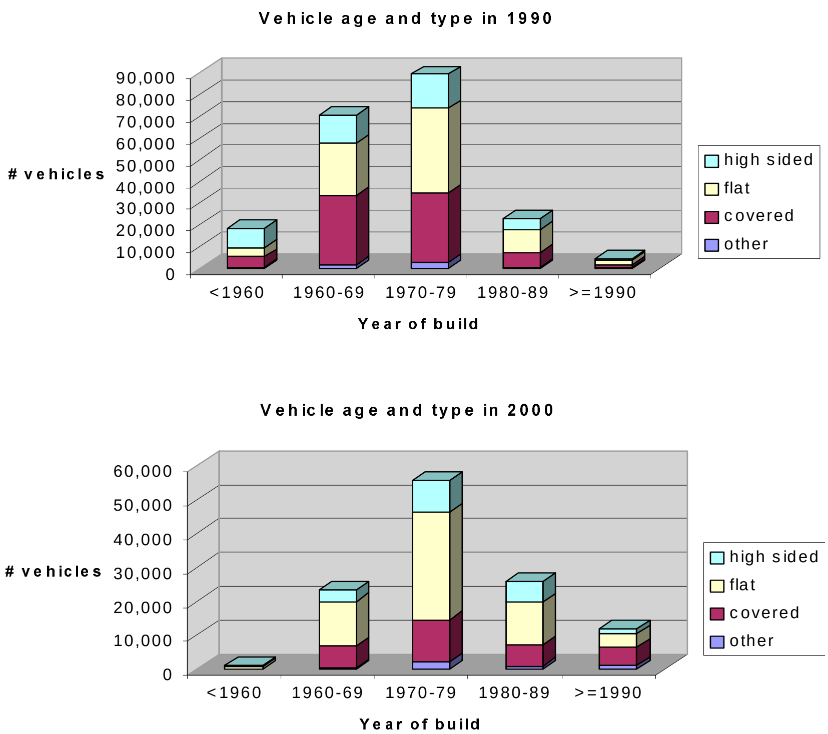

Figure 2.8. Fleet composition in 1990 and 2000. [Source: AEIF]

It can be seen from these graphs that the composition of the fleet in terms of age is shifting towards a “younger” fleet. The number of covered wagons is decreasing, new wagons are to a large extent flat wagons. The consortium confirms that there is a trend towards shorter technical as well as economical life span.

The interpretation of the above analysis is, that for the fleet development a life span of 30 years is both a future oriented and conservative approach to a LCC assessment.

Maintenance costs and wear

Additionally, the annual maintenance cost of the vehicle is included in the AEA Technology Life Cycle analysis. These costs consist of material costs and labour costs. They depend on the wear of the wheel and the wear of the brake blocks, determined again by the mileage and certain characteristics of the operation. Wheel and brake block wear depend on the type of break block used. This however is a complicated relationship.

Brake block wear is dependent on the brake block material and on the operation. When long stretches of undisturbed operation – e.g. in long distance transport – are possible, the block wear can be much lower than in traffic shared with passenger trains, where much interferences occur.

The wheel wear is only partly induced by the brake block. Other effects may cause wheel defects that have to be removed by periodic reprofiling of the wheel. Particularly the occurrence of wheel flats, caused by “skidding”, determines the wheel reprofiling schedule. The life span of the wheel is determined by the frequency of necessary reprofiling (typically once every 350,000 km or once every 18 years, whichever comes sooner) and the amount of material to be removed during reprofiling. Even if wheels do not wear significantly, something, which may be the case in some exceptional situations, reprofiling is likely to be needed at around 1 million km.

Table 2.9 below illustrates the base hypotheses for wear costs using K-blocks and cast iron blocks.

In this table, several figures occur as “average” values. In many cases, the average value does not reflect the reality, as the average may be something that never occurs. This holds e.g. for annual mileage, which is taken here as two average values, i.e. 100,000 km and 20,000 km. Average values need to be interpreted with great care.

Table 2.9. Hypothesis of shoes and wheels wear values for retrofitting with K-Blocks. [Source: UIC/UIP/CER Noise Action Program, march 2003].

Base Hypothesis		
Average life of wagons to retrofit	20 years	
Average distance covered per year	Hypothesis A:	100,000 km
	Hypothesis B:	20,000 km
Average shoe wear per 100,000km	Cast iron shoes	52.3 mm
	Composite shoes	16.8 mm
Average life of shoes	Cast iron shoes	75,000 km
	Composite shoes	240,000 km
Average wheel wear per 100,000km	Cast iron shoes	1 mm
	Composite shoes	2 mm
Maximum wheel wear		25 mm
Reprofiling at 350,000km	Cast iron shoes	3 mm
	Composite shoes Hypothesis A: 3 mm Hypothesis B: 6 mm	

From the above table, provided by the UIC/UIP/CER Noise Action Program[**)], it is seen that the estimate of the average life cycle of a wagon to retrofit is 20 years. The initial analysis suggests a slightly different figure in the order of 15 years.

Regarding the average life of the shoes, UIRR states that this that this should rather be 90,000 km for both cast iron and composite shoes. This experience reflects the UIRR operation conditions (many alpine crossings).

Different hypotheses have been suggested by the UIC/UIP/CER Noise Action Program regarding the average distance a wagon covers per year. Hypothesis A states 100,000 km and hypothesis B states 20,000 km per year per wagon. The difference in these figures has a large impact on the difference in wheel life span, and thus a great difference in cost. The AEA Technology analysis suggests a figure in the region of 25,000 km per year per wagon. The impacts of these differing assumptions has been tested in the life cycle assumptions.

Wheel degradation as stated above differs depending on the type of brake blocks used. The AEA Technology analysis of the life cycle of a wheel depending on the brake blocks used is presented in the table 2.10.

Table 2.10. Wheel life span using cast iron or K-Blocks.

Average distance covered by wagon per year	Wheel wear by braking only	
	Composite shoes (K-blocks)	Cast iron shoes
100,000km	12.5 years	25 years
25,000km	Longer than wagon life	Longer than wagon life

[**)] *By the technical WG - Mr. J. Raison (SNCF) February 2003*

The analysis so far suggests that throughout the life span of a wagon covering on average 25,000 km, it will be necessary to replace the composite K-Blocks 3 times or 10 times if using cast iron blocks. The life span of a wheel coincides with the life span of a wagon under the assumption that the average distance covered per year is 25,000 km.

Figure 2.9 diagrammatically illustrates the case of a wagon covering 25,000 km per year, using different types of blocks, based on a new wagon with an assumed life cycle of 30 years.

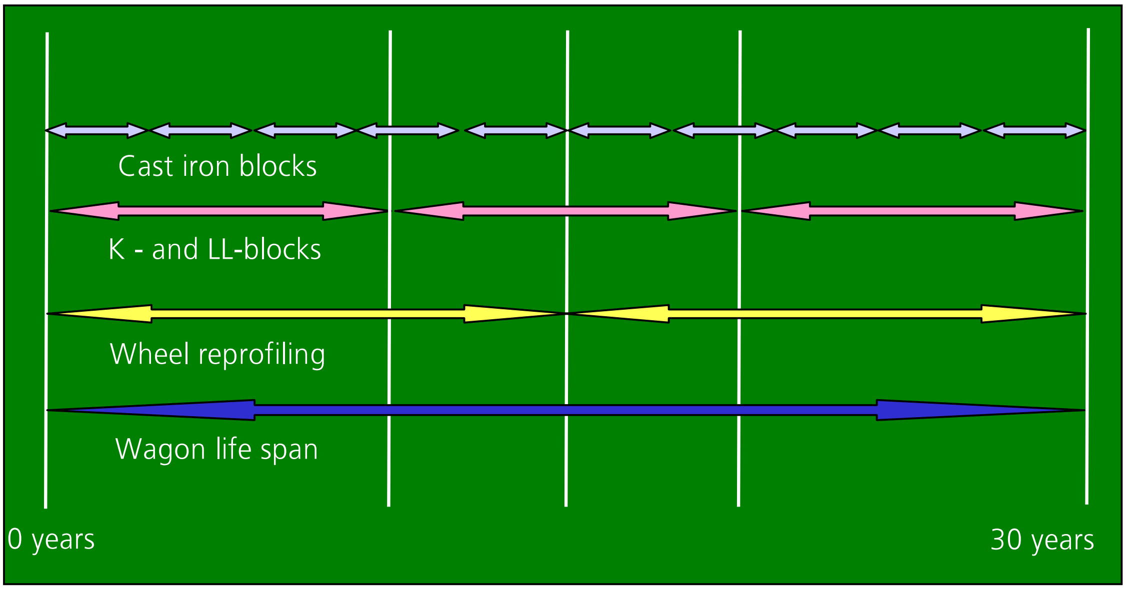

Figure 2.9. Illustration of the life cycle of a wagon with cast iron or K-blocks.

Some illustration and comment with respect to this figure is required:
Block maintenance costs are determined by block life span. At present, cast iron as well as composition brake blocks are replaced as a result of visual inspection, which is made as an element of the regular check that is carried out each time a train has been composed or decomposed. For cast iron, neither the material cost nor the labour costs of such replacement are usually shown in the finances of the company, as this replacement is carried out "without cost" on the basis of mutual agreement. Blocks are replaced when the wear exceeds a limit value, typically 50 mm, which can be read directly from the block. Cast iron block life spans have been reported to be between 5000 (in extreme cases) and 75,000 km. This large spread is due to the different operation conditions.

For K-blocks, the life span is reported to be around 3 times that of cast iron blocks [ref. 52]. However, under severe conditions (alpine passages) a value of 1.0 is to be used. For the AEA Technology analysis a life span is used that is three times that of cast iron. For sinter blocks a similar life span extension is assumed.

Wheel maintenance costs are determined by the wheel life span. At present, freight wheels are reprofiled when a check of the wheel profile indicates that a reprofiling is necessary. Such a check takes place during the regular overhaul, which is typically every 6 years. Reprofiling is necessary in the case of hollow wear of the wheel (loss of profile) and when wheel defects such as flats and out-of-round are detected. Reprofiling may take 10 to 20 mm from the wheel surface, so a wheel can be reprofiled up to 5 times during its life.

A regular visual inspection after train composition or decomposition may also lead to wheel defects being detected. At present this is only the case when the wheel defect is very obvious. Serious defects such as wheel flats may lead to thermal problems in gearboxes, which are detected by hotbox detection instruments. Alternatively, special detection techniques are used to identify wheel flats. In that case, an intermediate curative reprofiling will take place. The frequency of this happening is again highly dependent on the operation conditions. In the near future, automatic monitoring stations will be installed in many networks, which will check the presence of wheel flats in order to assess the damage that could be done to the track. It is therefore expected that intermediate, curative reprofiling will be intensified.

Influence of the brake block type
The brake block type certainly has an influence on the block and wheel life span, but this may not be decisive. K-blocks are reported to lead to higher wheel wear than cast iron. The first results from tests carried out by SBB, DB, SNCF and MAV suggest that wheel wear may be around 3 mm per 100,000 km, whereas for cast iron it is 1 mm per 100,000 km.

On the other hand, composition blocks tend to have a good effect on wheel defects, as they are known to grind away beginning defects. This applies even more for sinter blocks, but these may seriously affect the wheel wear due to braking (assumed twice the wear of composition blocks).

The above assumptions lead to table 2.10, which indicates several life span scenarios (the vehicle life span here is assumed to be 30 years). The following assumptions were used in this table:

- ✓ In the case of frequent wheel defects, wheels need to be reprofiled every 30,000 km. The necessity of reprofiling is not depending on the brake block type used
- ✓ In the case of rare wheel defects, the wheel wear will be mainly dependent on the brake block type. For composition blocks it is 3 mm per 100,000 km, for cast iron it is 1 mm per 100,000 km. The maximum wheel wear is assumed to be 25 mm

- ✓ In the case of low block wear, the block life of cast iron is 17 mm per 100,000 km and that of composite blocks is 52 mm per 100,000 km.
- ✓ A brake block is exchanged even if it is not worn out during the overhaul (every six years).

Table 2.11. Life span scenarios. (ETWL = equal to wagon life)

		Low annual mileage 25,000 km				High annual mileage 100,000 km			
		Frequent wheel defects		Rare wheel defects		Frequent wheel defects		Rare wheel defects	
		High block wear	Low block wear	High block wear	Low block wear	High block wear	Low block wear	High block wear	Low block wear
Cast iron blocks	Block life	6 months	2 years	6 months	2 years	45 days	6 months	45 days	6 months
	Wheel life	6 years	6 years	ETWL	ETWL	1.5 years	1.5 years	5 years	5 years
Compo-sition blocks	Block life	9 months	3 years	9 months	3 years	2 months	9 months	2 month	9 months
	Wheel life	6 years	6 years	ETWL	ETWL	1.5 years	1.5 years	2 years	2 years
Sinter-blocks	Block life	12 months	3 years	12 months	3 years	50 days	5 months	50 days	9 months
	Wheel life	6 years	6 years	ETWL	ETWL	1.5 years	1.5 years	12 years	12 years
Disc brakes	Pad life	Not applic.	Not applic.	3 years	6 years	Not applic.	Not applic.	12 months	1.5 year
	Wheel life	Not applic.	Not applic.	ETWL	ETWL	Not applic.	Not applic.	ETWL	ETWL

For the LCC-assessment it is assumed that reprofiling of a wheel will take place 4 times during it's total life span.

NOTE: Scenarios permit the calculation of averages but do not necessarily reflect realistic cases. Therefore the results should be evaluated with great care.

Life Cycle Costs
Further down in this report the Net Present Value (NPV) of the costs illustrated above for new wagons is estimated. These includes the discounted cost of 2 reprofilings and 3 brake block changes where K-blocks are used, and 2 reprofilings and 10 brake block changes where cast iron shoes are used. As stated earlier the inclusion of estimated approval costs (fixed costs) in the AEA Technology Life Cycle Costing shall be determined when the size of the overall impact of these costs is determined. Similar Life Cycle Costing shall be done for older wagons requiring retrofitting. The average life cycle of a wagon to retrofit for an older wagon shall be estimated as 15 years.

The life cycle cost of a freight vehicle is composed of the annual net value of the purchase price, depending on the total life span, which in turn depends on the annual mileage.

The NCO's have also provided information on the number of wagons per mileage categories as illustrated in Table 2.12 below.

Table 2.12. Percentage split of wagons per mileage per axle load (NCO April 1999).

applicable for period after 2005, all Europe

	less than 30,000 km/yr	between 30 and 50 km/yr	over 50,000 km/yr
2-Axled wagons	82%	15%	3%
4-Axled wagons	83%	11%	6%

For the AEA Technology analysis the total number of wagons was split into 'low mileage'-wagons (20,000 km/yr.) and 'high mileage'-wagons (100,000 km/yr.). Splitting the wagons into these categories will result in a more accurate estimation of the Life Cycle cost of retrofitting. For privately owned wagons (UIP members, 150,000 wagons in total) it is fair to assume that 20% to 30% of the wagons cover more then 40,000 km/yr.

The Noise Contact Officers have provided data on the total number of wagons, per network applicable after 2005, split into 2-axled and 4-axled wagons as estimated at the 5th workshop in November 2001. This percentage between 2 axled and 4 axled wagons has been combined with the number of wagons derived in the UIC statistics (which is illustrated in table 2.3 above.)

Table 2.13 illustrates the base hypotheses for wear using K-blocks, cast iron blocks, LL blocks and Sinter Blocks. As there are no values known on shoe and wheel wear using LL and Sinter blocks it is assumed that these are the same as for K-Blocks.

Table 2.13. Wear hypothesis.

Wear Hypothesis (K-Blocks)	
Avg shoes wear/1000 km in mm	0.168
Average life of shoes km ('000)	240
Maximum shoe wear (mm)	40
Avg wheel wear/1 000 km in mm	0.02
Maximum wheal wear in mm	25

Wear Hypothesis Cast Iron Shoes	
Average shoes wear/1000 km in mm	0.523
Average life of shoes km('000)	75
Maximum shoe wear (mm)	39
Avg wheel wear/1 000 km in mm	0.01
Maximum wheal wear in mm	25

Wear Hypothesis (Sinter-Blocks)	
Avg shoes wear/1000 km in mm	0.168
Average life of shoes km ('000)	240
Maximum shoe wear (mm)	40
Avg wheel wear/1 000 km in mm	0.02
Maximum wheal wear in mm	25

Wear Hypothesis (LL-Blocks)	
Average shoes wear/1 000 km in mm	0.168
Average life of shoes km ('000)	240
Maximum shoe wear (mm)	40
Avg wheel wear/1 000 km in mm	0.02
Maximum wheal wear in mm	25

The values used for K-Blocks and cast iron blocks were provided by SNCF in February 2003 and is base on experiments [ref. 52].

The LCC tool that was built for the analysis is totally flexible and dynamic. All input data can be altered and various hypotheses can be tested. The tool enables the user to specify the countries, which he desires to assess the LCC for. Furthermore, the model can easily estimate the LCC of retrofitting the wagons up to 30 years from the base year. The number of wagons currently used in the model is also easily overwritten to cope with a more detailed representation of the status and size of the fleet.

The LCC tool handles wagon disaggregation into 3 categories of mileage ('high' and 'low' as discussed before and 'medium', which is between these two) and age as seen in Table 2.14 below.

Table 2.14. Representation of wagon input page (in which Austria is taken as an example).

Austria						
Number of Wagons						
Res. age of wagons / Mileage	2 axled wagons			4 axled wagons		
	0	15	0	0	15	0
20		6,282			13,555	
40		1,149			1,733	
100		240			1,012	
Total			7670.4			16299.6

The discount rate of 1.5% is used, which is derived from the 3.5% discount rate for investments and appraisals of the UK treasury, which is in line with the European discount rate. As there is a tendency for project appraisals to be optimistic a risk premium is added to provide the full expected value of the base case. Hence, a 2% premium was added to offset and adjust undue optimism and hence uplift the project's net present value.

Summary of assumptions

The above paragraphs illustrate clearly that there is a range of different interpretations and assumptions, that may all affect the overall outcome of the LCC analysis. For the final analysis which forms the basis of this report, a series of assumptions were applied that reflect most of the discussions treated in the previous sections. These assumptions are summarised in the following table (table 2.15), which distinguishes UIC, UIP and UIRR fleets.

Table 2.15. Summary of assumptions.

	UIC	UIP	UIRR
Wagons to be retrofitted	440,000	150,000	10,000
% requiring wheel exchange	39%	0%	0%
Annual mileage	20,000	40,000	75,000

Assuming:

- ✓ Average shoe wear for cast iron blocks [mm/1000 km] = 0.523
- ✓ Average shoe wear for K-blocks [mm/1000 km] = 0.168
- ✓ Average shoe wear for LL-blocks [mm/1000km] = 0.168
- ✓ Wheel wear with cast iron blocks [mm/1000 km] = 0.01
- ✓ Wheel wear with K-blocks [mm/100 km] = 0.02
- ✓ Wheel wear with LL-blocks [mm/1000 km] = 0.02

Break even points

The analysis show that in principle there is a saving in maintenance cost (variable costs) for vehicles operated with K-blocks compared to vehicles operated with cast iron blocks. Under the present assumptions these savings arise only for annual mileage below 50,000 km. It is not possible to assess a realistic mileage at which the savings are sufficient to make up for the retrofitting investment.

Using the inputs as presented in the figures above, a sensitivity analysis was produced on the variable costs (brake change, wheel change, reprofiling) over the 15 years lifespan of a wagon for each for the examined brake retrofitting options. Keeping all other parameters constant, an analysis was carried out as a function of different parameters:

- ✓ The purchase price of the K-block,
- ✓ Average shoe wear per kilometre,
- ✓ Average wheel wear per kilometre.

The maintenance costs for cast iron and K-blocks break even at a K-block purchase price of around 60 Euro, which is far over the estimated price at a fully developed market.

The maintenance costs for K-blocks and cast iron blocks break even at an average shoe wear for K-blocks of more than 0.4 mm per 1000 km (the present assumption is that the shoe wear is 0.168 mm per 1000 km).

The maintenance costs for K-blocks and cast iron blocks break even at an average wheel wear of 0.034 mm per 1000 km (the present assumption is 0.02 mm per 1000km).

Since over 80% of the wagons across Europe cover an average of 20,000 km/year it is stipulated that for these there will be saving of 83 Euros (between the K-block and Cast Iron Block) per wagon over its lifespan, which amounts to a total of 43,700,000 across Europe. The approach of the precedent analysis is cautious since it assumes that the average wheel wear per km covered of composite blocks is twice as high as for cast iron blocks. This parameter justifies the apparent trend that suggests that when the annual mileage covered per wagon is over 40,000 km it is costlier to maintain the wagons with composite blocks.

LCC results
Running the LCC model with the above data produces the results presented in figure 2.14 below.

The LCC analysis estimates the Net Present Value (NPV) of the cost of retrofitting the wagons with new brakes assuming that 30 % of the wagons require a new relay valve and 70% do not. Additionally the costing includes the discounted cost of reprofilings needed and brake blocks changed. These consist of the fixed costs associated and the labour costs incurred.

Table 2.16. Average retrofitting cost per wagon (Euro).

	2 axled cars		**4 axled cars**	
	With wheel exchange	**Without wheel exchange**	**With wheel exchange**	**Without wheel exchange**
K-shoes for Bg wagon	6,017	3,812	9,993	5,471
K-shoes for Bgu wagon	6,678	4,473	11,110	6,700
Interchangeable LL-shoes	2,623	418	5,246	836

Table 2.16 shows the average retrofitting cost per wagon as used in the AEA Technology analysis given a 30-70 % split between wagons requiring a new relay valve and not. The analysis also assumes that 39% of the UIC wagons will require wheel replacement.

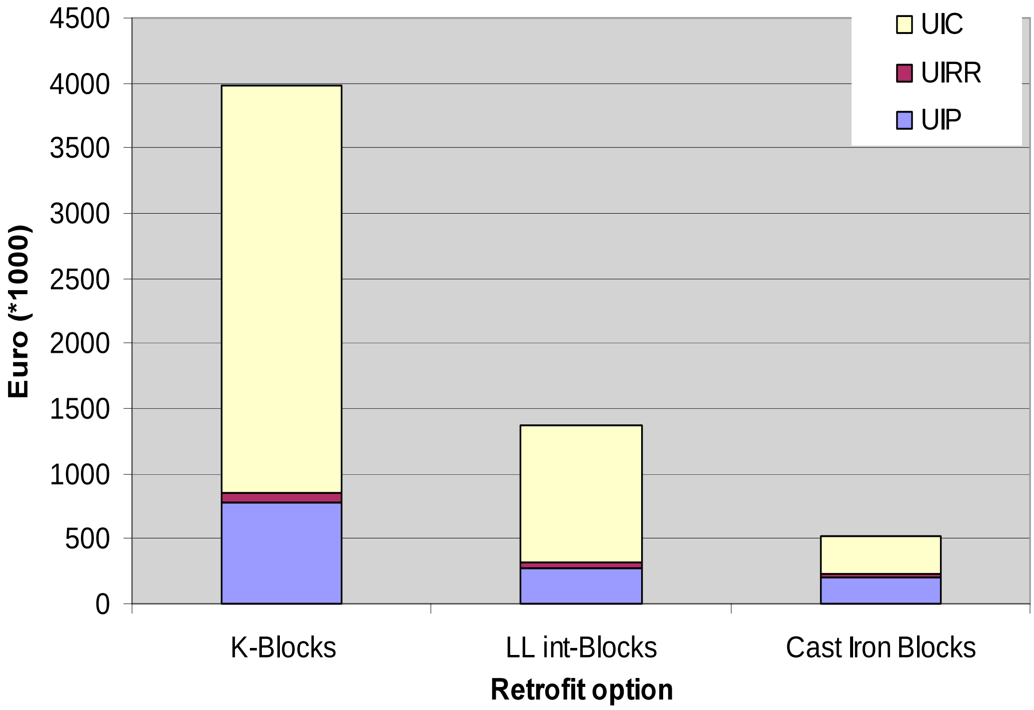

Figure 2.14. Total Life Cycle Costs (LCC) per retrofitting option (millions Euro) for the EU-railway-27 countries considering only the wagons that need retrofitting (i.e. 600.000)

Should the analysis have been made with the – optimistic – assumptions that no wagon would require wheel replacement, then the additional LCC for K-blocks would amount to 2.58 billion Euro (3.06 billion for K-blocks as opposed to 0.5 for cast iron).

As previously mentioned, the number of wagons to be retrofitted will be of the magnitude of 600,000 wagons, which suggests a scrapping of 27% of the total fleet across Europe which suggests a total Life Cycle Cost of the magnitude presented in figure 2.14 above.

The quality of the labour cost data might be considered an important element to the result of the analysis. In the presented AEA Technology analysis it is assumed that the labour costs are of Euro 41 per hour. This is an average value of the numbers that were presented by different sources. These assumed labour costs affect the level of investment required to retrofit the European wagon fleet. An hourly labour cost of Euro 41 for Europe is a reasonable estimate however one would expect this cost to be a lot lower in the Eastern European countries. As there is a 5 % labour cost difference between the Netherlands and Belgium[1], one could assume that between Western Europe (France, Germany, Italy) and Eastern Europe

[1] *Source: De Jong and Soete (1997), " Comparative productivity and structural change in Belgium and Dutch manufacturing", Research Memorandum No. GD-36, Groningen Growth and Development Centre.*

(Poland, Bulgaria, Romania) there is a cost difference of as much as 50 %. Previous comments about labour costs have been discussed earlier in the report.

The total LCC across Europe have been calculated using the proposed 41 Euros/hour cost and then conducted the same analysis using an estimated labour cost of 30 Euros/Hour which is probably a more realistic estimate of the average labour cost across Europe.

The difference in assuming a labour cost of 31 Euro across Europe is a LCC saving of 156 million Euro for K-Blocks.

2.2 Assessment Method and Data

2.2.1 Critical evaluation of sources

In the execution of the project, interviews have been taken from the following parties:

- ✓ Trenitalia, economic experts
- ✓ SNCF, technical expert
- ✓ SBB, policy expert
- ✓ DB Cargo, freight operator
- ✓ PKP Cargo, freight operator
- ✓ CP cargo, freight operator
- ✓ Railion Benelux, freight operator
- ✓ UIRR members (Hupac, Ökombi, Cemat, ÖBB), freight operators
- ✓ Nedtrain Consulting, engineering consultant
- ✓ EW&S, freight operator
- ✓ Freight Transport Association, operators association
- ✓ VTG, private wagon owner
- ✓ SAB/Wabco, brake manufacturer
- ✓ Trinity Rail, wagon manufacturer
- ✓ Knorr Bremse, brake manufacturer
- ✓ DG TREN, policy makers
- ✓ Freight Transport Association, association of operators
- ✓ EU working group Rail, policy makers

In general the sources can be evaluated as open and willing to provide information. The source base is considered sufficient for the purpose of the current study.

It should not be ignored that certain stakeholders have a certain interest in the outcome of the study. Clearly, some of the operators that were interviewed were not in favour of any interference with their business, particularly if it would lead to an operational cost increase. On the other hand, legislators tend to overestimate the urgency of the problem and tend to believe that the issue of this study should be treated basically according to the "polluter pays" principle. The responses to our questions may therefore be somewhat biased.

It was found that the process of homologating a single brake block make is lengthy and costly. It is in the interest of the end users that this process be looked into and simplified in order to establish healthy market relationships.

2.2.2 Critical evaluation of data

The UIC/UIP/CER Action Program has been evaluated by AEA Technology Rail on the basis of information and data that was provided both by the Action Program itself and by other sources. Existing knowledge and information from desk research was applied in the analysis.

The assessment demonstrated, that the basis of the UIC/UIP/CER Noise Action Program, i.e. retrofitting of the existing freight fleet, is an important step to make railways quieter. It is also a feasible step, as some of the technical solutions are available. The application of LL-blocks is certainly the better solution from the point of view of necessary investments. The ongoing efforts to achieve a homologation for LL-blocks should therefore be continued with great effort.

With respect to the expected life cycle costs, there is not sufficient experimental data upon which to base a full analysis. On the basis of first experimental results – which can be extrapolated – and common sense expectations, conclusions can be drawn.

There is a lack of reliable information with respect to the noise reduction that can be achieved with the application of various mitigation measures in practice. As this achievable reduction will be an essential element of any possible agreement between the wagon owners and the legislators, a clear common position should be achieved with respect to this point.

With respect to the retrofitting cost, the present market for K-blocks and LL-blocks is not developed, which may lead to an overestimate of the purchase costs for brake shoes. The purchase price for wheels, as well as the labour cost involved in replacing them, is very consistent and can be indicated with sufficient certainty. There is some uncertainty about the necessity to replace or modify other components, but the overall purchase price indicated by UIC is well within the range of the third party assessment. As these data are essential input for the overall LCC assessment, it is recommended to issue a formal invitation to tender to a range of qualified maintenance workshops throughout Europe in order to validate some of the estimates made in the present study.

2.3 Assessment, conclusions and open points

The third party assessment has indicated that the work carried out by the UIC Noise action Program can largely be confirmed. K-blocks represent an available alternative to cast iron brake blocks, particularly suitable for new wagons. For existing wagons K-blocks would be the preferred solution only if existing LL-blocks, that are presently in use, fail to make it to European wide homologation. For some specific partial fleets disc brakes may represent the best solution.

Smoother homologation procedures are needed to facilitate the transfer to use of composite brake blocks without creating a distorted market with only few brake block suppliers. It is the responsibility of UIC to ensure such improvement of procedures.

Both the number of existing wagons in Europe and the number of wagons to be retrofitted seem to have been overestimated. The investment costs for retrofitting can be assessed with sufficient detail and reliability, but the life cycle costs depend on wheel and block wear, which both depend very much on the type of operation. There is a lack of reliable data from practice to make exact and firm conclusions about Life Cycle Costs. An invitation to tender send to major workshops could be one way of achieving better information on some of the cost elements.

3 Scenarios for retrofitting

3.1 Framework and introduction for scenario building

The overall cost of a retrofitting program is principally dependent on the cost of retrofitting per wagon and the total number of wagons to be retrofitted. The former variable is influenced by the technology used and the timing of the retrofitting in relation to the normal cycle of maintenance. Both variables might change significantly over time.

The study has taken the results of the analysis described in chapter 2 above and developed them within different scenarios for an implementation program. This allows the evaluation of their relative cost profiles, which in turn facilitates decision processes relating to funding and time/cost trade offs. It provides information about the effects on stakeholders of the available options, which is important in securing commitment to the program at different levels, to ensure it success.

3.2 A flexible approach

From the technical and economical analyses reported in the previous chapters, it can be concluded that, for the purpose of retrofitting the existing fleet, the LL-block represents the preferred solution. It is difficult if not impossible to predict if and when the homologation of the LL-block can be achieved. On the other hand, the process of implementation needs to start in the short to medium term – it is assumed in the present study that the process should start in 2005.

As it is doubtful that the LL-block homologation will be finalised by then, it is conceivable to adopt a scenario in which the retrofit operation would start using K-blocks. As soon as homologated LL-blocks would become available, they could be applied, particularly in those parts of the freight fleet, where introduction of K-blocks leads to high investment cost (e.g. where tyred wheels need to be replaced if K-blocks are applied and do not need replacement when LL-blocks are applied; this is only hypothetical as it is not known yet under what conditions the LL-block can be used).

This approach is not further detailed in the following sections, but needs to be kept in mind as an economically preferred option.

3.3 Description of scenarios

Five implementation scenarios have been identified, some of which have variants within them. These scenarios are:

- ✓ Basic scenario
- ✓ Acoustic optimisation scenario
- ✓ Mileage optimisation scenario
- ✓ Logistics and cost optimisation scenario
- ✓ Accelerated schedule scenario

Basic scenario (0)

Within this scenario only K-blocks are considered. The possible implementation of LL-blocks has to be considered as soon as it is available and homologated.

It has been suggested by the UIC/UIP/CER Noise Action Program Steering Group, that the obvious implementation scenario would be to combine retrofitting with the large overhaul operation, which is part of the usual maintenance cycle of a freight vehicle. This large overhaul takes place typically every six years, although for wagons with low mileage longer periods may be applied. In general there is a tendency to extend this period; for tank wagons it has recently been extended to 12 years. The expectation is that retrofitting cost could be reduced if the retrofitting takes place in combination with this overhaul.

It has been suggested that the complete operation would take maximum 10 years when this scenario would be chosen. There are various reasons why the operation would take more than 6 years:

- ✓ The workshop capacity to carry out the work is limited.
- ✓ The frequency for large overhaul tends to get lower, so that sometimes the wagon is kept in service longer than the classical 6 years within overhaul,
- ✓ In terms of managing the project, a period of 6 years is not to be preferred, as most political decision making cycles are 4 or 5 years.

Retrofitting during normal maintenance is very cost efficient, because the wagon is in the workshop anyway. It is also assumed that in doing so, there is hardly any additional stand still time for the retrofit.

It is also assumed, that in addition to the normal maintenance revision cycle, every wagon that enters a workshop at least once more (SBB suggests that almost every wagon comes into its home workshop or some other workshop at least once additionally during the revision period) shall undergo the retrofit at that time. The retrofit shall take place whenever the wagon is in a workshop, which is used to the particular K-block. This will again reduce the additional wagon withdrawal time.

Also it is proposed that by especially planned actions every wagon or wagon type, which is out of service for traffic reasons for a certain amount of time, will be retrofitted in batches. Such wagons, which are then parked in well-known collection sites, can be transported to the main workshops without large additional cost and for the operator there are no withdrawal cost at all. A short consideration of the actual location of the wagons would be very helpful.

Acoustic optimisation scenarios (A)

European scale (A1)

The large number of freight wagons that need to be retrofitted in Europe to reduce noise emission pose a problem both in financial terms and in terms of the late effect. More than 80% of the fleet needs to be retrofitted before the average noise level will go down noticeably (see also figure A2.2). This is a conclusion based on random selection of wagons to be retrofitted.

If however, priorities are set to select particular wagons, especially those with most axles, long remaining lifetime and high mileage, the effect may be noticeable sooner. At the same time, noise charging can be introduced as a minor additional cost per axle per kilometre, which will provide an automatic economic mechanism to encourage the use of quieter rolling stock.

A priority scoring system to schedule retrofitting or replacement could be based on:

- ✓ number of axles
- ✓ number of kilometres run each year
- ✓ expected remaining life in years

A simple calculation exercise should be performed to illustrate how much earlier audible noise reduction would be achievable by applying the priority principle on some example lines. To do this in a meaningful way, some data is required on remaining vehicle life and mileage per year, and numbers of vehicles used on particular routes.

Annoyance scale (A2)

In this scenario, the objective is to achieve a reduction of noise annoyance in the shortest period of time in Europe. This can be achieved by combining the population density along the major freight links with the traffic density on those links, thus identifying major noise annoyance links in Europe. Then the freight traffic on that link should be identified - particularly with respect to trainload traffic carried out in shuttles – and these should then be retrofitted with priority.

The principal difficulty with this option is that patterns of wagon operation are not fixed, so even were the wagons operating on these noise annoyance links in Europe identified, the wagons, there is no guarantee that these same wagons will in the future continue servicing the same identified freight links.

Hence, for this retrofitting scenario to be effective a tight control system must be in place, ensuring that the same wagons always run on the same segments of routes. This is unrealistic and therefore also renders this option unrealistic.

Mitigation cost scale (A3)

In this scenario, a crude survey is made of situations in Europe where either urban development plans or infrastructure extensions would cause a need for noise mitigation measures such as noise barriers or façade insulation. When the traffic on such lines would be reduced in noise production, one might be able to avoid high cost for such "secondary" measures. The challenge here would be to identify the trains and wagons on these lines and treat these with priority.

Mileage optimisation scenarios (M)

The simple and straightforward approach here is to treat wagons with high mileage first. There are two alternative options, which reflect this scenario, i.e.

- ✓M1: European (EU-railways-27) scale: treat the wagons first which run the largest annual mileage in Europe,
- ✓M2: national scale: every country starts with the retrofit, treating those wagons first that run the largest annual mileage in the particular fleet.

Treating the wagons, which run the largest annual mileage in Europe, should be the preferred scenario given that a certain country's wagon fleet is all constituted of high mileage wagons. This is the case because if the retrofitting occurs on a country basis these countries that run high mileage wagons will be retrofitted after low(er) mileage wagons are retrofitted in other countries.

The implementation of scenario M1 requires a detailed analysis of the pan-European fleet and a tight control mechanism that specifies which wagons and in which countries should be retrofitted first. A technical limitation of this option occurs when many wagons requiring retrofitting are from the same fleet and need to be taken out of service and transported to a farther workshop then their usual service depot. Both the transport of the wagons and their withdrawal rent add large additional costs that need to be covered by the retrofitting costs.

The collection of data on the mileage profile per country and operator was not possible in this engagement and subsequently it's not possible to assess the cost of the mileage optimisation scenario. Also, the patterns to identify the wagons with the higher kilometres number in order to treat them as top priority or to accelerate the retrofitting procedure are unrealistic. In the first case, a wagon realising a great mileage on one year can really realise a very bad one on the n -1 year and vice versa.

Logistics and cost optimisation scenario (L)

Labour cost scale (L1)

In this scenario, a survey is made of the expected cost (mainly labour cost) for the retrofitting operation. This could be carried out on the basis of competitive tenders to be submitted by the workshops. These could be selected to be fit for the job first by means of a certification process. In this scenario, one would pick the workshops with the lowest price quotation first, and treat the wagons first that are maintained in these workshops anyway. Then one would direct the wagons to these workshops, which show the lowest distance and transportation costs for transport to these selected workshops.

Single optimised logistics scenario (L2)

In this scenario, the complete job is subcontracted to a consortium of certified workshops under one co-ordinating party. The railway stakeholders will then organise the logistics of wagon transport in the most economic way. Some wagon owners, organised in a project management team, could for instance for some wagon types supply substitute wagons during the retrofit in order to avoid costs for wagon withdrawal.

Accelerated schedule scenario (Q)

In this scenario, the objective is to achieve retrofitting of the total EU-railway-27 fleet in the shortest possible period of time, maybe with the exception of some vehicles with very low mileage. Probably the workshop capacity will then represent the limiting factor, but if the price is right this could be easily solved, because the specific expertise for retrofitting a freight wagon could be easily transferred to newcomers. Therefore, this scenario is split into two options:

- ✓ acceleration to 3 years total time
- ✓ acceleration to minimum time within the available capacity

3.3.1 Economic and technical consequences for each option

Basic scenario

This option has the best economic results because it is the least disruptive of the options to the current pattern of working. Therefore costs for all parties concerned are minimised, including out of use costs, additional haulage, and administration. There will still be significant additional costs, as the program itself costs over 3 billion euro with an average annual cost of 600m euro. This covers the cost of materials and labour. The burden falls in proportion to the numbers of wagons, so for instance, the heaviest economic effect is in Germany, France and Poland, which have the largest fleets.

Technically, this option is also relatively simple, as all wagons carry on with their maintenance regime. The Consortium has established that all the relevant depots that perform this maintenance are equipped and skilled for the additional work. However, the new type of brake blocks would need to be stocked.

Acoustic optimisation scenario

As with all the options that involve the selection of particular wagons and their retrofitting outside the normal maintenance cycle, the economic effects on the owner and operator are negative, (before compensation). The system also has increased unproductive train running, with transfers of funds to cover infrastructure costs. Operationally, it could also be a problem to shunt out and collect wagons scattered around the system.

The acoustic optimisation option has been discounted because there is no regular pattern of operations that would permit the reliable selection of relevant wagons.

Mileage optimisation scenario

This option is also has the characteristics described above: although it may be possible to identify certain wagons in regular use and with high mileage, many will vary, i.e. high mileage in one year may be compensated by low mileage in another. The economic effects will be particularly increased as these wagons, being productive, will have the most significant out of use and contractual losses if withdrawn out of the usual pattern to effect retrofitting.

Logistics and cost optimisation scenario

Under either of the two variants within this scenario, there is a potential economic benefit from achieving minimal unit costs for the labour part of the retrofitting program. This can only be determined through more detailed examination of the specific costs of specific depots not yet available, or through the competitive process described. In any case the savings over the expected average costs of the existing operation would need to offset the additional costs of haulage and infrastructure costs to get wagons to different depots. And as in other cases, there will also be costs for additional time. This last factor will vary with the number of depots selected.

Accelerated schedule scenario

The benefits of reducing the noise levels early through an accelerated retrofitting program would introduce additional cost for the extra movements to the depots, extra time out of use and any associated penalties, inefficiencies in that the job would be out of sync with the rest of the maintenance work thus losing the joint benefits.

SBB suggests that the accelerated schedule scenario would be advantageous when the execution would follow by a new, especially trained work shop, and then control and certification by a responsible main workshop or a railway expert (in accordance with the procedure in some countries). The certification will follow in the usual way.

However, the UIP comments that to accelerate the procedure should be a mistake economically speaking because:

- ✓ It could saturate some railways junctions, where the chosen workshops are situated.
- ✓ Could annoy the customers to whose the wagons have been removed.
- ✓ And could generate on top of that penalties to the users credit.

3.3.2 Description of logistics for practical retrofitting exercise

The practicability of the above scenarios is strongly dependent on the logistics. In the following table, the advantages and disadvantages of the different scenarios in terms of logistics are indicated qualitatively.

Table 3.1. Advantages and disadvantages of the different scenarios in terms of logistics.

Scenario	Description	Advantages	Disadvantages
0	Basic scenario: combination with overhaul	No specific logistics, other than usual for regular overhaul	May cause supply problems for replacing blocks
A1	Acoustic scenario, EU scale		Wagons are difficult to identify and may change from year to year
A2	Acoustic scenario, annoyance scale		Wagons are even more difficult to identify
A3	Acoustic scenario, Mitigation cost scale		Wagons are even more difficult to identify
M1	Mileage scenario, EU scale	Coincides with the basic scenario in a curative maintenance view	High mileage wagons are asked for, and therefore difficult to withdraw
M2	Mileage scenario, national scale	Coincides with the basic scenario in a curative maintenance view	High mileage wagons are asked for, and therefore difficult to withdraw
L1	Logistics scenario, labour cost scale		Introduces high transfer cost, which would not make up for the labour cost saving

Table 3.1. Continued.

L2	Logistics scenario, single workshop	Would allow easy project management and progress assessment	Introduces high transfer cost, which would not make up for the labour cost saving
Q1	Accelerated schedule, 3 years		Introduces additional transfer cost
Q2	Accelerated schedule, less than 3 years		Not feasible

3.3.3 Managing of the retrofitting-program

It is expected that, if additional funding can be acquired, the party supplying this funding will request some control on the progress of the retrofitting operation. Two basic options are possible:

- ✓ An *autonomous* process, where every vehicle owner is responsible for the realisation of the retrofitting program of his own fleet. The funding could be subject to certain conditions with respect to time and result of the retrofitting, e.g. if the retrofit is carried out after a certain date in future, no funding is available. The control desired by the funding party could be provided by e.g. independent audits, identifying complete lists of retrofitted wagons in the period and country under concern.

Figure 3.1. Freight wagons equipped with K-blocks with indication on the side of the car.

For freight wagons equipped with K-blocks, there is a particular indication on the side of the car (figure 3.1). This indication can be used to recognise what percentage of wagons has been treated. This would allow monitoring of the progress of the operation by independent monitors. Even more sophisticated could be to introduce an electronic tag in wagons which have been retrofitted, so that they can be recognised by track mounted monitoring systems, e.g. for noise dependent track access charges.

- ✓ A *centralised* process, e.g. by the railway associations, deciding on the priorities and timing of the process. This approach would allow priority setting between fleets and between countries, e.g. allowing former Eastern European operators to make the retrofitting later, when LL-blocks might be available. It would also allow a re-allocation of state aid funding between "rich" and "poor" countries. This option has the advantage of scale (lower price for workshops) and logistics (e.g. transport cost and withdrawal cost optimisation) and allows easy control by means of periodic reports. In this option the monitoring instruments suggested above could be omitted, unless of course they would be required for other purposes such as variable track access charging.

The above two scenarios are extremes, where a combination of the two is likely to be selected.

The work on scenarios for implementation of the retrofitting program is based on choosing a small number of realistic options, analysing their characteristics and feasibility, and presenting them for further discussion.

The number of wagons assumed to require retrofitting at day 1 is 450,000 (as defined earlier in paragraph 2.1.2), as per the analysis previously described. However, the longer the program takes to complete, the smaller the number of wagons actually required to be retrofitted, because the older ones will reach ages where they are scrapped or are not worth doing.

The principal variables in selecting the options are:

- ✓ number of depots to be used,
- ✓ timescale for the program.

The central option is based on a program lasting 10 years, as a maximum allowing the large overhaul for all wagons, which is typically at six years. This is the normal periodicity of major wagon overhauls and so is the 'least disruptive' time scale. To take longer would be of little benefit, as it would just miss the opportunity to do the work. To do it more quickly would reduce noise more quickly, but force wagons out of normal maintenance cycles. Three years were selected as a working example for comparison purposes. It is not considered feasible to do the work more quickly than this.

The number of depots is more complicated. It is not yet know which depots are currently equipped to do this work, or what it would cost to equip them. Selecting a limited number of depots to do the work would be of benefit in ensuring good quality, efficient throughput for lower costs and better management control. It would reduce set up costs if there were a need for training or for new equipment. However, the wagons will need to be able to be maintained in the usual depots thereafter, so those depots will need to be equipped to replace the composite brake blocks. Also using limited depots will increase the distances wagons travel to the retrofit locations, and take them off their usual pattern, incurring higher costs for downtime and access charges.

The retrofitting will absorb some of the depot's capacity. Assuming a capacity which is capable of treating 825,000 existing wagons (each using typically 15 days for large overhaul) the additional retrofitting for 450,000 wagons and one additional day in ten years time means an additional capacity of 0.4 %
The number of depots within any particular state needs to reflect its geography and the relative size and disposition of its wagon fleet.
It is assumed that the program could commence at the earliest in 2005 following the decision making process.

Management of implementation
Choices need to be made about how to manage the implementation strategy, under any of the implementation options. Experience suggests that a project of this scale, across many countries, would have the best chance of successful implementation, to time and to budget, with some form of unified control system, rather than just leaving it to happen under general management arrangements. Most probably a strong management will be required both on a national and on a European level.

One very straightforward approach would be to change the operators' leaflets that specify the maintenance work at large overhaul, so that it would no longer be feasible to overhaul any wagon without modifying its brakes at the same time.

Aspects of further consideration with respect to the management approach would be to distinguish between the management required to prepare and kick-off the project and the day-to-day management during the execution phase. Also there would be a distinction between the strategic management level and the operational level.

Other elements for consideration would be:
- ✓ Establishing nominated liaison officers in each state to report progress on a periodic basis.
- ✓ Establishing a special international unit to oversee the project as a whole, issues relating to depots, wagon release and journeys, and troubleshooting other obstacles to delivery.
- ✓ Putting in place technical systems to monitor the fleet as the work proceeds, such as vehicle tagging.

The most important issue is the commitment of the relevant authorities to make the scheme work. Incentives such as described in the section on financing options below may help, as well as any specific powers vested in the unit to require compliance with the retrofitting program.

Evaluation of scenarios
On the basis of the information above, table 3.2 was created.

Table 3.2. Overview of the scenarios and their relation with deliverability, acceptability, timescale and cost.

	Deliverability	**Stakeholder Acceptability**	**Timescale for noise reduction**	**Cost-performance**
Basic Scenario	GOOD	GOOD	FAIR	GOOD
Acoustic optimisation scenario	POOR	POOR	GOOD	POOR
Cost mitigation scenario	POOR	POOR	FAIR	GOOD
Mileage optimisation scenario	POOR	POOR	FAIR	POOR
Logistics and cost optimisation scenario	FAIR	FAIR	FAIR	FAIR
Accelerated schedule scenario	POOR	POOR	GOOD	POOR

Deliverability is a measure of the Consortium's confidence that a scenario can be made to work in real life conditions.

Stakeholder acceptability is an assessment of the extent to which the parties needing to cooperate would actually be willing to do so.
Timescale is based on a central value of the basic scenario taking 6-10 years. "Poor" means a longer timescale and "Good" a shorter one.

3.4 Recommendation by the Consortium and AEA Technology

The Consortium and AEA Technology strongly recommend the adoption of the basic scenario. This is because it combines the virtues of the lowest cost, simplest logistics and minimum disruption to the business of railway stakeholders and their customers. It is therefore likely to be the solution, which commands the widest level of industry support, which is vital for successful implementation. The only drawback is that the program will take over six years from commencement, and will therefore be completed only in 2011or later. However, the Consortium and AEA Technology concur that the risks to the program from pursuing a faster implementation are too great.

The number of running wagons has indeed considerably decreased during these last years and the working wagons are intensively used by the customers. To pick them out of the service just for a brakes change's operation would create working problems, dissatisfaction by users and a workshops' glut really unacceptable for all the market's actors.

The overall LCC of a Europe wide retrofitting operation depend very strongly on the timing. First of all on the start of the retrofitting operation, because the starting point will be decisive for the remaining cast iron braked wagons that have to be treated. Second, the speed at which the overall noise reduction has to be achieved is a decisive factor. With the present pace of wagon replacement, the whole operation could take place without retrofitting at all and would not take longer than 30 years to complete. Maximum cost would be incurred where the operation had to be finished in such a short period of time that dedicated workshop capacity and substantial wagon withdrawal cost would arise.

Finally, the management of such a complex and huge exercise should not be neglected. There is a need to establish means for monitoring and controlling the exercise centrally even though the exercise is taking place all over Europe. The consortium recommends that an implementation plan with elements like tagging of vehicles, auditing of workshops, and establishment of reporting procedures should be elaborated as a part of the preparations for the actual retrofitting.

4 Funding Mechanisms for retrofitting

4.1 Introduction to funding mechanisms for retrofitting

The options for retrofitting show required funding of up to € 3.4 billion Euro (estimated for K-blocks and 650,000 wagons to be retrofitted, with a required wheel exchange at retrofit for a large part of the wagons) spread across a timescale of several (6-10 in the central option) years and across 27 countries. This is a large amount of money even when viewed against the timescale and geographical cover. To deliver a credible program there needs to be clarity about the most appropriate sources and routing of funds for the scheme. Even before that, it is necessary to assess whether there are better value for money means of achieving the same objectives.

This chapter of the report therefore begins by addressing the value for money trade-off between the mitigation schemes – particularly relating to noise barriers, that are the main alternative to source based measures such as the retrofitting program. The significance of this comparison is in relation to the relative expense and effectiveness of these technical options, and how it relates to decision making on funding.

The chapter then examines the financial flows and incentives on the parties involved in the flow of funds through the industry, and the legal framework governing the application of funds for this kind of purpose, at EU and at national level, with particular reference to the significance of State Aid legislation.

It then identifies a range of approaches to the funding of the retrofitting program, the potential sources of funds and several specific funding 'instruments' to give practical effect to the program. It describes each of these instruments, how they would operate, evaluates them for economic, technical and organisational feasibility, and makes an overall comparative assessment.

4.1.1 Trade off: cost for mitigation measures (e.g. noise barriers)

Noise control can be very expensive. Particularly to mitigate noise from existing sources is known to be much more expensive than to control the noise production when designing new sources. Before determining to proceed with the retrofitting option, it is important to consider its value for money in comparison to the other options for noise reduction or mitigation that could be made available. This has been done within the work undertaken by the EU 5th Framework project STAIRRS. A cost scenario comparison was made based on a Europe wide extrapolation of different noise reduction options for all the main rail freight corridors. The principal relevant conclusions of that analysis are shown in the figure and the figure and box below:

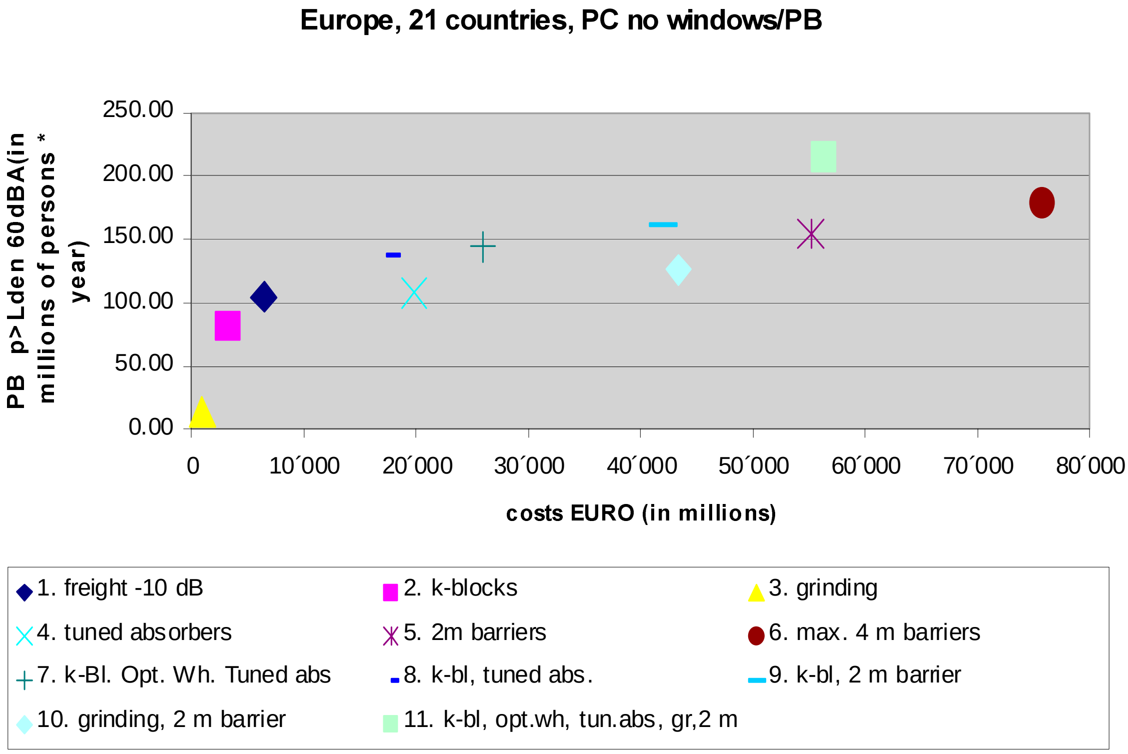

Figure 3.2.3a) from STAIRRS: discounted costs and effectiveness for the European area (21 countries). PC: present costs, PB: present benefits or effectiveness, PB L_{den} p>60 dB (A): effectiveness as reduction of number of persons above Lden of 60 dB(A), k-Bl: composite brake blocks, Opt. Wh.: optimised wheels, tun. abs.: tuned rail absorbers, gr: grinding, 2 m: 2 m noise barriers.

STAIRRS Conclusions [ref. 1, 3, 4]

- ✓ Freight rolling stock improvement has the best cost-effectiveness: with composite brake blocks, for about 5% of the cost of the option with the largest effectiveness, 38% of the effectiveness can be achieved.
- ✓ Noise barriers have low efficiency: noise barriers, especially if barriers up to 4 metres high are allowed, have low efficiency. Their effectiveness and efficiency can be improved, however, if K-blocks are added, because the total length of the noise barriers can be reduced.
- ✓ Track measures in combination with rolling stock measures are highly effective: Combining rolling stock improvement with track measures decreases costs while retaining the same effectiveness. Similarly the effectiveness can be increased and the costs decreased if K-blocks are added to a scenario consisting only of tuned rail absorbers.
- ✓ Costs for insulated windows are very high. Insulating windows for people with high exposure to rail noise would cost 4 to 5 times the cost of the freight rolling stock solutions.
- ✓ These results are common in almost all the 21 countries tested within the STAIRRS project.

So, while there is a total cost of euro **€** 4 billion for the retrofitting program, this is much cheaper than achieving similar benefits by other means such as noise barriers, and works well with a combination of further measures that could augment the noise reduction program at future stages. Thus it provides the most sensible starting point from the ‘value for money’ perspective.

4.1.2 The benefits

As mentioned in chapter 1.2.2, in Europe approximately 10 million citizens are annoyed by railway noise (1996 figure). In the STAIRRS project, the mitigation scenarios that have been compared show different efficiency with respect to the benefits they can achieve in terms of reducing the number of annoyed citizens. Nevertheless, such an assessment can be made on the basis of the data collected in the STAIRRS project. The analysis covered 127 million citizens, with 8.5 million people annoyed, which is in the same order of magnitude as the 1996 figure. It should be emphasised that these data are rather crude and that results can only be indicative.

The barrier scenarios show high costs, combined with high reduction of annoyed people:

- ✓ Up to 2 m high barrier option: 5 million people no longer annoyed by railway noise, at 47 billion Euro investment cost, or 55 billion Net Present Value of the LCC,
- ✓ Up to 4 m high barrier option: 6 million people no longer annoyed by railway noise, at 59 billion Euro investment cost, or 77 billion Net Present Value of the LCC

These figures can be compared to the benefits of the K-block retrofitting option, in the STAIRRS assumptions:

- ✓ K-blocks: 2 million people no longer annoyed by railway noise, at 30 billion Euro investment cost, or 4 billion Euro Net Present Value of the LCC

The European working group on Health and Socio-Economic Aspects of noise recently issued a draft position paper on the "valuation" of noise reduction (21 March 2003). It was estimated in that paper, that the value of 1 dB reduction of environmental noise, expressed in Euro per affected person per year, could be estimated to be around 25 Euro. The net present value of the valuation of a reduction of typically 5 dB for 2 million people would be around 200 billion Euro.
From this qualitative observation it can be concluded that the benefit of the retrofitting in terms of value for money is good, both compared to the alternative solutions and in terms of valuated benefits.

4.1.3 Allocated budgets for noise reduction

Railway noise barriers are generally financed from public funds, and are installed in cases where a new railway line is planned or where an existing line is significantly upgraded. Only very few countries maintain a system of "cleaning up", where noise barriers are provided from public funds in the case of excessive noise from existing railway lines. It is particularly in these countries, such as Italy and the Netherlands, that the legislator is now realising that, as traffic continues to grow, future demand for more noise barriers will grow with it. In such circumstances a trade off should be made between public funding for noise barriers and private investments for retrofitting. The core problem here is that the funds for future noise control due to increased traffic often have not been budgeted; authorities would prefer not to spend those funds at all rather than spending it on even the most cost effective option.

Nevertheless, in some of the EU countries, budgets are available for noise barriers and window insulation in existing situations. Table 4.1 presents some indicative figures. Assuming that the budgets could be maintained at this level for the future, it appears that these budgets would be sufficient to cover all (e.g. in the Netherlands) or at least some (around 10%) of the retrofitting costs, it they were re-allocated for noise reduction at source.

Table 4.1. Indicative figures of budgets available for noise barriers.

	Annual amount available for noise reduction (Euro)	**Remark**
Denmark	€ 2 million	44 km barriers, still 2.6 to go
Germany	€ 10 million (5 years program)	Barriers and windows
Netherlands	€ 10 million	200 km barriers

4.1.4 Description of financial flows and incentives

Despite the above case for retrofitting as the most value for money option, there is no automatic economic incentive for wagon owners or train operators to fund wagon retrofitting. In most legislative structures, the infrastructure manager is held responsible for compliance with environmental legal restrictions. With respect to environmental noise, the infrastructure manager has at his disposal different tools to achieve this compliance:

- ✓ To install anti noise barriers or to provide window insulation
- ✓ To reduce the intensity of the traffic
- ✓ To shift trains from the night to the day time or to introduce other operational restrictions such as speeds limits,
- ✓ To influence the composition of the fleet such that more quiet trains replace the more noisy ones.

For the first instrument, the funding is found either from the government or through track access charges. Some form of stimulus is required to initiate action by wagon owners and this may be based on legislation or financial regulations. The figure below illustrates the so-called institutional triangle in railway operation and the financial flows involved.

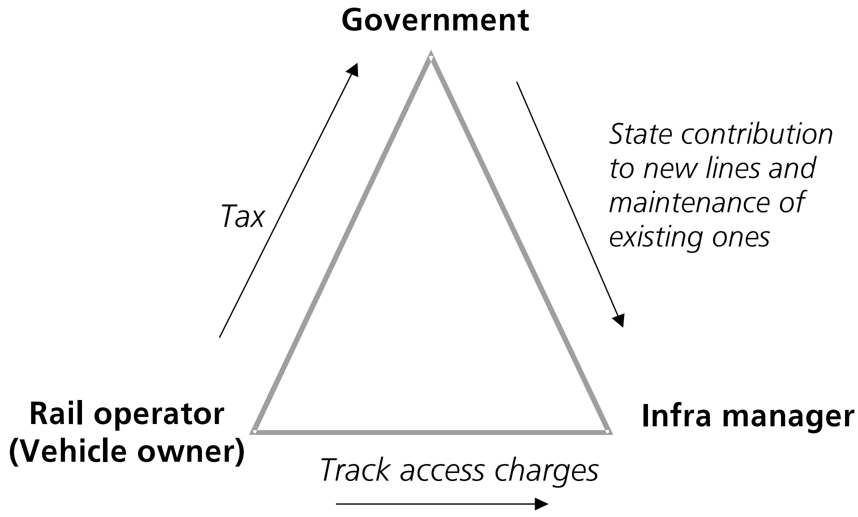

Figure 4.1. Institutional triangle in railway operation and the financial flows

It is through these financial flows that the infrastructure manager could in principle influence the behaviour of the rail operator, who, in his turn, could influence the vehicle owner if that is a different party.
The obvious way for the infrastructure manager to influence the operator would be through differential track access charges; track access charge differentiation is allowed for environmental reasons under the European legislation.

There are many stakeholders with financial interests in the use of freight wagons. These include the manufacturers, leasing companies, repairers, train operators, infrastructure companies, banks and other funders, suppliers of engineering materials and the freight customers. Sometimes, some of these may be the same person. The extent to which the retrofitting program would be reflected financially in the results of each of these depends on their specific contractual relationships, which may vary in different countries, and between individual companies.

There are both financial opportunities and risks for each of these parties in finding solutions to the problem of wagon noise.

Wagon manufacturers and leasers may benefit where procurers decide to renew rather than upgrade the existing vehicles, and potentially from reduced life cycle costs in some cases, but have risks from the early obsolescence of existing vehicles, and additional costs of retrofitting if not wholly borne elsewhere. Passing on all the cost may not be possible, with some needing to be absorbed. Wagon repairers will benefit from the additional work involved in the retrofit program, even if it is done within the normal cycle of heavy overhaul. They may lose work associated with older wagons withdrawn early from the fleet.

The suppliers of the brake blocks and, depending on the option chosen, other wagon parts and engineering materials, will gain increased custom. The focus on this project and the volume of materials required might, however, interest new competition, subject to homologation regimes (which might change). Infrastructure companies will benefit from the reduced track wear associated with the wheels fitted with non cast-iron blocks. The freight train operating companies might expect to share in some of the benefit of the long term cost reduction and potentially increased business as the mode capitalises on its environmental credentials.

Additional wagon costs in the short term, however, would result in a drag either on market share or profit. Society gains from the reduced environmental noise, the value of which it may be possible to quantify in economic terms, but pays for some of this from the public purse. As rail freight recovers from decline and becomes more economic, banks and other sources of capital may also see it as a more relevant and important sector for their services. They may have less positive views about its value if noise mitigation becomes a serious drag on profitability.

4.2 Current legal framework – National and Europe wide

Different legal considerations apply to different sources of funding for projects. In particular there is an important issue of whether schemes for funding would be caught by 'State Aid' legislation.

4.2.1 National

National subventions would face the issue of State Aid rules set out in Articles 87/88 of the Treaty and as amplified by secondary legislation and court rulings. State Aid is a form of state intervention used to promote a certain economic activity. It implies that certain economic sectors, regions or activities are treated more favourably than others. State aid thus distorts competition because it discriminates between companies that receive assistance and those that do not, and presents a threat to the running of the internal market. State Aid may also be aid not directly provided by the state but by other public or private sector bodies appointed by the state. In all circumstances, however, there must be a transfer of state resources.

However, it is accepted that there may be circumstances in which such aid may be justified. A system of notification is in place, which permits scrutiny and decision. The issue for the retrofitting program is whether, or under what circumstances, a funding route based wholly or partly on national subvention would fall within the State Aid rules. Key tests are whether the aid constitutes an economic advantage to the receiving company, is selective in its application, and has potential effect on competition and trade between member states. Much would probably depend on the uniformity of the approach taken by member states within a co-ordinated scheme.

The Commission's Guidelines for environmental aid (OJ C 72, 10.3.1994) discusses aid for investment in equipment to reduce or eliminate environmental pollution or protect the environment. In the case of aid that allows 'significantly higher levels of environmental protection to be attained than those required by mandatory standards', aid of up to 30% of eligible costs may be authorised. Where mandatory standards exist aid is limited to 15%. Also the aid has to be proportional to the improvement to the environment and to the investment needed to deliver the improvement. Discussion has taken place about support for a scheme to assist the adaptation of old rolling stock to meet and exceed TSI requirements. The scheme would need to be open to all, therefore non-discriminatory, and aid would be limited to 30%.

Examples of national approaches to noise abatement investment do exist, for instance in Switzerland and Germany. In Germany an abatement program started in 1999 and in addition to secondary measures rail grinding is applied. The Swiss example is examined in the box below.

The Swiss Model [ref. 1]

The current Swiss public funding for noise abatement program is the most advanced of all the programs implemented in many states in Europe. It covers the whole Swiss network and uses funding from heavy lorry taxes, fuel taxes and which gives priority to the retrofitting of vehicles and includes barriers and secondary measures like sound insulating windows.

In April 1987 a noise abatement ordinance was enacted to protect the population from different types of noise, with the main focus being on traffic noise including railway noise. Noise mapping is compulsory for all traffic networks. The noise maps are similar to the ones required by the EU noise Directive. Along the SBB lines the noise maps were completed in 1998. The aim of the noise ordinance is compliance with the given propagation and finally insulating buildings if the other measures do not have sufficient effects.

Between 1992 and 1995, noise maps were produced for a network of 3.000 km including more than 600 municipalities. The maps were based on a Geographical Information System (GIS) linked to a data bank and computer software that allowed the calculation of costs and benefits of different noise abatement programs.

Based on the above study, priority was given to rolling stock improvement. This program required all new passenger rolling stocks to be quipped with disk brakes and the retrofitting of all Swiss passenger vehicles and freight wagons in operation. Retrofitting is done by replacing current wheel sets with stress free wheels and composite brake blocks.

The cost for retrofitting is financed by the federal fund, which in turn is fed by fuel taxes, by a tax on heavy road vehicles as well as by general governmental funds. The Swiss electorate accepted this noise abatement program together with a general financing of public transport in a 1998 referendum. The cost for new rolling stock is financed by public transport in a 1998 referendum. The cost for new rolling stock is financed by normal railway budgets. Retrofitting Swiss rolling stock has started and will be completed in 2009. Noise barriers and window insulation will be complete in 2015.

4.2.2 Europe wide

At the European level there exist both public and private funding institutions. The public institutions such as EU may have powers to apply existing funds or possibly create new funding mechanisms to meet particular requirements such as the retrofitting program. The European Investment Bank, European Bank for Reconstruction and Development and other banks and financial institutions represent sources of capital for projects that can afford to pay a commercial interest premium (or at least where there is an agreement that this will be paid).

Centrally driven and administered funding initiatives do not face the State Aid problem, but there is the legal issue of identification or establishment of locus to provide public funds at this level for a particular purpose. Potentially this could require additional legislation.

EIB

The EIB provides loans for projects furthering EU policy at favourable conditions, and this option for funding the retrofitting program is discussed at 4.3.2 below. So far, the EIB has supplied 40 billion Euro for infrastructure projects in 2003. The funding is in the form of interest free loans.

EBRD

The European Bank for Reconstruction and Development provides loans aimed at projects, which help the transition of countries toward democracy. This is therefore probably less relevant in the context of this project.

ERDF

The European Regional Development Fund (ERDF) is one of the European Union's four Structural Funds. Its main aim is to promote economic and social cohesion in the European Union by working to reduce inequalities between regions or social groups. At the margin it could be possible to argue that poorer Member States should be able to apply for these funds to help finance their share of the retrofitting program. The ERDF and Cohesion Fund (the latter described in the next section) may be of relevance for the fleet of the accession countries, covering about 25% of the total EU-railway-27 fleet.

Cohesion Fund

Similar considerations apply to the Cohesion Fund. Alongside the four Structural Funds, the Cohesion Fund provides additional structural assistance to the four least developed Member States (Portugal, Spain, Greece and Ireland) by financing projects concerning the environment or transport infrastructure.
The Cohesion Fund provides money for environmental and trans-European transport network projects in the Member States of the Union whose GDP is less than 90% of the EU average.
The Fund was created by the Maastricht Treaty in 1993 and is intended to strengthen economic and social cohesion by helping the least prosperous states to participate in economic and monetary union. The Fund has enabled Spain, Portugal, Ireland and Greece to meet the convergence criteria for economic and monetary union and at the same time continue to invest in infrastructure to step up their development.

ISPA and PHARE [ref. 78]

IPSA (for Structural Policies for pre-Accession) and the PHARE program, which was established to finance applicant countries' administrative and legal systems and to develop their infrastructure, are also possible sources of funding for accession states.

4.3 Description of funding mechanisms for retrofitting exercise

The Consortium has identified and evaluated three broad approaches three sources of funds and eight specific potential funding instruments for the retrofitting scheme. They are not necessarily mutually exclusive.

The approaches are:

- ✓ Legislative restrictions forcing the industry to fund change
- ✓ Voluntary agreement between railways
- ✓ Incentivisation (on a national or EU wide basis)

Sources of funds are:

- ✓ EU/EIB
- ✓ Member States
- ✓ Rail sector

The potential funding instruments are:

- ✓ Scrapping scheme (including special fund)
- ✓ EIB loans
- ✓ Direct subsidy by EU or MS grants
- ✓ Track access charge rebate
- ✓ Transfer from other noise related funds
- ✓ Special taxation benefits
- ✓ Life cycle cost reduction
- ✓ Supply side funding

Legislative restrictions

The most straightforward approach would be to change the legislative structure so that from a certain moment in time it would no longer be allowed to run wagons with cast iron brake blocks. It would then be left to the wagon owners to decide whether to choose to retrofit existing wagons or to scrap them and purchase new wagons. The organisations involved in such an action would be:

- ✓ the AEIF, setting noise emission limits for existing wagons, to enter into force from a certain moment in time,
- ✓ the EC, DG TREN, requesting AEIF to propose these limits,
- ✓ the wagon owners, deciding on the necessary actions to take

The legislative approach, if used on its own, runs the risk that some wagon owners will decide to cease trading, because it would be unlikely that they can raise sufficient resources to carry out the necessary actions. Therefore, to sustain the transport strategy, the approach would require one or other form of subvention support, such as:

- ✓ investment subvention made available by national government, supporting a party that invests in environmental friendly assets (comparable to road vehicle catalyst exhaust device)
- ✓ Subvention made available either by EC or national government, for early depreciation and scrapping of vehicles that are no longer allowed (comparable to EC inland waterways regulation EC/718/1999 – see annex 4)
- ✓ Subvention for investment of retrofitting cost

(In the above description, "subvention" may include loans, grants, or tax deduction, e.g. VAT reduction for environmental friendly investment).

Voluntary agreement

Alternatively to strict regulation, a voluntary agreement could be considered. In this case, the AEIF would not be a major stakeholder. The voluntary agreement could be between the European Commission and the railway associations representing the wagon owners.

This approach to funding would require the associations to be willing to take a central role in organising the retrofitting operation, in justifying the expenditure and in distributing the resources. The major stakeholders would be:

- ✓ The European Commission,
- ✓ The railway associations, UIC, UIP and UIRR
- ✓ The wagon owners.
- ✓ The funding body (if not one of the above).

It is assumed in this option that the availability of a budget would be sufficient incentive for the wagon owners to carry out the retrofitting or scrapping operation. The associations are not capable of demanding that their members start a certain action, other then by common agreement.

Incentivisation

This approach to funding does not necessarily require legislative compulsion to scrap wagons, but puts in place both 'push' and 'pull' financial incentives that work in the market place to encourage the industry parties to do it themselves. Such incentives could, for instance, take the form of tax breaks for vehicles of different ages or noise characteristics, rebates on access charges working through the commercial agreements within the industry. A particular example of this approach in operation, from another part of industry, is the inland waterway regulation EC/718/1999 scheme. This scheme is outlined in Annex 4.

The incentives approach needs some form of budget. Were it to be completely self-financing, the pressures required to be put on the wagon owners and other parties would introduce a high risk of responses which would reduce the market, contrary to policy aspirations. However, if properly judged, this approach could minimise the financial burden on public funds.

The major stakeholders would be:

- ✓ The European Commission, proposing the incentives/scheme
- ✓ Member States, if administering the scheme

- ✓ The wagon owners, deciding how to respond

EU level loans/grants and a special fund for retrofitting

As discussed at 4.2.2 above, there are many funds in existence for regional, economic and environmental purposes at EU level. It is not clear that any of the funds currently available are suited for general application to the retrofitting program, although accession states may be able to apply for specific assistance. Therefore it has been suggested that some form of special fund be created, at EU level, but possibly administered by Member States, based on EIB funding. The loans or grants this would permit could be aligned with incentive schemes to ensure they procured retrofitting in the most effective and efficient manner. This is developed in section 4.3. 2 below.

Member State level subventions

Each of the Member States and the other countries involved in the retrofitting program could make funds available in relation to the wagons registered in their national territory. This would allow local conditions to be taken into account and relate to the transport and environmental policies and programs in each country. This would also avoid some of the difficulties of making a Community wide scheme and considerations of subsidiarity. However, different levels of priority given to the scheme and differing budgetary abilities could result in a patchwork effect for implementation when seen at the Community level.

Rail industry funding (including other private finance)

Given the requirement for large amounts of funds, private finance must be considered as one of the potential funding sources. Financial institutions already own many of the wagons, through involvement in the leasing market. A major benefit of this arrangement is in terms of cash flow. This is discussed at 4.3.6 below.

4.3.1 Scrapping scheme

Description of the instrument's basic characteristics

Scrapping, in this context, means the early removal from the total population of vehicles those, which are targeted for the purpose of reducing noise, so that they can no longer operate on the railway. Normally scrapping is decided on the basis of the age and condition of the wagon, as there is a balance between the cost of continued repairs and maintenance on the one hand, and investment in a new wagon on the other.

Also market conditions relating to the use of the wagon and any issues of obsolescence will influence the timing decision. A wagon removed on this basis will normally be sold for the value of the metal, possibly after the salvage of any useful materials. In this case the basis of the decision would perhaps be different, depending on which of the implementation options is selected, but to be useful in reducing noise there would in any case need to be a drawing forward in time of the wagons to be scrapped.

Early scrapping means fewer wagons to be retrofitted. The effect of the program in terms of numbers would be brought forward in time, and the numbers of wagons requiring physical retrofitting, and the associated cost of the retrofitting in the depots, would be reduced.

Operational use of the instrument

Preconditions

To be effective, a scrapping scheme would require the following preconditions to be met:

- ✓ An agreement between the partners of the actual size and characteristics of each wagon owners fleet
- ✓ Definition of scrapping conditions, such as type of wagons, parameters for scrapping, agreement on 'end of life' for scrapped vehicles, ratio of 'old for new', documentation etc.
- ✓ Definition of a broad plan of framework including the expected numbers of wagons and timescales of withdrawal
- ✓ Capacity to remove the vehicles to metal dealers or other places of interim storage, such as railway yards and sidings

Suggestions for concrete application

There are several different ways in which a scrapping scheme could be applied:

- ✓ Scrapping incentive of a fixed amount per wagon scrapped – or variations based on number of axles, age of wagon or other wagon characteristics.
- ✓ New for old arrangements, where there is a requirement to scrap an equivalent old wagon when the new wagon is introduced
- ✓ Penalties in lieu of scrapping, (may be a justified option in a rising market) to be used to help fund the scheme.
- ✓ Scrapping scheme based on quotas or targets from each administration
- ✓ Scrapping could be subject to loaning and/or subsidy arrangements

Evaluation of the instrument

Economic feasibility in a European context

- ✓ A scrapping scheme is likely to have a high level of economic feasibility because it can be calibrated to balance the desired rate of scrapping with the funding available to implement and administer the scheme. If linked to some form of compulsion, for instance limits to the use of noisy wagons from a specified date, and to fixed premia/penalties, a firm economic plan could be produced showing the economic effects on all the parties involved in moving toward the target reduction.

- ✓ The costs of the scheme may be spread over the timescale of the entire program. However, some funds would be needed to commence the scheme, and for its administration.
- ✓ It may be largely self-financing, depending on the specific conditions and rates imposed. At least a proportion of the costs would be borne by the industry itself, with public funding limited to the extent of, for instance, financing some of the interest on loans.

Technical feasibility (complexity)
The scrapping scheme option has a medium level of technical complexity:

- ✓ The approach has been used in other contexts already and worked, but this would be its first application for the rail context. There are a lot of wagons, widely dispersed.
- ✓ The wagons would need to be properly identified – which were to be scrapped, when and where, and which have been scrapped already. The technical processes for the collection of premia and the payment of any charges would need to be put in place, linked to the data on the fleet and the status of the wagons. So the IT would need to be capable of these processes in all the Member States.

Organisational feasibility in a European context (complexity)
The scrapping scheme option has a medium level of organisational complexity:

- ✓ A scrapping scheme could be set up to be administered by each Member State working within a framework set at Community level. Potentially this maximises the organisational feasibility through a combination of local administration and a common approach. The model used for the inland waterway scrapping scheme (see Annex 4) involved the Member States legislating to implement the scheme and create funds and administrative resources.
- ✓ The wagon scheme would be geographically more extensive, so there may also be merit in considering a more centralised option, to avoid organisational problems if some Member States were to find difficulty in legislating and funding the scheme.

4.3.2 European Investment Bank (EIB) loans

Description of the instrument's basic characteristics

The EIB is an autonomous body set up to finance capital investment programs furthering European integration by promoting EU policies. It raises on financial markets substantial volumes of funds, which it directs on very favourable terms towards the financing of capital projects. In 2002 it approved euro 43 billion in project finance. There is a particular emphasis on projects with strong environmental benefits as well as the furthering of economic and integration policy objectives. Therefore the wagon retrofit project could look toward EIB to provide part of the necessary funding.

Operational use of the instrument

Preconditions

- ✓ The eligibility criteria would need to be met for EIB projects. The size of this project would mean it would fall into the 'individual project' category.
- ✓ The project would be subject to the appraisal processes set out by the EIB. These include the provision of full information by applicants, including financial technical environmental and economic data, support from EU and relevant Member States, and benefits and risk assessment. The EIB also would monitor the project and undertake ex post evaluation.
- ✓ The co-funding limit is 50% of the costs.

Suggestions for concrete application

This instrument represents a source of funds, the transfer of which could be made operational through several channels. There are also different options for the details of how it could be applied:

- ✓ Loan to create a special wagon retrofitting fund, held centrally, or as funding for Member States to administer their part of the retrofitting program. In either case this could cover options such as the scrapping scheme described above, or other loan/grant regimes (e.g. per retrofitted wagon).
- ✓ The loans should run for the long term e.g. at least for 10 years, which is the length of the retrofit program
- ✓ There should be no interest or repayment within that period
- ✓ They should be guaranteed by Member States
- ✓ Loans could be made available at rates that allow wagon owners to retrofit wagons, and to offer reduced wagon hire prices, thus becoming even more competitive than wagon owners who do not take any action. This would provide a very positive incentive for the program.
- ✓ The loans eventually need to be repaid, but key variables are the timescale for repayment and the rate charged for the loan. Also the extent to which Member States would be passing all of this onward to the industry, or subsidising some of the cost themselves.

Evaluation of the instrument

Economic feasibility in a European context

This route to funding the program has a high level of economic feasibility because it fits within an established framework that has already been used to provide funding for a large range of Europe wide and nationally based projects of the large scale considered in this case. The inclusion of the accession states in this project is also not a problem, indeed much existing EIB funding is directed toward integration schemes for the accession states.

The loan nature of the instrument, with the inclusion of normal commercial terms (even though the rates may be very favourable compared to other sources) means that there is less of an issue relating to the provision and justification of subsidy. The funding cap means it is only part of the solution, so full economic feasibility relies also on other parts of the solution selected. It is likely that EIB funds would be available, subject to eligibility and project appraisal.

Technical feasibility (complexity)

The loan instrument of itself has a high level of technical feasibility, as it is both straightforward in principle and very flexible in its application to the project. It is also a practiced route. However the overall technical feasibility depends on the way in which the loan is used to deliver the program.
To secure the loan the following issues relating to the project need to be addressed fully to the satisfaction of EIB:

- ✓ Technical soundness
- ✓ Investment cost
- ✓ Implementation
- ✓ Operational risk
- ✓ Environmental impact
- ✓ Economic benefits
- ✓ Risk

In other words, there needs to be a fully developed investment case to demonstrate the viability, efficiency and value of the project.

Organisational feasibility in a European context (complexity)

The organisational feasibility of this instrument is high, as there is existing experience of procuring EIB loans at both EU and Member State level. The key risk areas relate to the long timescale of the project and the wide geographical spread, therefore linkages between the loan and the administration of the program to ensure efficient delivery across all Member States and the timescale of the project would need to be established, and appropriate monitoring arrangements put in place.

4.3.3 Subsidy through EU or Member State subvention

Description of the instrument's basic characteristics

This instrument is based on an approach that the EU centrally, or through funding via Member States, would make available direct subsidy to cover the cost of the retrofitting program. This could be in the form of a special fund to be administered according to agreed rules, with budgets based on the sizes of the fleets, rate of retrofitting, spread of financing over the period of the program, and delivery against predetermined targets etc.

Operational use of the instrument

Preconditions

- ✓ Agreement on the criteria for application of the subsidy, and the flow though from provider to receiver.
- ✓ Conformity with State Aid rules

Suggestions for concrete application

- ✓ Subsidy could be paid to the wagon operator on a per wagon retrofitted basis, calculated to pay for the additional costs of the work, any additional time out of use and additional movement cost, adjusted for life cycle cost changes. In practice this would need to be simpler, and a standard tariff developed to approximate the value.
- ✓ The subsidy could be for just a portion of the overall costs, if it is decided that the industry should absorb some of the cost of the program. A decision would need to be made about this split.
- ✓ Funding for the subsidies could come from redistribution from other noise mitigation programs, such as barriers, which have been shown to be less efficient than noise source-directed schemes.

Evaluation of the instrument

Economic feasibility in a European context

Direct subsidy has a low economic feasibility. This is because it places the burden on the public purse directly, and at national level there is a particular problem with State Aid rules to avoid distortion in competition. Despite this, there could be a place for some level of subsidy within the overall mix of funding. In terms of balancing budgets, there may be scope and justification to reassign existing funds where they exist relating to noise projects.

Technical and organisational feasibility (complexity)

Direct subsidy has a high technical and organisational feasibility. Arrangements would be needed to be made to establish and communicate the scheme, administer the subsidy payments and ensure they are fully auditable, and for the monitoring and reporting of the results. All of this should be similar to other subsidies.

4.3.4 Track access charge reduction

Description of the instrument's basic characteristics

This instrument is based on a reduction in the payments made by train operators to infrastructure providers for track access, in respect of any wagons that have been retrofitted with the non cast iron brake blocks. The regime of track access charges being implemented in Europe through the 'infrastructure package' legislation is based on the principle of short run marginal cost (of the use of the infrastructure) recovery, although other costs may be relevant in specific circumstances. The track charge reduction in this instrument would reflect the value of societal betterment from noise reduction, and act as an incentive for the train operator to run trains using retrofitted wagons.

Operational use of the instrument

<u>Preconditions</u>

This instrument would require:

- ✓ An agreed value for the benefit of retrofitting to be reduced from the charge, based on a simple metric (e.g. per axle/kilometre)
- ✓ A common approach to access charging on which to base the reduction, and sufficient headroom to allow its effective use.

<u>Suggestions for concrete application</u>

The Swiss model provides an example for concrete application. This incorporates a bonus directly related to the infrastructure charge. The train operating company estimates the axle kilometres to be operated the following year, based on the plan, and the rebate is calculated.

Evaluation of the instrument

<u>Economic feasibility in a European context</u>

This instrument would work best where there is a well-defined planning process and less scope for disagreement later because of deviations from the plan. It assumes that the train operating companies will exercise sufficient influence over the wagon owners to make retrofitting happen. The weakness is the chain from the source of funds through to the recipient, as railway management is increasingly disaggregated.

The instrument works where the access charge is sufficiently high to create a suitable margin. However, looked at from the system level, to the extent that the savings in cost of infrastructure maintenance are not reduced, there will also remain a funding gap, experienced initially by the infrastructure provider. Overall, therefore, from the incentive and funding issues, this instrument has a medium economic feasibility.

<u>Technical and organisational feasibility (complexity)</u>

The technical issues for this instrument relate to the different status of access charge development in different Member States and the accession countries. There is still a mix of different structures and charge levels existing across Europe. Therefore, for the immediate future, there would be difficulty in implementing a common approach and the same level of support through this route.

Regulatory concerns about the funding gap would also need to be addressed, (and any potential State Aid issues were a piecemeal approach to be taken by different Member States). Organising the rebate would not present insuperable difficulties, especially if the formulae adopted for calculation were to be kept simple, and suitable amendments made to the access and charging regimes already in place (or to be introduced where they do not yet exist). Overall, this instrument has a medium technical and organisational feasibility.

4.3.5 Call on existing noise reduction funds

Description of the instrument's basic characteristics

This instrument involves abstracting funds from the existing budgets for noise mitigation schemes to help fund the wagon retrofitting program.
In most European countries with established noise legislation, noise barriers and façade insulation represent the common mitigation measure for railway noise in excess of the applicable limits. Recently many studies have clearly demonstrated that this solution is the least cost effective solution from a macro economic point of view.

Noise barriers, especially those with large heights, are very costly, even in LCC terms, and represent a major visual intrusion. In the STAIRRS project, which was recently finished, it was clearly demonstrated on a European scale, that a combined approach of noise reduction at the vehicle and the track (e.g. combination of tuned rail absorbers and K-blocks) represents the most cost-efficient way to mitigate railway noise.

Operational use of the instrument

Preconditions

This instrument would require:

- ✓ Identification of the most cost effective transfer schemes (taking into account the characteristics of the routes, mix of traffic, investment amounts and conditions)
- ✓ Calculation of the revised overall benefits and the winners and losers from the revised approach
- ✓ Agreement with the sponsors of the original schemes and other interested parties

Suggestions for concrete application

Practical implementation of this instrument would involve:

- ✓ Each Member State to identify the best examples of barrier and other noise mitigation scheme that could be deferred or abandoned in favour of the wagon retrofit program.

- ✓ Criteria for the above assessment should include the relative costs and benefits of the change to the plan, against an assumed benefit from the retrofit program (to be agreed in each case). Legal or contractual obstacles would also need to be identified
- ✓ Selection of the schemes with the most favourable 'returns' from conversion to retrofit substitution, but ensuring a suitable distribution of the effects across different Member States.

Evaluation of the instrument

Economic feasibility in a European context

The economic feasibility of this instrument is high. It has the virtue that it is self-financing and provides overall net benefits for noise reduction, if suitable schemes are selected. However, disadvantages include the potential waste of sunk costs, and that at a micro level there will be winners and losers from the change of approach. This can only be evaluated on a case-by-case basis so would be somewhat laborious but, nevertheless, worthwhile if major savings and efficiencies can be obtained.

Technical and organisational feasibility (complexity)

Technically, the instrument is quite complex, and requires the deconstruction and comparison with a new option of all the previous work done to assess the relevant schemes. This information should be available within Member States railway engineering organisations (and from private contractors). What is then essential is an agreed common approach to assessment, which would have to be developed. This is overall a medium technical feasibility.

Organisational feasibility could be more difficult, as opposition may be anticipated from parties, such as the neighbours of the railway and their political representatives, at places where it would be proposed to substitute the barrier scheme with one which brings higher benefits overall, but not to them. This could in practice affect the priority of the schemes. This produces overall a medium organisational feasibility.

4.3.6 Other sources of funding

The Consortium has identified other funding sources. These are:

Special taxation breaks

Some of the industry parties have suggested special taxation, which would need to be effected at national level, but could be centrally promoted, to fund the retrofitting program. In the Swiss example there has been introduced a federal fund financed in part by taxes on fuel and on heavy road vehicles. This was acceptable in the particular context of Switzerland, and after a democratic process. It is less likely to be widely acceptable across all of Europe, and some countries are particularly resistant to additional taxation of this kind. However, instruments like tax exemptions (to suppress or reduce e.g. the income tax that is paid by operators or to allow accelerated depreciation) are well known, accepted and highly favoured by the wagon owners.

Supply side funding
The retrofitting program may introduce business opportunities for rail industry suppliers such as the manufacturers of the blocks and the owners of the depots at which the retrofitting would take place. Therefore it may be possible to involve them in the funding arrangement. Initial approaches have been made by the Consortium with a view to establishing levels of interest, and one wagon manufacturer has expressed tentative interest in involvement, although as yet there are no specific proposals. Of course any such proposals would have to sit within competition rules.

Life cycle cost reduction
It has been suggested that one result of the retrofitting operation, or one result of using modern wagons, could be to save life cycle cost. This could be achieved by reduction of wheel and block wear, or by a drastic increase in productivity of the wagons. Life cycle cost savings would then be used to become more competitive, to attract more customers or to return more to the shareholders.

However, as discussed in Chapter 2 of this study, it has been demonstrated that the level of life cycle cost reduction and higher profitability as such will not provide the incentive for the wagon owner to start retrofitting. Even were the assumptions to be varied to produce a higher estimate, complete reliance on the wagon owner to fund retrofit on the basis of future cost reduction is untenable. This is because profit margins are very low, so there are few resources available to invest at all, and the complexity of the contractual relationships between the different parties involved (fleet owners, freight operators) means the benefits of investment would not flow automatically to the wagon owner/investor. The owner in that case could find his investment places him at a competitive disadvantage. This lack of incentive could potentially be overcome through the funding mechanisms described in this section of the report (see 4.3.2) in particular through the application of loans.

4.3.7 Evaluation of funding options
On the basis of the information above, table 4.2 was created.

Overall the table indicates that the options with the highest individual potential for the funding of the retrofitting program are early scrapping schemes, EIB loans and consideration of transfers from within committed or planned budgets relating to other noise mitigation programs. Taken in combination, the top two become more powerful, and allied with push incentives (e.g. legislation on permitted noise levels) they could be sufficient to deliver the funding for the program.

The scrapping scheme could involve a mix of financial penalties for non-retrofitted wagons, financial incentives for those that have been retrofitted, thereby circulating money within the industry (possibly also via the taxation system) to encourage the most cost effective transformation of the fleet, and the spur of compulsion through legislation on which wagons can continue to be used after a certain date or in certain places/times.

Table 4.2. Overview of the funding options and their relative strengths and weaknesses.

	Organisational feasibility	Technical feasibility	Economic feasibility
Early scrapping	MEDIUM	MEDIUM	HIGH
EIB loan scheme	HIGH	HIGH	HIGH
Direct subsidy	HIGH	HIGH	MEDIUM
Track access charge reduction	MEDIUM	MEDIUM	MEDIUM
Call on existing noise reduction funds	MEDIUM	MEDIUM	HIGH
Taxation breaks	MEDIUM	MEDIUM	MEDIUM
Supply side funding	MEDIUM	MEDIUM	LOW
Life cycle cost reduction	MEDIUM	MEDIUM	LOW

Of the specific funding sources the least likely options are those that rely on the industry itself to finance the scheme. Without some form of external funding (even if it is in the form of a loan) there is simply not enough profit in the business to sustain the retrofit without reduced activity levels, which would go against transport policy. Timing is also key, given the requirement for large amounts of finance ahead of any benefit. However, it could still be possible to identify some contribution from net beneficiaries of the scheme.

National schemes have the disadvantage that they may all differ from each other and be introduced at different times in different ways and potentially with anti competitive issues. That would not promote a united approach. Also some countries, perhaps some accession states, would find it difficult to raise the finance. State Aid concerns would also need to be overcome, as they apply at this level.

Options linked to compulsion, such as an end date for the use of cast iron, could focus the parties to act, but would need to be backed by complementary funding to prevent a negative effect on business. These methods would be best if they linked performance in retrofitting directly to the receipt of the funds, rather than via indirect routes, such as track access charge reductions, through the relationships within the industry.

These factors all point toward the need for a central fund linked to an incentive framework, such as a scrapping scheme. This would allow disbursement to be in the form of loans as well as grants, so that some of the economic benefits, where they exist, can be clawed back to minimise the overall cost without destroying the basic incentives. As well as EIB co-funding, there is potential for the redirection of funds previously earmarked for barrier projects, as it has been demonstrated that retrofitting is a more efficient and flexible option.

The various additional sources of funds available to accession states should also be accessed where this is possible. It is almost certain that funding should come from a variety of sources for so expensive a project.

4.4 Recommendation by the Consortium and AEA Technology

The cost of retrofitting around 600,000 freight wagons is assumed to amount to up to € 2,5 billion spread across a timescale of 6-10 years and around 27 countries.

Market forces in the rail freight sector seem not to be able to match with this large amount of expenditure. As furthermore the objective of tripling rail traffic by 2020 should not be seriously endangered, financial funding of the retrofitting seems to be indispensable.

Without available sufficient funding a voluntary agreement between the stakeholder organisations and the EU seems to make no sense as the stakeholders will not obtain the support of their members. The need for funding also naturally exists in case of legislative noise restrictions.

There are different funding options for the retrofitting of in-use wagons. Among them a trade-off with a view to costly secondary noise abatement measures (construction measures: noise barriers and façade insulation) nationally planned in different volumes seems to be a promising option. This trade-off could be all the more justified as it is established that secondary construction measures are much less cost effective than noise reduction at source by retrofitting of the wagons.
In Germany, for example, it is estimated that the foreseen total costs of construction measures on the German rail network amounting to € 2 billion could be lowered to around 800 million by retrofitting of the in-use wagons.

Other options could also comprise Community and/or national funding programs, track access charge rebates, special taxation and scrapping schemes incorporating incentives.

As quite probably none of these options alone will present sufficient funding only aggregate funding options seem to be able to offer the necessary financial cover.

National funding schemes using the above-mentioned options will necessarily differ from each other and be introduced at different times in different ways. Therefore, there will be the risk of distortion of competition within the EU countries and in particular between established EU countries and application countries.

For this reason, funding recommendations and guidelines on an European level seem to be the only possibility to guarantee a timely, appropriate and balanced solution in order to achieve the necessary 85% retrofitting of all in-use wagons in Europe by 2011.

The Consortium and AEA Technology recommend that the following management arrangements be put in place, to give this large scale project the best chance of successful implementation to time and to budget:

- ✓ Nominated liaison officers in each state to report progress on a periodic basis.
- ✓ A special international unit to oversee the project as a whole, issues relating to depots, wagon release and journeys, and troubleshooting other obstacles to delivery.
- ✓ Technical systems to be put in place to monitor the fleet as the work proceeds, such as vehicle tagging, previously used re diesel locomotives.

The most important issue is that there is commitment among the relevant authorities to make the scheme work. Incentives such as described in the section on financing and funding options, below, may help, as well as any specific powers vested in the unit to require compliance with the retrofitting program.

5 Outlook

The present report is intended to serve as a basis for discussion between the legislators, in particular DG Energy and Transport, as well as national authorities on the one side and vehicle owners and operators, possibly represented by their associations, on the other.

The report provides the result of an independent third party assessment. Some elements of the analysis need validation and further precision. Important next steps would be:

- ✓ the further process of homologation of the LL-block
- ✓ extension of the variety of products that has international homologation, both in LL-blocks and K-blocks,
- ✓ assessment of the short term and long term noise production levels of a vehicle equipped with K-blocks, LL-blocks (both composite and sinter metal) and disc brakes, all along the same testing procedure (comparable to the NOEMI project for high speed trains),
- ✓ better and continued assessment of the long term wheel and block wear under different operation conditions for K- and LL-blocks

During 2003, the consortium has been discussing intensively the further development of the LL-block (as by UIC and the ERS project) in order to have a reliable alternative to the K-block for the retrofitting. In this context it would be possible to give, by mid 2004, a fair estimation of whether or not this solution would be available and usable by 2006/2007 (with a view to international homologation). If by then it is still not possible to determine, the entire development of the LL-block would have to be reconsidered.

The report provides a basis for discussion to reach an agreement on implementation scenarios and funding options. Once an agreement has been reached, further arrangements are required with respect to monitoring or progress and program management of the implementation.

The retrofitting program could start in 2005 and quiet rail freight traffic in Europe could be achieved by 2015.

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Annex 1. Definitions

Composition brake block
The term "composition" indicates that a mixture is used of any plastic material, which acts as a compound and a series of additives that determine the properties of the composition. Additives are often metals but other materials may also be used.

deciBel scale
The dB scale is the scale that is generally used to express both the intensity and the power of noise in. The dB scale refers to both noise reception and noise creation (see below). The dB scale is a logarithmic scale, which implies that dB values cannot be simply added arithmetically. 1 dB difference in noise reception level is about the smallest loudness difference that the human ear can detect, and that is when two signals are presented one shortly after the other. 10 dB is about the difference in noise reception level that is perceived as a doubling in loudness.

Equivalent noise level
The equivalent noise level represents the long-term average level, taking into account noise events and the pauses between them. Long-term average levels are by experience the best predictor for noise annoyance and therefore noise reception limits are usually expressed as long-term average. The long term stands for typically one year, but the time of the day is distinguished: think about the yearly average day-, evening and night period. Differences in long-term average levels are quite difficult to perceive. It is expected that the difference would need to be in the order to at least 5 dB for a person to be noticeable. For two passing trains – with sufficient intermediate time – the difference in average noise level during the passage needs to be in the order of 3 dB in order to be noticeable.

Europe
In the present report, different concepts of Europe are used.

- ✓ At present, the European Union consists of 15 member states: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, Netherlands, Portugal, Spain, Sweden, United Kingdom.
- ✓ EU 15+2 is the present European Union, completed with Switzerland and Norway.
- ✓ EU-Railway- 25 is the EU15+2, completed with the accession countries in as far as they are relevant to railways: Estonia, Hungary, Latvia, Lithuania, Poland, Czech Republic, Slovakia, Slovenia
- ✓ EU-Railway-27: EU-railway-25 plus Romania plus Bulgaria

Noise reception
Also known as noise "immission" in non-anglosaxon literature. Indicates the intensity of incident sound at a particular location, usually indicated as "the receiver". For legal limits, usually the noise reception outside the facade of a noise sensitive building (such as a private dwelling, a hospital, a school) is addressed. Legal limits for noise reception are set by national legislation. In future, setting these limits will remain the responsibility of national authorities.

Noise reception limits
Noise annoyance is best described and predicted by the long-term average (that is yearly average) noise reception level. This level is averaging over all noise events and all the pauses separating these events. The louder the events, the higher the average level. The fewer events, the lower the average level.
Noise annoyance during the daytime differs from that during evening or night. During the day excessive noise may cause general annoyance or interference with communication, during the night sleep may be disturbed. This difference is taken into account in the limit values, that are usually 10 dB more stringent during the night (typically between 23.00 and 7.00 hours) than during the day. In the harmonised indicator L_{den} that is to be used for applications of the Environmental Noise Directive, the penalty for evening and night time amounts to 5 and 10 dB respectively, is already included in the indicator and therefore does not need to be referred to in the limit value.

Noise reception levels and traffic intensity
As indicated above, the more noise events occur during a fixed period of time, the higher the resulting average noise reception level. A doubling of traffic intensity (twice as many vehicles with the same speed in the same period of time) results in a 3 dB increase of noise reception level. A trebling of traffic causes a 5 dB increase and tenfold as many traffic results in a 10 dB increase. Similarly, a reduction of noise creation level for each train by 5 dB would allow for a trebling of traffic without the noise reception level being increased!

Noise creation
Also know as noise "emission". Indicates the amount of sound energy radiated by a particular source or group of sources such as a train. The noise creation depends on the operating conditions of the source, such as its speed. Noise creation limits have been applied in the past by operating companies in specification and procurement of new rolling stock. Compliance checks with the noise creation limits is carried out through so-called type approval tests. In the Environmental Noise Directive the European Commission announces their intention to define noise creation limits for all noise sources including railway systems. In practice, the Commission has mandated the task of defining such limits to the AEIF (Association Européènne pour l'Interopérabilité Ferroviaire). Noise creation

limits will be linked to the TSI (technical specifications for the interoperability) as agreed by the AEIF.

Noise impact
The noise impact describes the effect that environmental noise has to citizens in general. These effects can comprise of general annoyance, but also more specific effects such as sleep disturbance, disturbance of communication, etc. occur. Such effects may deteriorate the general health of affected people. Annoyance effects are described in terms of dose-response relationships, where numerous field studies confirm that noise annoyance is best described using the long term average noise level (and not for instance the peak level of particular noise events such as a passing train) to predict the resulting noise annoyance. Different sources have different impact at similar average noise level; railway noise causes substantially less annoyance than road traffic noise at similar average noise level. The difference is often indicated as “rail bonus”. It may lead to noise *reception* limits for railway noise being up to 5 dB(A) higher than for road traffic.

Roughness
Roughness is the general term that describes the amplitude of the surface irregularities on wheel tread and railhead, which are responsible for rolling noise. Roughness amplitudes are typical in the order of 1 m to 1 mm and the wavelength of the irregularities (which often show a very periodic character) is roughly between 2 and 10 cm.

Trainload transport
In this type of transport, as opposed to wagonload transport, a complete train is composed of similar wagons carrying similar cargo. This type of transport is seen in coal and ore, automobile and chemicals transport. The operation involves fewer shunting than wagonload transport and therefore the average speed can be higher.

Tread braking
All forms of braking where the wheel running surface is part of the braking system. Usually a brake block or brake shoe is pressed against the wheel running surface where the kinetic energy is then transferred into heat.

Tyred wheels
Unlike solid wheels a tyred wheel is equipped with a circular wheel tyre, which is mounted around the wheel flange. The wheel tyre can be replaced without changing the flange. This is a method of saving material cost in wheel maintenance. For a solid wheel, when the tyre is worn, the complete wheel has to be replaced.

Wagonload transport

This is the type of rail transport where individual wagons carry a specific load. The wagon type may be adapted to the cargo. Trains are then composed of single wagons with different loads and different destinations. The wagonload transport operation involves regular decomposing and composing of trains (shunting), which affects the average speed.

Annex 2. Technical Aspects

A2.1 Freight traffic noise

Freight traffic is recognised as the dominant source of railway noise annoyance in Europe [ref. 1]. This is due to the fact that freight traffic is often taking place during the night period where noise reception limits(*) are stricter than during the day. The fact that freight traffic takes place during the night is caused by the long distance character of most of the rail freight transport and by the general priority that is given to passenger transport when infrastructure capacity becomes scarce. Another reason for freight traffic to be the predominant noise source is the fact that freight wagons are equipped with cast iron brake blocks, which render the wheel surface much more rough than braking systems used in most passenger service.

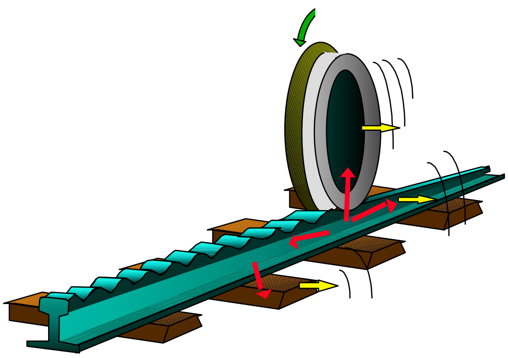


Figure A2.1. wheel and rail vibration

Freight trains typically run at maximum speeds of up to 100 or 120 km/h (in exceptional cases higher speeds of up to 200 km/h are allowed), but the average speed for a complete transport link is much lower. This is due to different control procedures at the interfaces, some of which are directly related to the tread braking system. At speeds between 50 km/h and 200 km/h rolling noise is the dominant generating mechanism. Rolling noise is generated by surface irregularities on the running surfaces of wheel tread and rail head. These surface irregularities are indicated by the general term “roughness”. The irregular wheel rolling on the irregular rail causes both wheel and rail to vibrate (figure A2.1) and the vibrating wheel and rail radiate noise into the surroundings. The cause of rail roughness is not completely understood yet, but rail roughness can be controlled by regular grinding. Wheel roughness is caused by the thermodynamic loads on the wheel that result from tread braking.

Very often the noise radiated by the wagon superstructure is indicated as one of the major noise sources for freight vehicles. This conclusion cannot be confirmed by measurements, e.g. using advanced directional microphone systems such as antennas. The impression is probably due to the fact that this judgement is based on observations at very low speed.

(*) *See Annex 1, Definitions (for clarification of specific terms such as noise reception)*

A2.2 Necessity of noise reduction

Noise is felt to be the weak point in the otherwise environmental friendly image of the railways. Railway transport is considered to be an essential element in the European Commissions future transport policy, which supports a modal shift from road and air to rail. The ERRAC strategic rail research agenda predicts, as an impact on the so-called Scenario 2020, a reduction of both emissions and perceived noise levels by up to 10 dB(A) in combination with the trebling of freight traffic and doubling of passenger traffic [ref. 2].

Traffic noise in general can be controlled at different levels, all with the objective to reduce or control the noise reception level.

- ✓ First of all the traffic flow can be controlled. Because the noise reception is described as a long term average (see Annex 1) a reduction of the number of vehicles passing per unit time will result in a reduction of the overall noise reception level. Obviously this contradicts with the political objectives to intensify the share of rail transport to the overall transport of freight in Europe. Large reductions in traffic flow are required to achieve a substantial noise reduction, e.g.
  - for an overall reduction of 3 dB(A) only 50% of the traffic can still be facilitated,
  - for an overall reduction of 5 dB(A) only 33% of the traffic can still be facilitated,
  - for an overall reduction of 10 dB(A) only 10% of the traffic can still be facilitated
  - Note: in the above observations it is assumed that trebling the amount of cargo transported means trebling the actual freight movements. This is a very conservative assumption, as higher utilisation would also facilitate higher transport amounts.
- ✓ Operational restrictions may reduce the resulting noise reception level. Conceivable operational restrictions are e.g. speed limits (resulting in lower noise creation), night time bans (provided that there is sufficient track capacity to facilitate the freight traffic during day time wherever necessary all along the route). It is clear that the operators feel very strongly against any operational restrictions, as they face many restrictions already today.
- ✓ Reduction of noise creation can be achieved by mitigation measures applied to the vehicle and/or the track.

The above observations illustrate the interrelationship between traffic flow and noise control. If a trebling of rail freight transport has to be facilitated (conforming to the objectives of the ERRAC), it means that an overall reduction of the noise creation levels by 5 dB(A) is required in order to maintain the noise reception at the present levels. If a larger noise reduction can be achieved, then there is more room for further growth in future, or else the reduction may be considered an environmental and societal improvement.

The European Commission has issued the Environmental Noise Directive (2002/49/EC) in June 2002. In this directive it is announced that noise creation limits will be set for railway vehicles and track. The task to define these limits is mandated to the AEIF (Association Européènne pour l'Interopérabilité Ferroviair). Limits for high-speed rolling stock have been defined and agreed. Limit values for conventional speed rolling stock have been proposed.

The draft TSI-CR-Noise of 31 July 2003 proposes the following limit values for wagons at 7.5 m from track centreline (very low roughness track).

The following section is quoted from the draft TSI:

The indicator for the pass-by noise is the A-weighted equivalent continuous sound pressure level $L_{pAeq,Tp}$ measured over the pass-by time at a distance of 7.5 m from centreline of track, 1.2 ± 0.2 m above top of rail. The measurements shall be made in accordance to prEN ISO 3095:2001 except that the reference track shall meet the requirements stated in Table 1.

Table 1. Limiting values $L_{pAeq,Tp}$ for the pass-by noise of freight wagons.

Wagons	$L_{pAeq,Tp}$
Wagons with an average number of axles per length (apl) up to 0.22 m^{-1} at 80 km/h	< = 83 dB(A)
Wagons with an average number of axles per length (apl) higher than 0.22 m^{-1} at 80 km/h	< = 85 dB(A)

Reference [ref. 6] presents pass-by noise levels for existing freight wagons at 80 km/h as 85 dB(A) in 25 metre distance from the track. This is identical to a level of 93 dB(A) in 7.5 metres distance. For existing cast iron braked wagons, a large survey was carried out by Müller-BBM in 1998, which led to the conclusion that the average pass-by level (average quality track) was between 89 and 93 dB(A). Compliance with the limits for conventional speed will only be feasible if cast iron tread brakes are avoided. Therefore, for new rolling stock in interoperable service, after implementation of the TSI for conventional speed, and assuming that the actual limits will be in the same order of magnitude as the proposed limits, the use of cast iron brake blocks will be rejected.

The above regulation, when it has come into force, will apply to new vehicles only and will be applied for homologation purposes, i.e. for vehicles that will be allowed to circulate in international traffic.

The introduction of this TSI will gradually result in an overall reduction of railway noise. Existing vehicles with high noise creation will be gradually replaced by new vehicles with low noise emission. Rail vehicles have very long life. 40 years is not unusual. The adjacent picture illustrates the reduction in overall railway noise when existing vehicles are replaced by new vehicles with a 10 dB lower noise creation level, assuming a linear replacement pace over 40 years.

Figure A2.2 illustrates that, in order to achieve a noticeable reduction within 10 to 15 years, it is not sufficient to wait for the autonomous replacement of existing vehicles. This is one of the main reasons why the action plan was proposed by the railway associations UIC/CER/UNIFE/UIP/UIRR.
Note: in the above figure, one may replace the years (0-40) by percentage of fleet treated (read "40 years" as 100%, 20 years as 50% and so on)

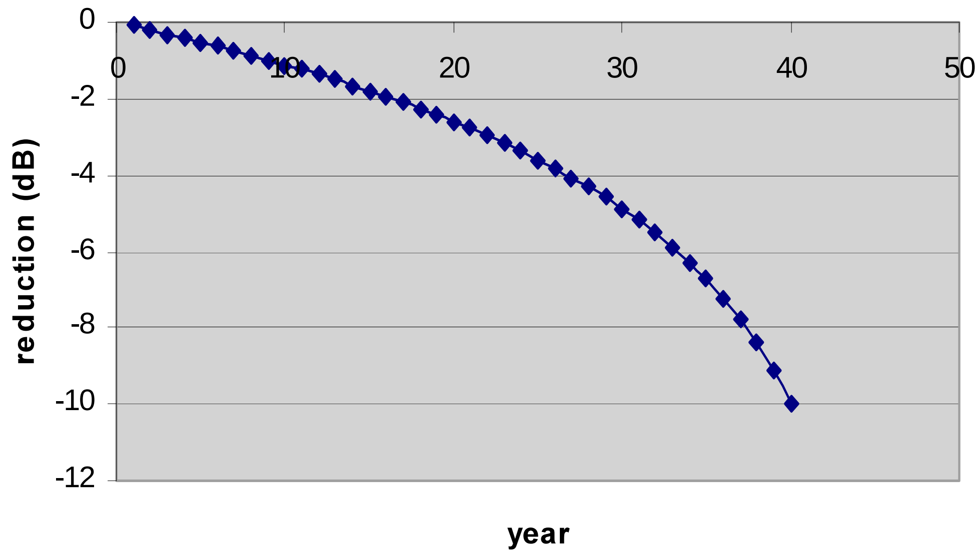


Figure A2.2. Overall noise reduction.

A2.3 Wheel tread roughness control vs. alternative options

A2.3.1 Direct control of roughness

As indicated in chapter 2.1 rolling noise is the dominant generating mechanism in rail freight transport noise. Rolling noise is caused by roughness. The most direct and straightforward way to reduce rolling noise is therefore to eliminate roughness. In the case of tread braked rolling stock and normally maintained track, the roughness of the wheel is dominant over the roughness of the track. Although the resulting noise is radiated both by the track and the wheel, the best way to reduce rolling noise in that case is to reduce the wheel roughness. Only in the case of disc braked rolling stock and normally maintained track, the roughness of wheel and rail are in the same order of magnitude, and noise reduction should best be attacked by reducing the rail roughness. This can be achieved by intensified maintenance of the track, often indicated as "acoustic grinding".

Wheel roughness can be reduced by choosing a different brake system than tread braking with cast iron brake blocks. Braking systems applied in railway transport are listed in table A2.1, with some remarks.

Table A2.1. Braking systems applied in railway transport.

Brake system		Comment
Tread braking, cast iron blocks	*Brakes acting on the wheel tread*	The most common system for existing freight vehicles. Very reliable, cheap and highly standardised.
Tread braking, composition brake blocks		Commonly used in some networks, mostly for passenger stock, exceptionally also for freight stock
Tread braking, sinter metal blocks		Used in some passenger stock, considered to be aggressive in terms of wheel wear, sometimes used as "scraping" block for better adhesion
Disc brake with additional tread brakes		Seen in some passenger stock, famous to lead to high wheel roughness
Disc brakes (disks can be mounted on the axle or on the wheel)	*Brakes not acting on the wheel tread*	High performance system when multiple disks are installed, commonly used in modern passenger stock on non-powered axles, sometimes also on powered axles. Rarely used in freight vehicles
Electro dynamic braking		Uses the electric engine to brake, using the motor as a generator. For locomotives and EMU's only
Mechanical (magnetic) rail braking		Not sufficient to replace other brake systems, as additional or emergency brake only, often seen in urban transport. Not applied in freight vehicles. It may cause damage to the rail
Foucault current rail braking		Similar

Concluding from the above table, the way to directly control wheel roughness in freight rolling stock is either to change from cast iron blocks to composition blocks, to sinter blocks or to disc brakes. These options will be considered below.

A2.3.2 Non-source related noise control

Railway noise is traditionally controlled by wayside mitigation measures, i.e. noise barriers. Noise barriers are quite efficient in the sense that they represent a substantial reduction (up to 15 dB) of the reception levels along the track. On the other hand noise barriers have obvious disadvantages:

- ✓ They are quite expensive (1000 Euro and more per m length for a barrier of only 1 m height above rail head),
- ✓ They have only local effect,
- ✓ They represent a visual intrusion, which is less and less accepted by the residents.

In the STAIRRS project [ref. 3] different options for noise reduction, both wayside, at the receiver and at source were compared in terms of their life cycle cost. It was clearly demonstrated, as it was in many previous studies, that to control noise reception by means of noise barriers only is by far the least efficient and most costly option.

Alternatively to noise barriers, façade insulation is a usual option. Double-glazing, soundproof ventilation and insulation of light weight façade panels can result in a lower noise reception level inside the house. It is not completely obvious that this will result in a lower annoyance (some studies claim that it will not) and it is also a very expensive solution with very restricted effect. Therefore noise reduction at source would have to be considered as the preferred option.

A2.3.3 Noise reduction at source

Other options for noise reduction at source have been investigated in the STAIRRS project in terms of their costs and benefits. A summary of the different measures, the expected noise reduction and some remarks with respect to their efficiency are presented in the following table. The expected reductions are order of magnitude, not exact values.

Table A2.2. Summary of the different measures and the expected noise reduction.

Noise mitigation measure	Expected reduction of noise creation	Comments
Acoustic track grinding	3 dB	No effect as long as wheels are rough, so no effect for conventional freight traffic, but a necessity to have the full effect of K-blocks. However, on normal well maintained track the effect of K-blocks could be almost complete.
Tuned rail absorbers	3 dB	Still in experimental phase, costs need to be reduced. Adverse effects need to be avoided
Wheel shape optimisation	1 dB	Heavier wheels are not an option for freight stock
Wheel dampers	1 dB	Elastomer material does not withstand high temperatures that are caused by tread braking. Can only be applied if tread braking is avoided Ring dampers without elastomer have small effect
Bogie shrouds	1 dB	Not effective as long as the track is not treated
Bogie shrouds and low trackside barriers	12 dB	Combination was demonstrated to be very effective, but only if sufficient overlap between shroud and barrier is guaranteed even with varying load. This is not a practicable condition in international traffic
Speed synchronisation (100 to 80)	2 dB	Could be an option near urban areas, but possible bottleneck effects on line capacity
Night time ban	5 to 10 dB	Depending on whether the shift is towards the evening or towards the day. Highly criticised because of the drastic effects for international long distance transport

The conclusion from the above table is that a change of brake blocks represents the most efficient way to reduce rolling noise at source. It is therefore the preferred option.

The EC working group Railway Noise, in it's position paper, indicates – among others - the following priority instruments for railway noise reduction:

- ✓ "Noise emission limits for new interoperable vehicles,
- ✓ The retrofitting of the existing cast iron block braked freight wagons
- ✓ Incentives for the use of low noise vehicles
- ✓ Normal maintenance grinding programs should take noise emissions into consideration"

A2.4 Behaviour of different brake block types

Freight wagons in Europe are mostly equipped with cast iron brake blocks. This material has been applied for tread braking for a very long time, and this was never changed because the resulting brake system is very reliable and has low costs. There is a high degree of standardisation, because the wagons have to circulate in international traffic and maintenance must be quick, reliable and straightforward. Cast iron blocks are available with different material properties, depending on the amount of additives (such as phosphor), but the general behaviour is quite typical: the friction factor of cast iron varies with speed and tends to increase with reducing speed (figure A2.3). This results in a braking behaviour that makes it more "easy" to stop the train because the "grip" increases when the speed is reduced.

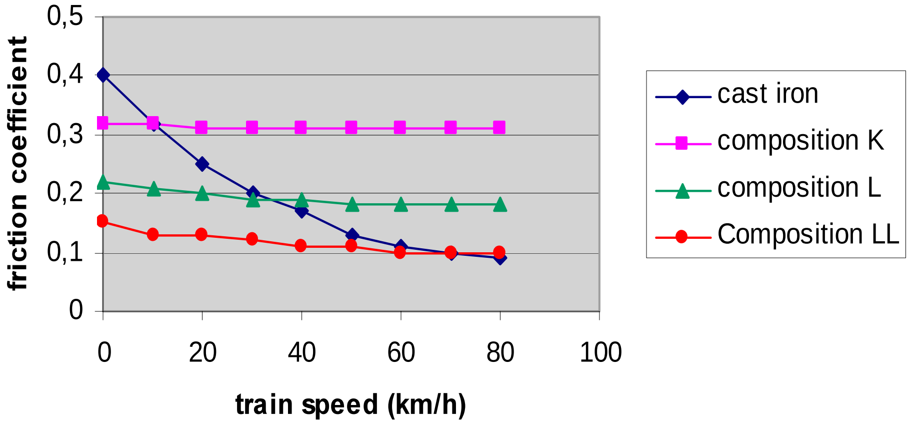


Figure A2.3. Typical friction coefficient for different types of brake blocks.

The brake behaviour for composition brake blocks is quite different; the material shows substantially higher friction coefficient, which does not or hardly change with speed. This could cause longitudinal stability problems when wagons with composition blocks and wagons with cast iron blocks would be mixed in the same train. There would be certain speeds where the composition blocks would have to provide the full braking power to stop the whole train, at other speeds it would be the cast iron blocks taking the full load. This would cause the wagons to move longitudinally amongst each other and would affect the overall braking performance of the train. The L block is generally a special composition brake block with very low friction coefficient. At high speed it would behave more or less like a cast iron block, however large differences would occur at low speeds.

The above difficulties have been encountered by different proposed solutions. The first and preferred solution is the so-called LL block, which is supposed to behave very similar to cast iron, without being a cast iron block. The intentional development of an LL-block has been the objective of the 5th Framework project Eurosabot [ref. 4], which was finished in 1999 without being able to deliver the ultimate solution, and is presently the subject of the 5th Framework project ERS (Europe Rolling Silently). So far both projects have not been able to come up with a solution, but the ERS project is presently testing alternative products that might comply with the specification to be considered LL. It is almost impossible to predict a time scale. LL-blocks are being used without problems in Portuguese railways. But the requirements in mainland Europe are apparently more severe and the testing and certification process is more elaborate.

Another solution that has been suggested is to introduce a speed dependent brake pressure valve, which would allow simulation the friction coefficient behaviour of a cast iron block with a composition block (or any other block). The brake pressure can be varied either continuously or stepwise. This solution was suggested and tested by the Technical University of Berlin (Prof. Markus Hecht). This has now been applied in 125 locomotives [ref. 7]. The presence of relatively fragile electronic control devices does not relate very well with the rough environment of a freight wagon.

When braking a train with mechanical brakes the kinetic energy of the train is transferred into heat. Both the brake blocks and the wheel serve as heat capacitor for the generated heat. The wheel is cooled down again partly by the contact with the rail, both wheel and block are cooled by the airflow around the running train.

Different brake operations show different effects on the wheel block system. A stop brake (i.e. bringing the train speed down from cruise speed to stop) causes high heat load with a short duration, whereas a drag brake (i.e. braking the train e.g. when running down a slope with constant speed) causes a steady heat flow into the wheel block system in a more or less balanced situation. Composition brake blocks have lower heat capacity than metal brake blocks. As a consequence, more heat has to be absorbed by the wheel when composition brake blocks are used, particularly in drag braking. This heat causes the wheel tread to expand, which will lead to thermal stresses in the wheel tyre. Because the wheel web will not expand in the same manner, high forces may occur. When composition brake blocks were first used in test runs with retrofitted passenger vehicles on mountainous links, particularly on the Gotthardt pass in Switzerland, severe wheel defects with potential safety risks occurred due to these high stresses.

Modern locomotives allow electro-dynamic braking, where the kinetic energy is transformed into electric energy, which is then either fed back into the overhead wire or dissipated in resistances. For a freight train with this type of locomotive, the long slopes do not represent a problem. In that case the regular stop braking would be the dominant cause for wheel defects (if any).

Special so-called low residual stress wheels have been developed by several manufacturers to overcome this problem. These wheels comply with UIC leaflet 510-5. A market survey was made by the Technical working group supporting the Noise Action Plan and concentrating on wheels, which is chaired by Mr. Fortmann. The market survey demonstrated that the low residual stress wheels are not more expensive to purchase than conventional ORE 920 wheels.

A2.5 Homologation

The International Union of Railways UIC is responsible for defining the requirements that vehicles and components have to fulfil in order to be allowed for use in international rail traffic. Homologation is the process of acceptance of a certain product with the consequence that – after acceptance – it cannot be refused by any operator. For the homologation of cast iron blocks there are UIC leaflets, which are quite general. There are also some leaflets for K and L blocks.

The process of homologating a new product is quite lengthy and elaborate, which is probably one of the reasons for the low level of innovation in railway technology. The process starts with a technical specification being drafted by a responsible committee within UIC. Then, for brake blocks, manufacturers would start to test the behaviour on their own test rigs, simulating drag and stop brakings under various conditions. After these internal tests the product could be offered to UIC, who would then engage into formal homologation tests on one of the dynamometer test rigs (DB, SNCF, PKP or FS). The rig test would demonstrate the friction coefficient as a function of brake pressure, of speed, and of wet or dry conditions.

If the product passes the rig tests, then it is included in a decoupling test, to be carried out with an empty wagon, 50% of normal load and full normal load, again in wet and dry conditions, according to Leaflet 541. If the product passes this test, it is “preliminarily homologated” on the basis that it can be expected to be safe. The exact performance depends on the brake configuration (Bg, Bgu).

If the product passes these tests, then it is submitted to a commercial test, in normal service. This would include Alp transits with long drag braking on slopes. After 1 year one might observe excessive wear, wheel cracks, etc which would then cause the product to be rejected. If not, the test is continued for 2 to 3 years. Only after the first real wheel reprofiling can one assess the real LCC. This LCC is then determined from: price of the shoes, life span of the wheel and life span of the shoe. After this test is passed, the final homologation is effectuated.

In previous tests it was found that failures of the product occurred in each stage of the testing process, even when the product had passed the previous stage. This shows how important it is to maintain the multi step homologation process, even if it is lengthy and costly.

Cast iron brake blocks have been homologated for a long time under UIC Leaflet. For composition brake blocks in international freight traffic a leaflet has been developed defining the performance in freight operation. The results of the tests are usually presented to the Technical and Research Commission of UIC, where all member companies are represented. This Commission then decides whether or not the product is acceptable. In 2002 the Commission decided to grant a temporary homologation to the technique of using K-blocks, for use in international freight traffic. In September 2003, the Commission has agreed on a final homologation for two manufacturers.

A2.6 Noise reduction to be achieved with K-blocks

Different experiments with composition brake blocks on freight vehicles have been carried out in different countries. The resulting noise reduction in relation to a similar vehicle equipped with cast iron brake blocks has been reported in different ways. The status of the experiments and the reporting is very often unclear. Generally a reduction potential of 5 to 8 dB(A) is reported for composition brake blocks compared to cast iron blocks. The UIC report [ref. 7] mentions a reduction potential of 3 to 4 dB(A) with respect to cast iron blocks. Some researchers report up to 15 dB reduction from their experiments. General comments that can be made with respect to this issue:

- ✓ There is a serious lack of formalised, more or less official measurement documents, which describe in full detail both the subject of the measurement, the conditions of the measurement and the measurement method applied.
- ✓ Often a valid reference lacks. Typical wheel roughness develops within the first 2000 to 5000 kilometres of operation after reprofiling the wheels. For a proper comparison one would have to take identical wagons with identical wheels, reprofile all wheels, submit the wagons to identical run in processes of at least 2000 kilometres with sufficient braking operation, then carry out the measurement.
- ✓ The measurement method to be used is specified in ISO 3095 draft 2002. This draft is still under discussion. It has been found at different occasions that the track roughness and the track dynamic properties have a big influence in the measurement result. A track specification is given in the latest draft of ISO 3095, but there is a general consensus that, if one were able to produce a track with a roughness that is far below the maximum specified roughness level according to ISO 3095, there would be a clear advantage in the measurement result. The advantage of very smooth track is bigger

for smooth wheels than for rough wheels. Therefore, carrying out the measurement on such track would result in a reduction for K-blocks with respect to cast iron blocks, which can never be reproduced on average roughness track in real practice.

Summarising: there is an urgent need to either decide on formalising one of the existing measurement reports (provided that it complies with the above requirements with respect to subject, conditions and method) or to carry out such a measurement in order to put an end to the existing discussion.

A2.7 Adverse effects

In the above sections it was shown that composition brake blocks, either with K-, L- or LL-behaviour, could represent a substantial improvement with respect to the acoustical performance of freight wagons.
Some networks however report also substantial drawbacks as a result of the experiments and field tests they have carried out. These drawbacks stand in the way of a smooth homologation and need to be addressed.

One set of drawbacks refers to a phenomenon, which is not very well understood yet. It is clear that wheel surfaces remain smoother with composition and sinter metal blocks than with cast iron blocks. One explanation for this phenomenon is that the composition blocks and sinter metal blocks are more abrasive than cast iron blocks. This would then lead to the wheel tread being polished. The result of that would be that the wheel is smooth, but also that it wears out faster than a cast iron braked wheel. Excessive wheel wear has been reported in some cases where new composition brake block materials were tested [ref. 4]. Wheel wear is an important parameter in the life cycle cost analysis that is referred to in chapter 2.

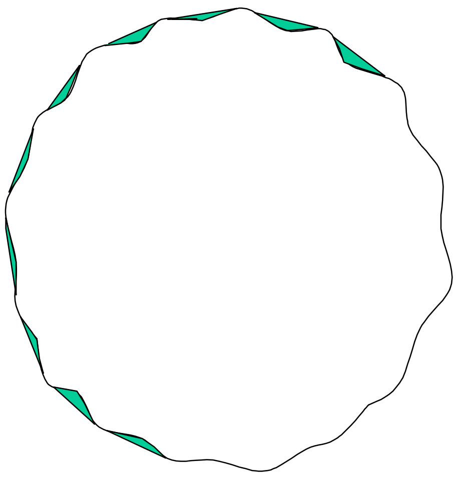


Figure A2.4. Composition material smoothening the surface of a corrugated wheel

Another explaining hypothesis [ref. 4] is that the composite material of the brake block tends to melt onto the wheel tread (see also figure A2.4), equalling out the pits between the peaks of the wheel tread roughness. This would then result in a film of composite material on the wheel tread, which smoothens its surface. This film however would also interfere with short-circuiting of the electric current, which is used for signalling and vehicle detection.

This so called loss of shunt is a serious safety issue, which is brought up by some networks as a problem they recognise, whereas others say it never occurs. This issue needs to be addressed in the homologation of K-blocks and LL-blocks. For the purpose of the present study it is assumed that this does not represent a cost issue, but may jeopardise the easy introduction of K-blocks into practice.

Further there is the issue of braking performance at low temperature, which has been raised by the Swedish representative in the Technical and Research Commission. It was underlined by this representative that in severe winter conditions, ice would form on the composition brake shoe and the brake shoe holder. This ice would then interfere with the proper performance of the brake shoe. The standard way to overcome this is to instruct the train driver to carry out a short drag braking operation regularly, which is intended to make the ice melt from the brake shoe. Introducing this technique has largely solved the problems of winter conditions. Qualitatively (no experimental evidence) it is to be expected that the winter behaviour of LL-blocks is similar or better than for K-blocks, as LL-blocks will require higher brake forces.

A minor problem is that some reports exist of particularly bad smell emerging from composition blocks, which might be annoying to passengers on platforms.

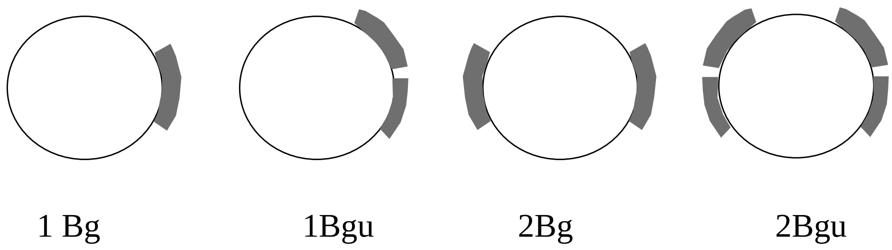
Finally, some researchers report that composition brake blocks may be the cause of increased brake screech compared to cast iron. Brake screech is a cause for annoyance both for passengers in stations and for residents living near railway depots and marshalling yards. At present there is no solid information as to this behaviour of composition brake blocks.

Annex 3. Retrofitting existing vehicles

A3.1 The brake shoes

Brake shoes for standard ORE920 railway wheels come in two different standard lengths, viz.

- ✓ 320 mm circumferential length for wheels on wagons operating in 2Bg mode, which means two brake blocks per wheel
- ✓ 250 mm circumferential length for wheels on wagons operating in 2Bgu mode, which means four brake blocks per wheel



The cost are strongly dependent on these characteristics, first because the Bg blocks are more expensive than the Bgu blocks, second because twice as many blocks are required for a Bgu vehicle than for a Bg vehicle.
The distribution of Bg and Bgu wagons in the EU-Railway-27-fleet, which is essential for the total cost assessment, has not yet been assessed, neither by AEA Technology Rail nor by Trenitalia.

When cast iron brake blocks are replaced by composition brake blocks (be it K behaviour or LL behaviour), the shoe clamp needs to be replaced at the same time. Composition brake shoes can only use a slightly modified shoe holder, so that it is not possible to use cast iron brake shoes once the vehicle has been modified.

The purchase price of the brake shoes has been estimated by Mr. Raison c.s. on the basis of experiments within SNCF and the ERS project. The estimated prices are indicated in the following table.

Table A3.1. Purchase price of the brake shoes.

Shoe material	Shoe type	Purchase price in Euro excl. Vat (from Noise Action Plan)
Cast iron brake shoe	Bg type	€ 6
	Bgu type	€ 5
Composition brake shoe	Bg type	€ 28
	Bgu type	€ 23
Sinter brake shoe	Bg type	€ 50
	Bgu type	€ 40

The above figures have been checked using different sources of information. The results are summarised in table A3.2.

Table A3.2. Comparison of the purchase price of brake blocks.

Shoe material	Supplier base	UIC Noise Action Program	Source A	Source B	Source C	Source D
Cast iron brake shoe (Bg size)	EU	€ 6	€ 10 – 11		€ 10 – 12	
Cast iron brake shoe (Bgu size)	EU	€ 5				
Composition brake shoe K-type (Bg size)	EU	€ 28	€ 14-21	€ 31 (500 ordered)	€ 50 – 70	€ 23 – 30 (K-type)
Composition brake shoe K-type (Bgu size)	EU	€ 23				
Composition brake shoe K-type (Bg size)	USA		€ 11			
Composition brake shoe LL-type (Bgu size)	EU					€ 40 – 50
Sinter brake shoe (Bg size)	EU	€ 50	€ 115 (present)			
Sinter brake shoe (Bg size)			€ 63 (future)			
Sinter brake shoe (Bgu size)	EU	€ 40				

Summarising: there is still a substantial inconsistency in purchase prices. One explanation for this is that the market for composition shoes in Europe has not yet fully developed. So far only two suppliers have gained homologation approval. It is expected that in a fully developed market the purchase price for a composition block will be up to 1.5 times that of a cast iron block.

A3.2 The brake cylinder

The brake cylinder is a pneumatic container providing the air pressure to release the brake shoe from the wheel before the wagon starts running. The proper functioning of the brake cylinder is checked by the so-called hammer test: hitting the wheel with a hammer tells the inspector whether or not the brake shoes have indeed been released from the wheel.

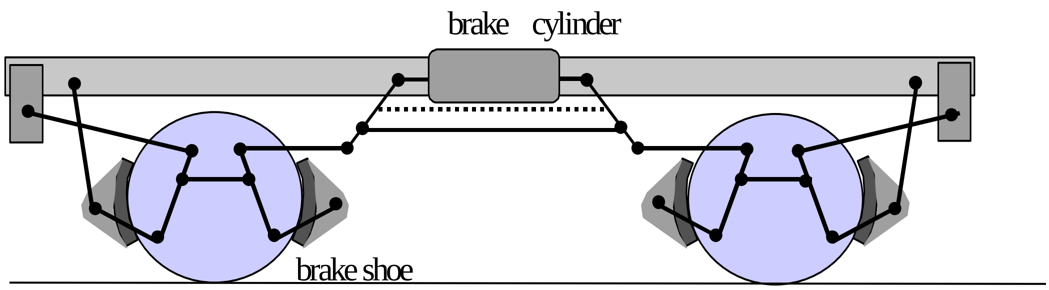
Changing from cast iron brake shoes to composition brake shoes implies that the brake force has to be changed; as the friction coefficient is higher for composition blocks, the brake force and thus the brake pressure must be reduced. In some cases this adaptation can be made by means of a change of the rigging (levers) (see 3.3), in other cases the brake cylinder needs to be replaced. This is a substantial source of retrofitting cost, both in terms of purchase costs for the cylinder and in terms of man-hour cost.

It has been assumed in the Raison analysis that the brake cylinder(s) had to be replaced in all cases. This is a conservative estimate since in some cases it might be sufficient to change the ration in the rigging.

The estimated purchase price for the cylinder (smaller than for cast iron brake system) was around € 1000,- This was seen to be a conservative estimate (might be € 700,-).

A3.3 The rigging

The rigging between brake cylinder and brake shoe holder provides a ratio of brake force. For cast iron block braked stock, the ratio normally is set to 1:1. By changing the ratio of the levers, the brake force can be reduced, as it is necessary for the application of composition brake blocks. When the ratio is already different than 1:1, there may be problems to change the ratio further and then the brake pressure cylinder may need to be replaced.



1 *Figure A3.1. Simple representation of the tread brake system with brake cylinder, rigging, brake shoe clamps and brake shoes*

A3.4 Other elements

Other elements may need to be replaced. Some wagons are equipped with an automatic load dependent relay valve. This valve is controlled by the load of the vehicle. When the load is high, the valve will steer the brake pressure such that the maximum braking force is available from the brake pressure cylinder. When the vehicle is empty, the brake pressure will be less, in order to adapt the vehicle's braking performance to that of the rest of the train (which may contain loaded vehicles). When this load relay valve is available, it may require replacement when the vehicle is retrofitted.

Other wagons may have a simple manually operated loaded/unloaded switch valve. This may then require replacement when the vehicle is retrofitted.

It was assumed in the assessment of Mr. J. Raison c.s. that 70% of the EU-Railway-27- fleet to be retrofitted would be equipped with the automatic valve and 30% with the manual switch. There is a significant difference in cost involved. Therefore this distribution needs to be assessed with the best possible accuracy.

Annex 4. Inland waterways regulation - the 'old for new' rule

The most important reasons for the EC to create a Regulation in 1989, on the granting of aids for inland waterway were:

- ✓ the structural overcapacity in the fleets operating on the linked inland waterway networks of Belgium, France, Germany, Luxembourg and the Netherlands appreciably affected, in those countries, the economics of transport services, particularly of the carriage of goods by inland waterway.
- ✓ Also, forecasts showed no sign of sufficient increase in demand in this sector to absorb this overcapacity in the next few years.
- ✓ Whereas the share of the total transport market taken by inland waterway transport continued to decline as a result of progressive changes in the basic industries supplied mainly by inland waterway.

The regulation was set up for each of the Member States whose inland waterways are linked to those of another Member State and the tonnage of whose fleet is above 100,000 tonnes. The inland waterway vessels used to carry goods between two or more points by inland waterway in the Member States were subject to measures for structural improvements in inland waterway transport under the conditions laid down in this Regulation.

This Regulation applied to cargo carrying vessels and pusher craft providing transport services on their own account or for hire or reward and registered in a Member State or, if not registered, operated by an undertaking established in a Member State.
Vessels excluded from this Regulation were:

(a) vessels operating exclusively on national waterways not linked to other waterways in the Community,

(b) vessels which could not leave the national waterways on which they operate and cannot enter the other waterways of the Community (captive vessels),

(c) vessels operating exclusively on the Danube (and its tributaries) up to Kelheim without leaving it;

(d) pusher craft with a motive power not exceeding 300 kilowatts,

(e) sea-going inland waterway vessels and ship-borne barges used exclusively for international or national transport operations during voyages which include a sea crossing,

(f) vessels used exclusively for storage of goods, i.e. vessels used for loading and subsequently unloading goods at the same place,

(g) dredging equipment, such as hopper vessels and pontoons and floating construction plant,

(h) ferries,

(i) vessels providing a non-profit-making public service.

The competent authorities in the concerning Member State have set up under its national legislation and with its own administrative resources, a scrapping fund. The fund had a reserve fund consisting of three separate accounts; one for dry cargo carriers, one for tanker vessels and one for pusher craft. This reserve fund was financed by:

- ✓ the surplus funding from the structural improvement schemes conducted up until 28 April 1999, consisting solely of financial contributions from the industry,
- ✓ the special contributions paid by the owner of a vessel (as will be mentioned further on),
- ✓ the financial resources which could be made available in the event of serious disturbance of the market (as referred to in Article 7 of Directive 96/75/EC.)

Vessels covered by this Regulation, whether newly constructed, imported from a third country or due to leave the waterways as mentioned above, were brought into service subject to the condition (the 'old-for-new' rule) that the owner of the vessel to be brought into service:

- ✓ either scraps, without receiving a scrapping premium, tonnage in line with the ratio between old and new tonnage set by the Commission,
- ✓ or pays into the Fund a special contribution based on the above mentioned ratio or,
- ✓ if the owner scraps a tonnage smaller than required by the above mentioned ratio, pays the difference between the tonnage of the new vessel and the tonnage scrapped.

The special contributions and scrapping premiums were calculated for cargo-carrying vessels on the basis of the deadweight tonnage and for pusher craft on the basis of the motive power of the vessel. The vessel offered for scrapping as compensatory tonnage must have been scrapped before the new vessel is brought into service. The owner of the vessel had the choice between paying the special contribution or scrapping old tonnage:

- ✓ either at the time that the firm order for construction of the new vessel is placed or at the time the application for import is lodged,
- ✓ or at the time that the new or imported vessel is brought into service.

Owners who scrap a vessel received a scrapping premium at the rate set by the Commission. However, this premium may be granted only in respect of vessels which the owner proves form part of his active fleet, i.e.:

- ✓ Vessels which are in good working order, and
- ✓ Vessels for which the owner can produce valid certificates of water worthiness and tonnage or an authorisation to engage in national transport issued by the competent authority of one of the Member States concerned, and
- ✓ Vessels that have made at least ten voyages during the 24 months preceding application for the scrapping premium. The word 'voyage' means a commercial transport operation over a distance normal for the carriage of goods of the same type (over 50 km) and carrying a volume of cargo in reasonable proportion to the cargo capacity of the vessel (at least 70 %).

No premium was paid for vessels which, as a result of a wreck or other damage suffered, were no longer repairable or for which the repair costs were higher than the amount of the scrapping premium.