Study noise on the railway corridor

Rotterdam-Genoa

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1 Introduction

A joint initiative of the Ministries from NL, DE, CH and IT in respect to reduction of railway noise on the corridor Rotterdam-Genoa pursues the utilisation of silent wagons in detriment of noisy ones. This measure has been proved the most cost-effective in comparison to a number of other measures, among which: absorbing walls, rail grinding for noise purposes, insulate windows and shake absorbers.
Wagons utilising cast iron (Ci) blocks as thread braking element are considered noisy wagons; they can be turn into silent if another braking system is installed (e.g. disks), or, more inexpensively, if other brake blocks' materials, namely K or LL, are employed. These solutions are not cost neutral since there are important initial investments derived from the installation of K-blocks, as well as important extra LCC costs result of the extra maintenance of wagons retrofitted with K and LL-Blocks. This entails a rejection from the sector. In spite of that, since 2007, all new produced wagons have to comply with the EC Directives TSI NOI and TSI WAG which oblige them to be manufactured silent. This guarantees that by c.a. 2035 the whole fleet in the EU should be silent because of mere renewal processes. However, the objective is to achieve this earlier by retrofitting a part of the existing noisy freight rolling stock.

The report provides an overview on the ongoing developments in the corridor countries and on EU level (chapter 2), a summary of the results of the stakeholder consultation (chapter 3), an introduction to the chosen scenarios (chapter 4), the result of the modelling of the scenarios (chapter 5) and the implications for railway undertakings calculated in a business case (chapter 6). In chapter 7 the study is summarized followed by the impact assessment and recommendations to the ministers (management summary).

2 Policy overview

2.1 Introduction

Task 1 aims to give an overview, comparison and evaluation of national and EU-approaches and initiatives on rail noise track access charging.

2.1.1 Background literature

The basic information sources for this task are existing academic literature and relevant studies as well as expert interviews. A lot of information that is required can be derived from recently published studies. Among other sources, the following sources are used:

Country (or EU)	Literature
EU	• Analyses of preconditions for the implementation and harmonization of noise differentiated track access charges. (KCW, 2009) • Rail noise Communication and Impact assessment study on rail noise abatement measures addressing the existing fleets (PWC, 2007)
The Netherlands	• Indicators from Dutch Prorail, network statement[1] • Analysis 'omloop goederenmaterieel, Studie in het kader van het innovatieprogramma geluid stiller treinverkeer[2]
Switzerland	• National policy on railway noise in Switserland (annex to ToR of this study) • Indicators from SBB, network statement[3] • Ein Trassenpreissystem aus Umweltsicht unter besonderem Augenmerk des Lärms – Studie, Schriftenreihe 143 (IVT) Lärmsanierung der Eisenbahnen, Standbericht 2008
Germany	• National Traffic Noise Protection Package II "Avoidance of Noise – Protection Against Noise"27 August 2009 (Federal Ministry of Transport, Buildings and Urban Affairs) • The reduction of Sound Emissions caused by Rail Freight Transport. Position Paper of the German Rail Freight Sector, January 2010
Italy	• Environmental guidelines for the rail sector (AICQ – Italian Association for Quality) • Línquinamento acustico derivante dal traffico ferroviario in Italia

[1] http://www.prorail.nl/Vervoerders/Documents/20686705%20v1.0%20-%20Netverklaring%202010%20%27Gemengde%20net%27.pdf

[2] http://www.innovatieprogrammageluid.nl/data/files/algemeen/Bevordering%20Implementatie%20Omloopstudie%20goederen.pdf

[3] http://mct.sbb.ch/mct/en/infra-oss_network_statement_e_2010.pdf

2.2 National and European policies on rail noise, measures and analysis of their effectiveness

In the following subsections a description will be given of EU and national policies on rail noise including assessments on the various measures. Recent studies, are used as the main information source regarding the policy aim of the national initiatives for retrofitting.

2.2.1 European Union

On an European level, the European Commission favours a coordinated approach at the European level using the instrument of a NDTAC to incentivise the involved stakeholders to retrofit freight wagons. The Commission had announced its intention to introduce the noise-differentiated track access charges (NDTAC) scheme on a harmonised and EU-wide basis in its Communication on "Rail noise abatement measures addressing the existing fleet" of 2008 (COM(2008) 432). Point 4.2 of this document states:
"Non-harmonised introduction of noise-differentiated track access charges at national level would risk not being effective as the incentive for railway undertakings might not be sufficient if only some Member States introduced such schemes, the timeframes were contradictory and different types of silent wagons were treated differently. Administrative costs for non-harmonised schemes would also be unnecessarily high. This instrument providing the necessary incentives for retrofitting therefore needs to be implemented simultaneously on a mandatory and harmonised basis in all Member States concerned. Beside the harmonisation of the main elements of charging schemes, the development of a common noise classification system for wagons is needed."
The European Commission is planning the proposition of legal requirements for the mandatory implementation of noise-differentiated Track Access Charges, against the background of the recast of Directive 2001/14/EC.

Noise is considered still the environmental Achilles' heel of European Railways. 10% of EU Citizens are exposed to thresholds of "serious annoyance". External costs amount to about 2.4 billion Euros a year[4]. There are particularly sensitive areas, for example the Citizen's groups in the Rhine Valley: more than 100.000 persons.

In line with the Rail noise Communication, the EC will propose legal requirements for implementation of noise differentiated track access charges by means of a recast of Directive 2001/14/EC. A mandatory introduction of NDTAC would be required. The general principles would be set out in an annex, which is open to regular revision. It should ensure the effectiveness of charging schemes and harmonization of approaches. Possible date for adoption by the EC would be in summer 2010.

[4] CE Delft

After the re-casted Directive will enter into force there will be a legal obligation regarding NDTAC, including a transition period. The modifications to the Directive itself will be rather minor: only the introduction of the obligation to adopt a NDTAC. The new directive will not contain many details concerning TAC's (they will be in the annex). Expert group(s) and joint guidelines should ensure the harmonization.

2.2.2 The Netherlands

The Netherlands started a large noise abatement programme that is running from 2011 until 2020. In total, €650 million will be invested in noise reduction programmes for road and rail. Speed reduction of trains in noise-threatened sections or limiting traffic can realize this reduction. However, this would affect the available capacity. Therefore, an approach that deals with the source of the noise seems more attractive. Making rolling stock less noisy accomplishes a noise reduction too while leaving available capacity and traffic flows unaffected.

2.2.3 Germany

In Germany there is no noise differentiated track access charge (NDTAC). There are initiatives to diminish rail noise. The first to mention here is "Leiser Zug auf realem Gleis" in which Deutsche Bahn, the German government, the rail industry, and scientific institutions are combined. Another is "Leiser Rhein". Leiser Rhein focuses on the highly used north-south route through the Rhine corridor.

2.2.4 Switzerland

The Swiss railway-specific noise abatement programme is planned to last from 2000 until 2015 and it is financed by toll road revenues. The programme consists of retrofitting all rolling stock, building noise barriers, and installing insulated windows in locations where noise thresholds are being exceeded[5].

2.2.5 Italy

The first intervention issued by the Italian Government concerning noise abatement originated from the railway activities refers to the law number 447 of 1995. This law:

1 Defines the noise sources in the railway network considering both the sources of the move and the fixed sources.
2 Orders the issuing of a specific decree in order to regulate the noise emission originate from the railway traffic.

[5] Analyses of preconditions for the implementation and harmonization of noise differentiated track access charges. (TU Berlin, 2009)

In compliance with (2), it has been issued a "*D.P.R. n. 459/1998*". This regulation describes the railway infrastructure as the whole of: rolling stock, tracks, stations, good yards, railway squares and electric stations.

This regulation defines moreover:

- The maximum emission values within the band relevance of the railway infrastructures both in place and for future construction.
- The maximum emission values for the rolling stock of new construction. Two targets with two different set of values have been planned:
  - Rolling stock which has been used from01/01/2002:
  - Rolling stock which will be used from 01/01/2012.

Besides this, another Italian noise reduction policy has been issued by the Environmental Ministry in November 2000. This policy is called: "Criteri per la redazione di piani di azione atti a limitare e ridurre il rumore generato dalle compagnie dal trasporto pubblico".

Since the beginning, namely since the issued date, the noise reduction policy has been structured in three main steps:

- The IM - Infrastructure Manager (RFI - Reti Ferroviaria Italiana) had to promote a study along its whole network in order to find those areas where the noisy level has been estimated higher than the law admit. After the IM gathered all the information, it had 18 months time (till the end of July 2002) to send those figures, first of all, to the Environmental Ministry and, second, to the regional and local authorities involved in the project.
- The main purpose of the second aspect was "the planning of the mitigation measures". During the next 18 months (till the end of February 2004), the Environmental Ministry, together with the Infrastructure Manager worked on a detailed scheduling of the intervention plans in order to reduce noise within the areas, which came out in the first step. The plans supplied a complete and detail description of the intervention measures included: work scheduling, cost estimation and priority level of each measure in comparison with the other.
- The third and last main step of the Italian noise reduction policy is the real implementation of the intervention measures planned in step two. 15 years (till the end of 2020) represents the given time window to guarantee a fully implementation of the intervention measures.

2.3 Policy objectives

In this chapter, the aim of the noise policy from an EU viewpoint, as well as the Member States along the corridor will be highlighted.

2.3.1 European Union

Objective of European noise policy is to attain noise reduction (and to reduce the number of people that are regularly affected by rail noise) without jeopardizing rail transport competitiveness. Means to do this are the abatement measures with the highest cost-effectiveness ratio and health benefits.

As a part of the Greening Transport package (July 2008) the Rail noise Communication which announced the need to retrofit the existing, was adopted. Its aim was to identify and promote measures to overcome obstacles for retrofitting of freight wagons. Retrofitting should include all freight wagons with annual mileage greater than 10.000 km and a remaining life expectancy of at least 5 years.

2.3.2 The Netherlands

The aim here is to reduce noise levels by 10 to 12dB. Since the beginning of 2008, retrofitted freight wagons and retrofitted passenger coaches that are considered "silent" could receive a bonus of 0.04 €/wagon-km. Newly built silent wagons and coaches, do not qualify for the bonus, only wagons and coaches from before 2008 and that have been retrofitted with K-blocks or equivalent technology. LL-blocks are expected in about 2-3 years to reach authorisation, so that wagons with LL-blocks are eligible as well[6]. Moreover the Netherlands is adopting legislation (proposal to Parliament in 2009) to introduce a maximum level to noise on each infrastructure section. Capacity restrictions could be introduced per section in case the noise level remains above the level agreed upon for that section.

2.3.3 Germany

In Germany goal is to retrofit 5,000 wagons with composite brake blocks. Germany combats noise also with more passive noise measures, such as noise barriers or insulated windows.

2.3.4 Switzerland

Switzerland's aim is to combat noise by realizing the retrofitting all rolling stock, noise barriers and insulated windows in case that areas after taking measures are considered still too noisy.

2.3.5 Italy

The aforementioned noise map of the Italian railway network shows that 8.000 km., about 50% of the entire network (the whole network measures about 17.000 km.) needs mitigation measures in order reduce the noise emissions below the maximum limits dictated by the law. During the first 4 years, the building of about 700 km. of 3-4 (sometimes 7-8 meters) meters high noise barriers has been planned. The Italian noisy abatement program covers 15 years. That is because, on one hand, the intervention measures needs to be financed and adequately planned.

[6] Analyses of preconditions for the implementation and harmonization of noise differentiated track access charges. (TU Berlin, 2009)

2.4 Level of financial incentives, steering effects in charging concepts

This chapter will be focused on the financial aspects of the approaches in the different corridor / Member States, as well as the incentives / steering effects that they create. Funding sources and mechanisms differ. For example, the Swiss noise abatement programme is largely financed by toll road revenue. The existing charging concepts that are in use show different financial incentives for the Wagon Owner in order to retrofit wagons that are considered too noisy.

2.4.1 European Union

It is important here to mention the study "Analyses of preconditions for the implementation and harmonization of noise-differentiated track access charges". The study concludes that a pure bonus system is recommended because otherwise competitiveness of the sector might be harmed. The bonus should consist of the costs for retrofitting but also operational and administrative costs from the side of the RU / WK. The bonus should be based on the number of brake blocks per axle. Funding should be available for any wagon which is TSI Noise approved; different bonus levels depending on the costs of retrofitting (K- or LL-blocks). The study recommends a focus on LL blocks. Differentiations of the bonus should be avoided. The bonus has to be granted during a fixed period. After this period the higher costs must be paid by the sector. The funding period should be fixed in order to secure planning reliability and avoiding overcompensation. The study recommends a funding period of 6 to 12 years as multiple of the timeframe for wagon revision, after this period the higher costs have to be paid by the particular player. To reach optimal effectiveness, the NDTAC scheme should be implemented EU-wide, at the very least at the main networks of each Member State.

The use of cast iron blocks should be prohibited after a certain transition period. An almost entirely "silent" train could be given an additional bonus.

2.4.2 The Netherlands

The Dutch NDTAC concerns only wagons which have been retrofitted after the beginning of 2008. New wagons are not eligible. The incentive bonus levels are: 0.04 € per wagon*km with a maximum per freight wagon of €2,600. The RU's get the bonus after self declaration of their wagons' mileage on the railway network. The IM then reimburses the RU the amount, that is limited to[7]:

- a total of 120,000km and 3 years for passenger coaches: maximum bonus of 4,800 €/coach
- a total of 120,000km and 3 years for freight wagons: maximum bonus of 2,600 €/wagon

[7] Analyses of preconditions for the implementation and harmonization of noise differentiated track access charges. (TU Berlin, 2009)

Because Dutch Government funds the programme an undesired modal shift as a result of a lesser competitive position compared to other modalities is avoided. The bonus is related to the wagon performance and there is also little risk of overcompensation as the costs to supply wagons with K-blocks are relatively high. Using LL-blocks – when homologated – will also be compensated adequately. Care has to be taken not to make a difference.

If bonus levels are too low WOs/WKs will not retrofit their wagons. Bonus levels do not necessarily require a computation of mileage since the IM can trust the self-declaration of RUs and keep record of declared distances[8]. In a European-wide implementation, IMs should be interchanging information about wagons and their distances travelled in order to know the total amount of distances travelled declared by each wagon in Europe. Currently the level of the bonus seems not high enough to account for RU's administrative costs that would be involved. Further, kilometres dependent bonus systems would require communication between IMs with respect to performance of wagons and matching networks. The bonus levels given for a single wagon make the incentive for retrofitting questionable, especially for K-blocks. The limitation of bonuses to a maximum of 2,600 € per freight wagon is too low to create a real incentive.

3–4 years after the authorisation of LL-blocks, a malus system will be introduced though it is not yet quantified. This could trigger more rapid conversion of wagons, it is also possible that this will have e detrimental influence on modal shift. A malus is always a financial burden to the railway sector and is likely to divert traffic from train to trucks. The level of the malus is therefore very important.

It is discriminatory that only wagons which were retrofitted after start of 2008 are eligible for the bonus. These RUs are using old CI brakes instead of new K-blocks since the Life cycle costs (LCC) are lower for the CI brakes. The impossibility to receive bonuses for new wagons is also discriminatory and furthermore does not help reduce rail noise.

As large-scale use of RFID[9] is not economically viable., another control mechanism has to be established. Noise pollution limits controlled by measuring stations are planned. This will lead to a decrease in capacity.

2.4.3 Germany

Currently in Germany there are no incentives to encourage wagon owners to retrofit noisy freight wagons[10]. A feasibility study of for a noise-differentiated track access charging system is being implemented.

[8] Analyses of preconditions for the implementation and harmonization of noise differentiated track access charges. (TU Berlin, 2009)

[9] RFID: Radio frequency identification

[10] Source: http://www.leiser-gueterverkehr.de/index.php?id=814 and "The Pilot and Innovative Action Programme for Freight Traffic Noise Abatement in Germany", T. Quernheim & M. Arnold, Freight Noise Focus, October 2009

The idea is to adopt a simple noise-differentiated track access scheme by 2012 and a harmonized EU-wide system after 2016[11]. Aim here is to ensure that all freight wagons are retrofitted with low-noise composite brake blocks within a reasonable time. Conversion of wagons, planned by 2012, can already reduce noise on the Rheinstrecke. The decision how a possible emission dependent track access charge will look will be taken after the results of the pilot project are known. The railway sector itself seems to be of an alternative opinion: 'A noise based track access charge system… hardly provides incentives for a change-over".

2.4.4 Switzerland

A Track Access Charges bonus was introduced to reward 'silent' wagons utilizing Swiss rail infrastructure. The bonus is paid to RUs based on the number of 'silent' axles per kilometre. These axles use K-blocks, disc or drum brakes. LL-blocks are still in the process of authorisation and therefore not in the programme at the moment.

Current bonus is 0.01CHF/Axle-km (~ 0.03 €/wagon-km) and will be halved for passenger trains in 2010. The bonus represents between 5 and 8% of the access charge and is paid on a yearly basis. For example, a 29 million CHF (~19 million €) bonus was paid for passenger trains and 3.1 million CHF (~2 million €) were paid for freight trains in 2005. For freight trains, this amount represents 77 million wagon-km. Assuming an average travel distance of 30,000 km a year per wagon, this means that a total of 2,580 freight wagons have received the bonus in 2005. The total noise bonus paid until 2009 amounts 220 million CHF (~145 million €). The main characteristics of the system are[12]:

- Direct subsidies for retrofitting Swiss wagons;
- NDTAC of 0.01 CHF per 'silent' axle (about 0.03 €/wagon) with no maximum; (paid to RU based on self declaration of RUs. The forwarding to the WO is not organized and should be part of the contracting.

Next to the Track Access Charge bonus, retrofitting Swiss freight wagons can also be covered by direct subsidies. Non-Swiss wagons are not covered by these subsidies though. They only benefit from the NDTAC if they are silent. Swiss keepers/owners of 'silent' wagons can benefit from:

- The NDTAC bonus passed on from the RU,
- The direct subsidy for retrofitting from the Swiss government, and
- Willingness of the RUs to pay a higher price for 'silent' or less 'noisy' wagons.

[11] NDTAC can theoretically be implemented by end of 2012. Therefore – among others – economical efficiency of this incentive model, especially related to administrative and transaction costs, has to be proven. In order to analyse transaction costs of different incentive models (including the model proposed by the German sector) a study within the WG 3 of the project Leiser Rhein will be conducted

[12] Analyses of preconditions for the implementation and harmonization of noise differentiated track access charges. (TU Berlin, 2009)

There is no limitation for the NDTAC bonus, given that a 'silent' axle can receive the bonus uninterruptedly as long as it is so declared by the RU and as long as the NDTAC bonus programme continues – which will be at least until 2015. Currently there is no malus system.

The Swiss NDTAC system (an axle-based bonus) is more accurate, with respect to noise abatement, than the previously mentioned wagon-based one. The axle-based bonus can better cover retrofitting costs because it takes into account the various possibilities of the numbers of axles per wagon.

Common information technology systems employed by the IM and RU enables easy punctual checks for specific cases and minimize administrative costs.

However, there is a risk of overcompensation due to the absence of a maximum bonus amount. Wagons may be heavily used may cover. On the other hand they compensate for the unclaimed bonuses for wagons which are not used much. The lack of an upper bonus limit leads to a need for higher funding. This can raise the total costs of the system.

The level of bonus is not significant. About € 2 million of bonuses were granted for silent In 2005 rail freight transportation. This sum seems to be irrelevant compared to the total costs that an RU has to invest. For foreign RUs, the bonus is only significant if they generate a large amount of trans-alpine transport.

About 90% of the bonuses have gone to passenger coaches which were mostly silent in the first instance and did not need an incentive for being retrofitted. The focus should have been set on freight wagons.

The NDTAC is complemented with direct subsidies for retrofitting Swiss wagons which distorts the actual effect of the NDTAC. The Swiss system cannot be fully exported to the rest of Europe. Direct funding, only for national WOs/WKs, is discriminatory and goes against the ideas defining the European market.

2.4.5 Italy

The total cost of the entire program has been estimated in more than 6.8 billions of Euro In Italian noise abatement, there is not a real incentive scheme or charging concept.

As the noise reduction was issued both the IM (RFI) and the RU - Railway Undertaking (Trenitalia) were aware that a retrofitting program of the rolling stock could be a better solution in terms of both costs and landscape effects. At that time the main problem concerning the retrofitting was to move the costs from the IM to the RU.

Since 4 years the IM spent about 15 millions euro per year: 80% for the planning operations and 20% for the construction.

2.5 Technical and administrative implications

Schemes for technical and administrative implementation are described, as well as the technical and administrative tools that are necessary. Switzerland and The Netherlands use different schemes for technical/ administrative implementation. A prerequisite for the charging concepts to work, is that the right behaviour is stimulated. This implies that the organisations get rewarded that can actually make the decision to retrofit wagons. A threshold level of charging has to be set in order to make the wagon owners act. The incentive should also reach the wagon owners, different approaches exist here.

2.5.1 European Union

There are a number of legislative measures concerning rail noise and its reduction. The Technical Specification for Interoperability (TSI) - Rolling Stock for High Speed Rail and TSI Noise for conventional rail, adopted in 2002 and 2005 respectively, are the most significant as they tackle the problem at the source by limiting the noise level of new wagons. Furthermore, the Directive 2002/49/EC (Environmental Noise Directive) states that Member States are legally competent to set limits on environmental noise.

There is a need for additional measures addressing the existing freight wagon fleet. The investments done are considerable. Using the most cost-effective technology (LL-Blocks) would require an investment of max. 850 M€ over the period 2009-2024.The estimated benefits of retrofitting over that period are tenfold that amount.

The NDTAC can be theoretically funded by the sector – either through a malus or through an overall increase of the TAC. These possibilities could weaken the sector's position. Therefore, a funding through Member Sates could be a feasible solution. Also a share of the costs between the sector and the Member States is possible. The reimbursement of the costs at the side of the IM should be considered carefully. A possibility is to transfer the bonus from the IM to the RU which in turn pays the bonus to the WK.

2.5.2 The Netherlands

To date, no companies applied for the bonus. Most likely the incentive to do so is too low. In case of a bonus application, the RU should send a self declaration of wagon mileage. As the bonus is limited in terms of time and distance, the IM needs to record for every wagon for which a bonus is granted. Also the Dutch Ministry of Transport receives a copy of the bonuses granted and the distances travelled. After validation, the IM is compensated. The programme started with 15 M€. Plan is to replace the current bonus system with a bonus-malus-system. 3-4 years after the authorisation this malus will be introduced. The financial flow go between IM and RU. In turn the RU could pass on the bonus to the WO, but it is not mandatory to do so. This is left to the market. Self-declaration is a simple procedure. In fact, the RU is the only party that is able to give detailed travel data of single wagons.

Later on, information technology systems such as GOTCHA[13] and QUO VADIS[14] could be utilized for making the necessary calculations. Software to do so is expected to be operational in 2011. As an extra measure tuned absorbers for rails and insulated windows can be deployed in order to push noise emission levels below maximum acceptable levels. These levels vary across the Netherlands and are not expected to be in place before 2011. The levels will be controlled by measuring stations: that monitor real emissions. Upon reaching the maximum level, capacity could be restrained. At the moment there is no link between existing measuring stations and the NDTAC.

An important development are the imminent changes in the Law on Environmental Protection. Mid 2010 noise emission ceilings for the whole rail network in the Netherlands will be laid down. These ceilings will be determined based on current noise intensity, with margins for future development. Then these are the noise limits that a rail trajectory is allowed to produce. Traffic is only allowed to increase if adequate noise reduction measures are taken, so that the ceilings are not crossed. Noise reduction is envisaged to be reduced in several possible ways: from noise barriers to measures such as rail damping. A plan to improve certain rail infrastructure sections or corridors will be developed (Policy Document on Mobility, NoMo). The approach will be further detailed in the preparatory studies.

2.5.3 Germany

Diminishing rail noise is organized via the earlier mentioned associations of stakeholders such as "Leiser Zug auf realem Gleis" or "Leiser Rhein". With the "Leiser Rhein" pilot project, obstacles to an initial conversion should be reduced by knowledge at the required engineering and approvals required to be practically obtained and tested. These will be available for future cases and form the basis for procedures with minimal administrative and technical effort. The pilot phase will be used to further investigate how the costs can be related to number of wagons. Regulatory measures, including an emissions-track pricing system, should be prepared with a program module for vehicle detection. A Radio Frequency Identification System (RFID) will be used for verification, in addition to operational data provided by the railway companies.

2.5.4 Switzerland

For a bonus, the RU's first need authorization from the Ministry of Transport after which they can send an application to the IM. Then the IM pays what is applicable to the RU which also gets an equivalent compensation through the general subsidies received from the State. There is no thorough check on the bonus allocation, the transfer itself, or distances travelled by 'silent' axles.

[13] GOTCHA is used to measure the weight in motion as well as wheel defects by the maintenance company NedTrain

[14] The mileage can be calculated with the QUOVADIS system operated by ProRail. This system employs radio frequency identification (RFID) readers along the track that can identify the axles having RFID-tags.

A considerable administrative effort would be required to do so. In general, the likeliness of the system is assesses added with random checks. Detailed travel information of each wagon and the information on whether or not the wagon is suitable for a bonus are made available by the participating stakeholders. Interviewed experts have declared that Swiss RUs are reliable in forwarding the bonus over to other parties. The fact that the RUs and the IM in Switzerland use the same wagon information database (CIS) can facilitate further a more severe control process[15].

Following from the fact that the bonuses are not limited and due to the fact that the system is based on self-declaration, the administrative burden is low. Automation of the system would probably make the system more complex and thus more expensive. The Swiss self-declaration system is based on trust. Application in a wider trans-national EU context may not be feasible.

2.5.5 Italy

RFI started the construction programme along the entire country. In the areas of Venice and Florence 5 km. of noise barriers has been installed. In Pescara and Trento 6.5 km. and 6 km noise barriers has been installed. Other projects have been activated on the corridor Milan-Venice and in Sicily between Messina and Palermo.

2.6 Conclusions

a) At an EU level, the EC envisages the recasting Directive 2001/14 with regard to NDTAC's
b) Several initiatives with regard to noise differentiated track-access charges are running in the Member States in order to combat noise
c) Switzerland and the Netherlands have implemented such approach, improvements could be made, though.
d) Taking the above into account, there seems to be a good possibility to come to an integrated approach, taking the experiences of the front-runners into account.
e) The experiences of the front-running counties indicate that:
    a. Experiences from the Netherlands show that it is important to set the level high enough
    b. A NDTAC system needs a proper incentive levels to make it work. As can be learned from the Dutch experiences, if levels are set too low the opportunities will not be used.
    c. Self declaration systems are based on trust and might not work with a malus system

[15] Analyses of preconditions for the implementation and harmonization of noise differentiated track access charges. (TU Berlin, 2009)

3 Stakeholder consultation

3.1 Aim

The aims of the stakeholder consultation were the following:
- gather economic, financial and technical data for the impact assessment
- gather stakeholder point of view on different scenarios
- involve actively and positively stakeholders: listen to their point of view / fear / recommendations for scenarios
- find a participant for a business case
- get other information that will contribute to the definition of the final recommendations to the involved Ministries

3.2 Contacted Stakeholders

Four categories of stakeholders have been distinguished:
- Ministries of Transport (MoT)
- Infrastructure Managers (IM)
- Railway Undertakings (RU)
- Wagon Owners / Wagon Keepers (WO)

To retrieve the information needed a questionnaire was thought to be the best way to approach the stakeholders. Therefore, each category of stakeholders received a specifically designed questionnaire.

The authors were aware of the fact, that the questionnaire does contain questions asking for possibly confidential data. Also, the time frame to return the questionnaire was very tight. Therefore it could not be expected to get answers to all questions.

The following stakeholders had been contacted, which are thought to represent a good sample of stakeholders involved in the Rotterdam-Genoa Corridor:

All Ministries of Transport along the Corridor:
- Netherlands (Ministerie van Verkeer en Waterstaat)
- Germany (Bundesministerium für Verkehr, Bau und Stadtentwicklung)
- Switzerland (Bundesamt für Verkehr)
- Italy (Ministero delle Infrastrutture e dei Trasporti)

All Infrastructure Managers along the Corridor:
- ProRail (NL)
- DB Netz AG (D)
- SBB Infrastruktur (CH)
- BLS Netz AG (CH)
- RFI (I)

Selected Railway Undertakings:
- NL: DB Schenker, ACTS, ERS Railways
- D: DB Schenker, TX Logistik
- CH: SBB Cargo, BLS Cargo
- I: TRENITALIA, NORDCARGO

Selected Wagon Owners:
- Sabic
- Cobelfret
- VTG
- Transwaggon
- DB Schenker
- VPI (Vereinigung der Privatwagen-Interessenten)
- AAE
- Hupac
- GATX
- Wascosa

Some RU's which are wagon owners themselves were asked to fill in the questionnaire for WO's as well.

3.3 Results

3.3.1 General remarks

- Positive: most stakeholders returned the questionnaire (in some cases represented by their holding company in another country or by an association)
- Negative: partly not / incomplete answered questions
- Data from stakeholders helped to fill the model with reasonable data. Still reasonable assumptions / projections had to be made
- Unfortunately stakeholders were reluctant in providing commercially possibly sensitive data (cost distributions, ...)
- Partly stakeholders used different basis / definitions for providing data which made it difficult to compare (e.g. definition of block trains)
- No participant for a business case could be found

In the following a summary of the answers by the stakeholders is given. For confidentiality reasons the results of the individual stakeholder cannot be presented.

3.3.2 Data on Traffic

Data on traffic along the corridor and nation-wide was provided by the Infrastructure Managers and in Switzerland by the Ministry of Transport. They usually refer to the year 2008.

	corridor					nation			
country	trains	train-km	wagon-km	% of nation	% of corridor	trains	train-km	wagon-km	% of total
NL	18'000	2.7 mio	66 mio	22%	5%	100'000	12 mio	298 mio	4%
D	min. 172'000	32 mio	800 mio	12%	57%	2'500'000	264 mio	6'600 mio	78%
CH		12 mio	300 mio	57%	21%		21 mio	530 mio	6%
I	60'000	7.9 mio	200 mio	18%	14%	280'000	45 mio	1'100 mio	13%
Total		*55 mio*	*1'400 mio*	*16%*	*100%*		*342 mio*	*8'500 mio*	*100%*

Green fields = own calculation, assumption of 25 wagons/train

It can be seen that about 16% of total train-km in these countries are run on the corridor Rotterdam – Genoa. Whereas in Switzerland corridor traffic accounts for almost 60% of nation-wide train-km, this is only about 12% in Germany. Looking at the km-shares along the corridor, Germany covers about 57%, Switzerland 21%, Italy 14% and the Netherlands about 5% of the km run on the corridor.

No data was available on axle-km.

3.3.3 Data on Fleet

Answers from Railway Undertakings:

- Train-km run on the corridor: 2 – 95% (wide range!)
- Train length: 450-550m (max. 750m)
- av. wagons/train: 20-30 (CH: 15-25)
- Own wagon property:
  - 3 answers: 80-100%
  - 1 answer: close to 0%
- Percentage of silent / retrofitted wagons:
  - 2 answers: ca. 5% / 0%
  - 1 answer: 78% / n/a
- 2/4/6-axles: 23% + 75% + 2% (1 answer)
- av. age: ~25 years (2 answers)
  (thereof one answer with 60% > 25 years)

Answers from Wagon Owners:

- av. mileage: 20‘000 – 125‘000 p.a.
  (combined traffic: up to 150‘000 km;
  on some corridors up to 225’000 km)
- Silent / retrofitted wagons:

Answers:	1	2	3	4	5	6
Silent	0%	5%	5%	9%	20%	78%
Retrofitted	0%	n/a	0%	0%	n/a	45%[16]

- av. axles: 3.5 – 5.5 (there are wagons with 8 axles!)
  thereof ss-able (>120 km/h): 10 – 90%
- av. age: 10 - 25 years
- av. lifetime: ~30 years
- Renewal rate: 1 - 5% p.a. of fleet

[16] Source: „Lärmsanierung der Eisenbahnen, Standbericht 2008“ (BAV) and „Statistisches Vademecum, Die SBB in Zahlen 2008“ (SBB)

3.3.4 Economic Aspects

Answers from RU's and WO's:

- Relevance of corridor Rotterdam – Genoa:
  - RU's: 7-8 out of 10
  - WO's: relevant for 4, irrelevant for 1
- WO's possession title of their wagons:

Answers:	1	2	3	4
Ownership	100%	100%	93%	0%
Operative leasing	0%	0%	7%	100%

- av. rental time: wide range from days up to 10 years (4 answers)
- Maintenance: mostly in responsibility of WO's, depending on the rental contract
- Investment costs and additional maintenance costs:
  Most stakeholders refer to a Position Paper of the German Rail Freight Sector[17]
  According to a table in their Annex IV they state the following costs for a 4-axle wagon (not including transaction costs):

	LL-blocks	**K-blocks**
Retrofitting costs: Service life: Internal rate of return:	1250,- € to 2280,- € 8 years 12%	5650,- € to 7.450,- € 8 years 12%
→ Annuity:	225,- € to 410,- €	1015.- € to 1340,- €
+ additional maintenance costs:	500,- € to 600,- €	600,- € to 770,- €
= extra costs per year	725,- € to 1010,- €	1615,- € to 2110,- €
÷ 30.000 km	2,4 to 3,36 Cent/Wagon-km	5,4 to 7,04 Cent/Wagon-km
Per axle-km	0,6 to 0,84 Cent/axle-km	1,35 to 1,76 Cent/axle-km

- Expected impacts on the railway business in the short and long term from retrofitting:
  In general, without an appropriate subsidy, the additional costs on the sector are thought to lead to a modal shift of freight traffic to the road. It is also stated that on the long term low noise wagons are important to maintain the social acceptance of rail freight.

[17] „The Reduction of Sound Emissions caused by Rail Freight Transport, Position Paper of the German Rail Freight Sector", incl. "Anhang IV Kostenindikatoren des Sektors" (VDV / VPI / DB Schenker / DB Netz, January 2010)

3.3.5 Opinions on the Scenarios

Answers from stakeholders on questions concerning different parameters of the scenarios to be studied:

- Is it a realistic target of retrofitting all noisy wagons in Europe until 2020?
  → Different opinions, depends a lot on availability of LL-blocks. From a technical point of view it seems possible. From an economic point of view, most stakeholders will delay retrofitting existing wagons as long as possible, if the underlying conditions are not 100% clear, reliable and covering preferably whole Europe.
- Incentive level: 100%, must cover all costs (retrofitting, additional maintenance costs, administrative costs).
- Almost all stakeholders prefer a direct funding (easier, lower transaction costs) to a bonus.
- Most stakeholders prefer direct funding only for retrofitting wagons (i.e. not for "new" wagons which have to comply with TSI noise anyway).
- Bonus: very clear statements that a bonus should be handled as a separate factor, not within the TAC.
- Extra bonus for silent trains: maybe possible, but very expensive, rather ineffective.
- Preferred area of noise reduction policy: An introduction on national level is widely preferred to just a corridor level. A European-wide level would be even better.
- Level of harmonization: A full harmonization between the countries involved is widely preferred, but it is acknowledged that there are significant difficulties in implementing a fully harmonized solution.
- Basis of bonus: The costs depend on the number of axles, therefore an axle-based bonus would be the optimal solution. Because the information of axle-km per wagon today is not (easily) available, some stakeholders suggest basing the bonus system on wagon-km or even on train-km. In the future it might be possible to get axle-km by linking the National Vehicle Registers (NVR) with the information in the General Contract of Use for wagons (GCU).
- Technology: LL-blocks would clearly be preferred (after having passed authorisation).

3.4 Conclusions

- Most stakeholders were willing to cooperate and to contribute to a good solution.
- The feedback on scenarios and their parameters lead to slight adaptations / emphasis of the initial scenarios. I.e. a higher focus was set on the nation-wide scenario (details see chapter 4.1).
- The feedback on the scenarios will flow into the recommendations to the Ministries (see chapter 7).

4 Scenarios

4.1 Considerations for defining the scenarios

Based on the terms of reference 3 scenarios had been defined and discussed with the client. As a result of the feedback from the stakeholders (see chapter 3) the scenarios have been adapted. In the following the findings and interpreted consequences for the scenario formulation are presented.

The identification and definition of scenarios follows the principle of feasibility, this is that the majority of stakeholders (IM, RU, WO) recognise the viability of the options and show favourable positions upon a given instrument, measure or consideration for a scenario. The opinion and acceptance of the stakeholders is fundamental for the success of the program since there is a priority settled by the ministries of not damaging the freight railway transportation in benefit of road transportation. Certainly, this would occur if a law obligation against noisy rolling stock would be issued, triggering a rapid conversion of wagons into silent ones, yet entailing thereby important extra costs for the sector. Hence a survey has been carried out to discern the position of the market and to estimate the financial and technical challenges the sector may be ready to deal with. A cooperation and voluntary commitment of the stakeholders will enable a smooth transition and will let the technology and processes adapt to the new situation. As expected, the majority of stakeholders' branches show similar positions upon the different scenario aspects, achieving in many cases even agreed positions among them. The following aspects have been specially remarked by the stakeholders and thus included within the scenario considerations:

Preference for fully harmonized solutions; which guarantees a homogeneous incentive for silent wagons within the touched upon countries. The wagons eligible for being retrofitted are not usually captive of a given corridor, nor captive of an area/hinterland, neither a nation; the same happens with the railway companies, wagon owners and in some cases even infrastructure managers, which might have (or will have) undefined interests all over Europe.

A disharmonized approach adds more complexity and uncertainty to the retrofitting processes and funding schemes, which would increase the stakeholders' scepticism when taking active part of it. Therefore apparently harmonized solutions could be basic requirement for stakeholders' acceptation. Likewise, existing measures and programs running at present for retrofitting in Switzerland, in the Netherlands and in Germany (Leiser Rhein) should be reviewed and changed if not cleared in favour of harmonized solutions, altogether pursuing a clear and frontal action. Optimally, a harmonized European action should be representing the final approach for ensuring an effective and efficient retrofitting exercise of noisy rolling stock.

Bonus should be handled separately from the TACs (Track Access Charges) and considered as a direct funding scheme. By this harmonized solutions are possible and funds can flow directly from the public body to the cost-incurring parties (wagon owners, wagon maintainers) avoiding undesired bonus forwarding operations through railway undertakings.

The TACs are a very good example of disharmonized charging schemes in Europe. Therefore introducing a noise-dependant factor within the TAC for each country could easily lead to a disharmonized system. The majority of infrastructure managers point out the difficulty for implementing such a dedicated charging system and the railway undertakings declare that apart of the initial and running costs they may encounter important costs -transaction costs- for achieving proper bonus forwarding to the wagon maintainers. In conclusion, a direct funding scheme, this is from the public body to the final costs' bearers, being the wagon owners and wagon keepers, should make a more efficient use of money and resources (see chapter 5.1, transaction costs and technical solution).

Bonus should refer to axle-km performance because it portrays more accurately the LCCs of silent brake technologies. Additionally, initial investments costs, e.g. brake alteration to accommodate K-blocks, should be treated as one-time funding amount and not included in a km-dependant bonus. There are some stakeholders that would prefer a one-time direct fund that may cover not only retrofitting costs but also the future LCCs derived from the use of K- or LL-blocks. However, by this a WO has an interest to first retrofit wagons with low mileage because then he gets more money than he needs for additional maintenance costs. Moreover this option could fund wagons that are actually not circulating in the country and thus rules for discriminatory funding should be necessary.

There is a high diversity on LCC cost declarations depending on which party is being consulted about it, the stakeholders acknowledge the highest costs and EC consultants the lowest ones, with the values of Leiser Rhein being somewhat in the middle. The variability of conditions for utilisation, exploitation regimes, wagon and brake system layouts, axle loads, track geometry, etc. have influence on the final costs. Still in actual discussion and investigation are the costs derived of the increase of the equivalent conicity, so further costs' reviews should be expected (see also chapter 5, about the costs of the technologies).

The one time costs for retrofitting a wagon depend on the wagon characteristics and therefore they should be easily addressed by a one time fund, independently of the km performance. The categorization and delimitations of these funds, as well as the procedures and mechanisms for the fund solicitation and execution could be derived from the German project Leiser Rhein or the Swiss retrofitting program were experience is available.

Homologated LL-Blocks are preferred as silent brake technology for retrofitting. There is a rejection of K-Blocks due to principally high investment costs (one-time costs) for retrofitting. There are also important certification costs necessary for validating the altered brake system of wagons retrofitted with K-blocks. Another cost may be the risk incurred when installing K-blocks (opportunity costs), by which the wagon owner may not be able to install again Ci-Blocks, or to retrofit with LL-blocks if authorisation is eventually achieved.

Only a law obligation, as it is the case of TSI NOI and TSI WAG for new wagons, would induce the conversion of noisy wagons into silent ones with K-Blocks. However this would entail an undesired modal shift from rail to road, although this modal shift has not been quantified.

Additionally it has to be clarified that since 2007 the law obliges all new produced wagons to be released silent into the market and therefore they are equipped with K-Blocks as the only silent brake technology fully homologated at

present (with exception of disk brakes). This law does not affect old wagons (produced before 2007).

LL-Blocks are still under development and testing. Their LCCs are considered unacceptable for many stakeholders, especially when it comes to sintered LL-blocks, and some problems compromising safety have appeared (equivalent iconicity problem). Hence, LCC and safety problems of LL-Blocks need further studies and tests (EUROPE TRAIN Project). Apparently, a final authorisation could be achieved by the end of 2012 (optimistic).

Stakeholders may retrofit with LL- or K-Blocks if 100% of all the extra costs are covered by a funding program. These costs have been declared in a position paper of the sector [18]

There is a general inclination for the Nation-Wide scenario (and against the corridor specific scenario). The majority of consulted stakeholders agree upon a necessary national approach which would lead to a nation-wide bonus, the Europe-wide approach is even more defendable. Arguments for the nation-wide approach are:

- It is non-discriminatory with other corridors, tracks and persons that might have noise problems as well.
- There are only few wagons that are captive in the corridor. The immense majority circulates extensively all around their national networks or Europe-wide, doing on average only 15% of their mileage on the corridor (TUB estimate). A corridor-specific assignment of wagons by the RU is possible but it demands a special allocation effort, entailing very high costs. It furthermore goes along with economical disadvantages as the assignment of wagons attending to their noise emissions is not logistically effective. Leiser Rhein project itself has difficulties encountering wagons to be targeted in the corridor.
- It is administratively difficult, and thus expensive, to account the mileage done by a specific wagon or axle on a specific section. The information per section could be retrieved on train-km basis but for wagon or axle basis it should be necessary to employ additional systems, for example RFID chips and reading stations, which increases substantially the administrative costs of the program.
- Silent-train-km bonus could be suggested as instrument for a corridor specific targeting, however RUs consulted declare that the assignment of silent wagons to trains (silent train forming) is an exercise with immense costs. And in any case the administrative costs to compute and grant silent wagons belonging to silent trains should be high.

Bonus should be dedicated for retrofitted wagons; and not as a grant for new, and therefore silent wagons. The majority of stakeholders acknowledge that new wagons are and will still be employed regardless of their silent condition, so there is no reason for allocating funds for them for incentivising their acquisition. However this consideration should have more meaning if a sharp corridor scenario may be the case. There, the intentional assignment of silent wagons on the corridor should have its benefit in terms of noise reduction, though in detriment of other corridors/areas. Unfortunately in so doing, important costs

[18] The reduction of sound emissions caused by rail freight – position paper of the German rail freight sector (January 2010)

could be incurred by the RUs when intending to assign wagons upon their silent condition; RUs declare very poor influence on wagon allocation attending to their silent condition.

Summarizing, the funds of a nation-wide scenario should target exclusively the retrofitting exercise, being this furthermore a cheaper solution for the public body. Conversely the funds for a sharp corridor scenario (this might be the case) should target all silent rolling stock without distinction.

Malus or Ci-blocks prohibition is in general rejected by stakeholders. As example, an important loss is estimated by the Association of German Transport Companies – VDV (24.03.10 Communication from VDV to Leiser Rhein project) reporting:

- 306 Mio€/Year with K-blocks if a NDTAC (Noise Dependant Track Access Charges) with no funding is implemented (high transaction costs, similar to implement a malus)
- 204 Mio€/Year with LL-blocks if a NDTAC with no funding is implemented (high transaction costs, similar to implement a malus)
- 194 Mio€/year with K-blocks if the sector solves it internally (similar to a Ci-block prohibition)
- 92 Mio€/year with LL-blocks if the sector solves it internally (similar to a Ci-block prohibition)

The introduction of a malus threat or a Ci-prohibition threat is however necessary to impel a rapid and satisfactory retrofitting of the fleet and to avoid a hypothetic re-retrofitting, this is to install again Ci-blocks, especially when it comes to easy substitution of LL-blocks by Ci-blocks.

4.2 Scenario Definition

Attending to the above mentioned arguments and pursuing the feasibility of the retrofitting exercise the scenarios are defined as follows:

Scenario 1	**Scenario 2**	**Scenario 3**
Level of harmonisation full	Level of harmonisation full	Level of harmonisation full
Area Nation-wide	Area Nation-wide	Area Sharp corridor
Direct bonus per axle-km and direct aid for initial retrofitting cost of wagon	Direct bonus per axle-km and direct aid for initial retrofitting cost of wagon	Direct bonus per axle-km and direct aid for initial retrofitting cost of wagon
Addressing only retrofitted wagons	Addressing only retrofitted wagons	Addressing silent wagons
Technology LL (starting from the full authorisation of LL)	Technology K (LL does not achieve full authorisation)	Technology K and LL combined (LL achieves authorisation some years after starting the program)

Further descriptions are provided in the chapter 5.2.2 Scenario Analysis.

5 Model

5.1 Model description and input data

A functional spreadsheet has been programmed with the aim of simulating scenarios for wagon retrofitting and its derived noise abatement effect. The model is capable of forecasting the impact of several incentive mechanisms on the basis of silent or retrofitted axle-km deployed on a given area. During the development process of the model the stakeholder consultations have shown that certain considerations for scenarios had more adequateness and feasibility than others. This has paved the way for aligning the model with the feasible cases, enabling to achieve more accurate and meaningful results.

The following concepts have been included within the model, some of them parameterized.

5.1.1 About the fleet and fleet to retrofit

The input parameters for the model look as follows:

No. Freight Wagons	Netherlands	Germany	Switzerland	Italy	Total
Total Fleet (2009) (Source)	4.600 (KCW EC Study)	170.000 (Sector, BMVBS)	21.400 (BAV)	52.800 (Eurostat)	248.800
Meaningful Fleet to retrofit in 2013 (estimation)	2.400	90.000	4.600	27.000	124.000

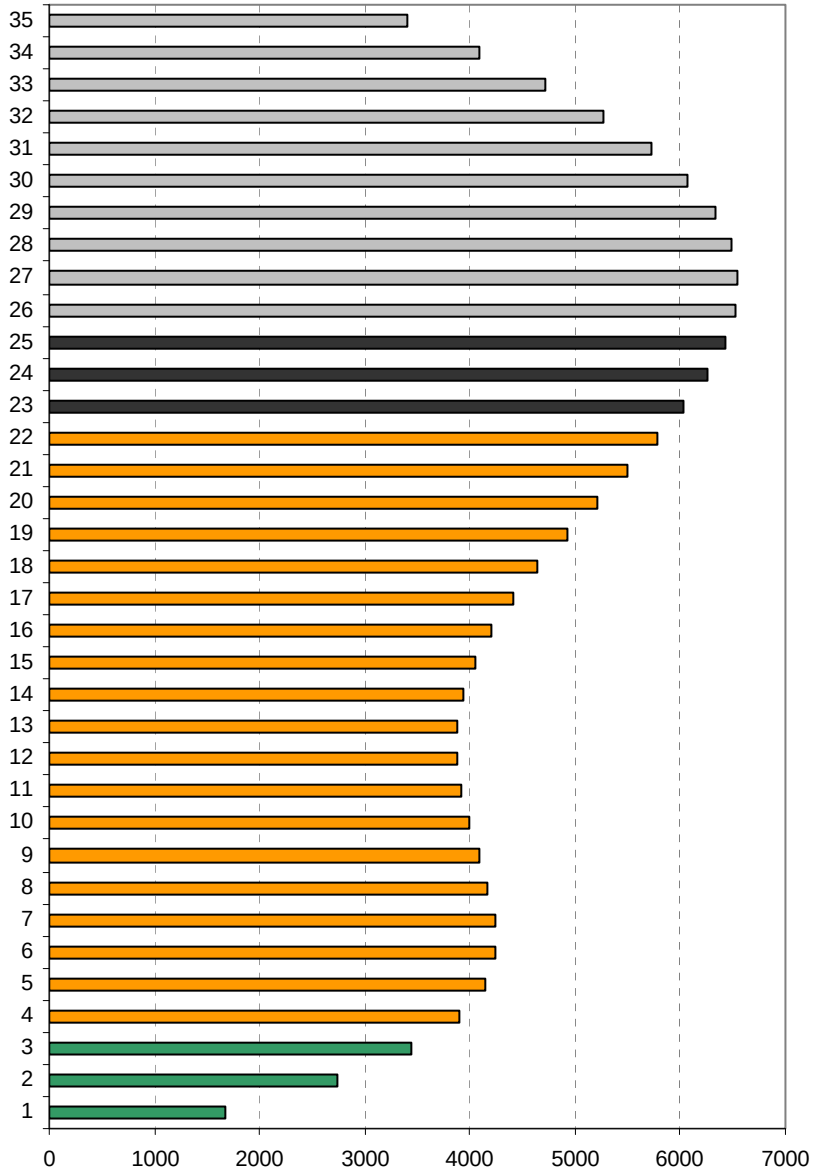
The estimation for the fleet to retrofit in 2013 derives from intermediate calculations, which are described as follows:

As regards as the importance of Germany (~77% of wagon-km and 68% of wagons in 2008/09) in the area under study, it is crucial to investigate its fleet characteristics and evolution, furthermore it is possible to obtain percentages and ratios that can be extrapolated to other fleets where detailed data has not been available.

170.000 wagons of total fleet in Germany is the result of adding the input values of DB Schenker (100.000) and private wagons (70.000) provided in the questionnaires from VPI and DB. The age distribution of the fleet was only partially available for private wagons; therefore a plausible estimation was necessary for DB fleet.

This was obtained considering that the DB fleet is on average 10 years older than the private fleet and with previous estimations contained in the document *"PWC 2007 Impact Assessment Study on Rail Noise Abatement Measures Addressing the Existing Fleets"* . Hence the age distribution for freight wagons in Germany has been assumed as:

Age distribution of freight wagons in Germany 2010
(Wagon age / number of units)



Source: DB (Partial) VPI, PWC 2007, own calculation; grey (old wagons in 2010); black (wagons that will be old in 2013); orange (wagons to retrofit); green (wagons built after 2006, TSI Compliant)

The amount of wagons meaningful for retrofit is a somewhat subjective value. Not all wagons of a given fleet are to be retrofitted, namely:

- Firstly, TSI NOI compliant wagons are already silent and they do not need to be retrofitted. These wagons are mainly wagons built after 2006 and few retrofitted wagons, making about 10.000 units in total according to the position paper of the German rail freight sector. This is about 6% of the total fleet.
- Secondly, old wagons may not be retrofitted because it may exist an unfavourable opportunity cost reason. In the questionnaires it is stated that the average lifespan of a freight wagon is 30 years, although there might be some wagons older than that. Thus wagons with an age close to 30 may be not interesting to retrofit, especially if K-block is the case. By LL-blocks this condition may be somewhat relaxed but it still will remain important. The assumption is that wagons older than 25 years will be retrofitted neither with K- nor with LL-Blocks. Considering this, the remaining wagons for retrofit will be around 110.000, (64% of total fleet)
- Thirdly, the program will not start in 2010 but apparently in 2012-2013, when LL-blocks might be homologated for regular operation or eventually K-Blocks recognised as only possible solution. In that future point a number of wagons will get old too and therefore they will be excluded from the retrofitting program too, resulting in about 90.000 for being retrofitted (53% of total fleet in 2009).

As Switzerland has initiated a silent conversion of their relevant freight fleet, there is an important amount of already silent wagons, which are the sum of the retrofitted and the new ones, this amount can be approximated in 7.000 units in 2010 (5.500 of the retrofitting program + 1.500 new wagons). In 2013 the retrofitted wagon amount will be higher, 6.700 units according to [http://www.bav.admin.ch/ls/01298/index.html]. If the same freight wagon age distribution and retrofitting criteria applies then it can be approximated that there will be 4.600 meaningful-to-retrofit wagons in 2013. Furthermore in the model it is considered that already retrofitted wagons (6.700 units) will be eligible for getting a km-dependent bonus that may cover their extra LCCs.

In the Netherlands there is not a significant silent conversion of the fleet although a retrofitting program has been launched, this is mainly due to the conditions and limitations for funding. Furthermore, the German company DB Schenker introduces a polarized decision factor on the retrofitting process in the Netherlands since it operates an important amount of the train-km within the country. There is apparently about 4.600 Dutch wagons [EC Study KCW], which by using the same ratios and percentages of the German case may result in 2.400 meaningful-to-retrofit wagons in 2013.

In Italy there is not a retrofitting program to report. Therefore same percentages and ratios of the German case have been applied obtaining a total amount of 27.000 meaningful-to-retrofit wagons by 2013.

5.1.2 About the retrofitting rate

The retrofitting rate is a very important parameter that determines the success of the program, it depends mainly on the amount and conditions for the funding bonus, as well as on the market capacity to supply properly the brake blocks and workshop capacity to undertake K-block retrofitting of wagons. The German fleet is a crucial element of the program, it is regarded with special interest since its evolution may influence and determine the performing of the other fleets.

The German rail freight sector, mainly represented by VDV, VPI, DB Schenker Rail and DB Netze, declares that to retrofit the meaningful noisy fleet with K-blocks may take 8 years.

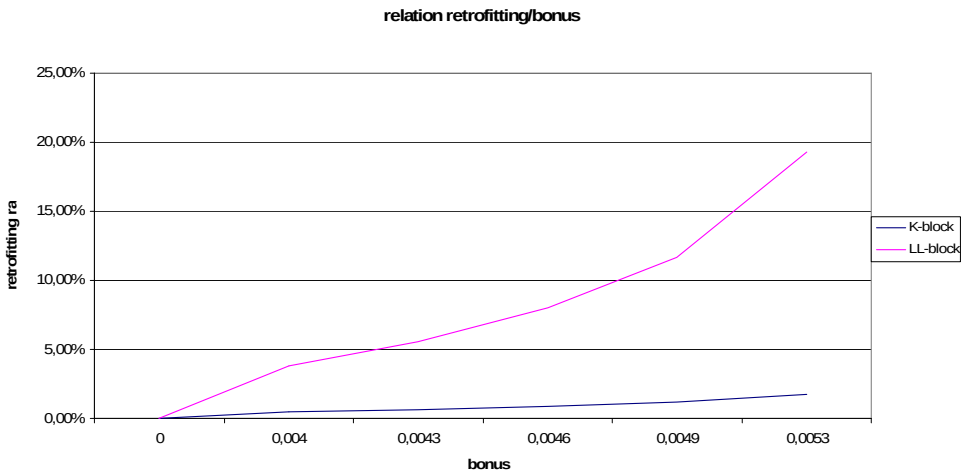
Considering that the amount of wagons relevant to retrofit in Germany are in 2009 about 110.000 of a total fleet size of 170.000 wagons, a first estimation of a retrofitting rate would be: 110.000/8=13.750 wagons per year (only Germany) which is about 13.750/170.000=8% of the fleet to be retrofitted per year; this percentage may be extrapolated to other countries due to a lack of data.

The retrofitting rate with LL-blocks should be higher than the one with K-blocks because the easier process, where only a mere substitution of blocks has to take place. On this subject, the stakeholders declare that the retrofitting process with LL-blocks should be depending more on the supply performance than on any other factor. In so doing, the supply market of LL-blocks should attend a very high and extraordinary demand of LL-blocks at the very beginning of the program and having a drop after this. The theoretical demands should be (German case): LL-blocks for 90.000 wagons during the retrofitting process and LL-blocks for 40.000 wagons a year after it. This last amount is calculated as:

- 120.000 km averaged duration of an LL-block (Leiser Rhein) / 55.000 km averaged mileage of a silent wagon per year (see below discussion about wagon mileage) = 2,2 (average duration -years- of the LL blocks in a wagon)
- 90.000 wagons /2,2 ≈ 40.000 wagons that will need new LL-Blocks per year in Germany

It is assumed that the LL-block producers will try to fine-tune their production output with the expected mid-term demand in order to optimise their business, so a 40.000 wagons/year might be a reasonable retrofitting rate for LL-blocks. This is 23% of the total fleet to be retrofitted per year.

In order to simulate the wagon owners' reaction to the incentive mechanisms, a nonlinear function is created to present the likeliness that the WOs decide to retrofit under certain conditions. By this, a retrofitting rate – in % of retrofitted wagons p.a./total fleet - can be obtained in relation to the bonus amount.



Therefore, higher bonuses should lead to higher retrofitting rates (up to the limit for the supply) and lower bonus to lower ones, being the decrease an exponential function depending on the costs expectations of the sector.

The above graphic applies for additional LLC of 0,3 Eurocent/axle-km for K- and 0,4 Eurocent/axle-km for LL-blocks.

The expected retrofitting rate is adjusted with the calculations and desired bonus rates from the German rail freight sector in annex IV of their position paper from January 2010. It function reacts to cost changes the same it does to bonus payments.

And the estimated max. retrofitting rates employed for the model:

Est. max. Retrofitting Rate (No. Wagons/year)	**LL-Blocks**	**K-Blocks**
the Netherlands	1.000	360
Germany	40.000	13.750
Switzerland	7.000	2.400
Italy	13.000	4.500
4 Countries	61.000	21.010

5.1.3 About the costs of the technologies

The majority of stakeholders acknowledge that with 100% of costs covered by the program they will retrofit, additionally they have provided figures of their cost expectations (Annex to the Position Paper of the German Rail Freight Sector) namely:

German rail freight sector		
Technology	Initial Costs EUR / axle	Extra Maintenance Costs EUROCENT/ axle-km
LL-Blocks	312-570	0,4-0,5
K-Blocks	1412-1862	0,5-0,6

Stakeholders costs (calculated per axle)[19]

Hence if the bonus covers the maximum LCC declared by the stakeholders, the retrofitting rate may rise to the plausible maximum, conversely if the bonus is decreased, the retrofitting rate may decrease as well (exponentially), especially if going below the minimum costs declared by the stakeholders. Retrofitting rates may be modified if malus or prohibitions for noisy wagons are introduced.

[19] *Source: Attachment to position Paper of German rail freight sector*

The retrofitting rates for K-block technology are lower than the ones for LL technology because the higher initial costs.

There are other costs figures estimated by the Leiser Rhein project that look as follows:

Leiser Rhein		
Technology	Initial Costs EUR / axle	Extra Maintenance Costs EUROCENT/ axle-km
LL-Blocks	277-700	0,35-0,45
K-Blocks	1800-2300	0,27-0,32

Leiser Rhein costs (calculated per axle)[20]

By this, the figures of Leiser Rhein project show a high variability on investment costs that may respond to the different configuration of the brake pads, being these Bg (simple block) and Bgu (double block). The material of LL-blocks is also determinant for the cost being the organic LL-blocks cheaper and more silent than sintered ones. Further cost reductions of initial costs for LL-blocks should be expected if authorisation is achieved because economies of scale in production. A simple calculation may reveal a long term figure for initial costs of LL retrofitting (considering Bg configuration):

Cost of LL-block 35€ (cost assumed similar as K-block, from Leiser Rhein) –Cost of Ci-Block 8€ (Leiser Rein)= 27€; Extra cost per axle= 27x4= 108€. The extra retrofitting costs for Bgu (double block configuration) could be double, an averaged value could be 150€/axle

At the moment there is ongoing work on in-service tests (Hupac, AAE) that should be useful to get a better comprehension of LCC and wear behaviour of LL-braked wheels in standard conditions of operations.

For the moment the averaged values of the Leiser Rhein are employed for the calculation on the model, being:

Model Costs		
Technology	Initial Costs EUR / axle	Extra Maintenance Costs EUROCENT/ axle-km
LL-Blocks	488 (150€/axle long term)	0,4 (0,3 eurocent/axle-km long term)
K-Blocks	2091	0,3

There are nowadays several ongoing pilot tests for LL-blocks that will bring about more knowledge on LCC and behaviour of this kind of technology. Optimally, by the authorisation of LL-blocks, in 2012, more knowledge of these costs may be available. For the moment, a conservative value of 0,4 Eurocent/axle-km is being employed. However this cost may decrease because of experience and learning curves, better production processes, better maintenance operations etc.

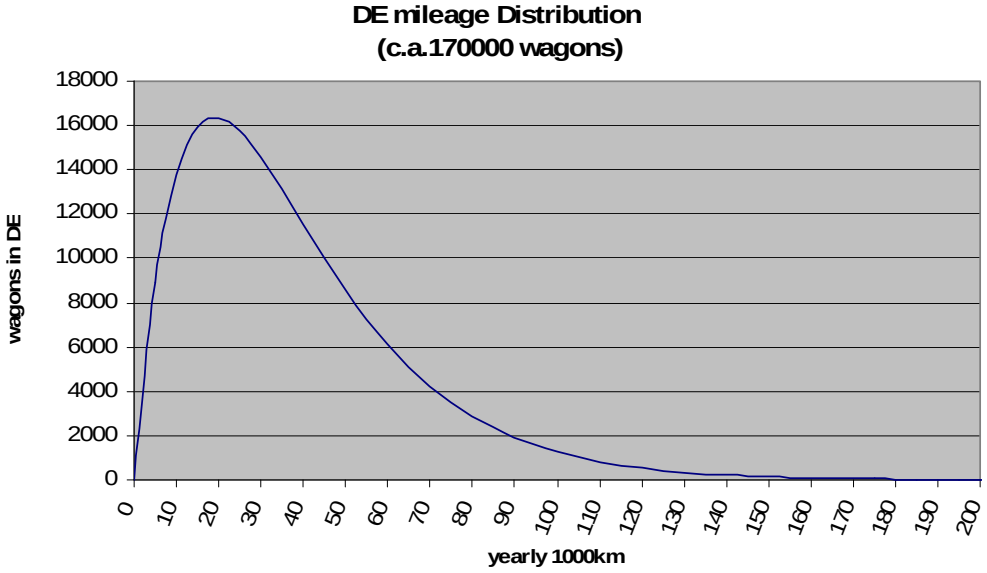
[20] *Source: Ingenieurwerkstatt*

The costs of the LL-blocks and their LCC may resemble in the long run to the ones of K-blocks.

5.1.4 About wagon mileage

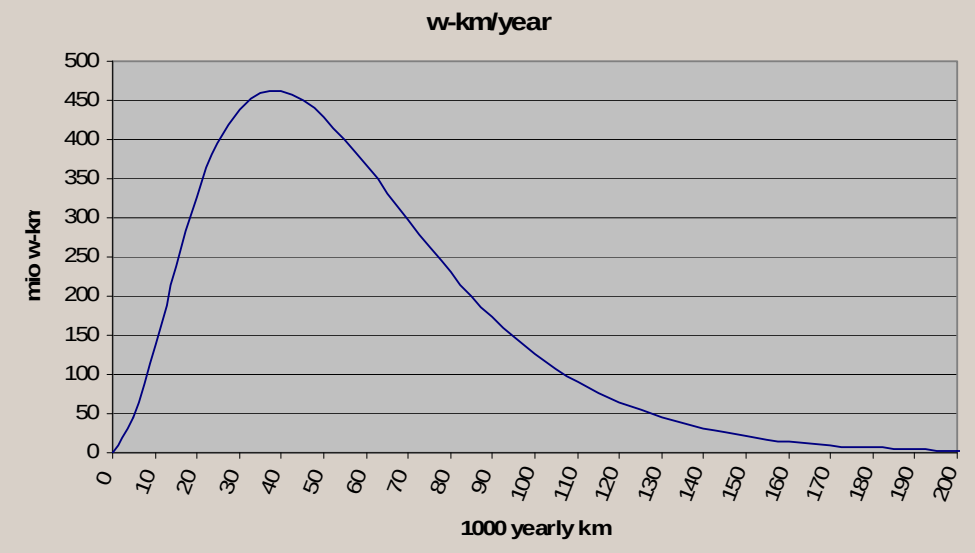
The yearly mileage of the wagons circulating within the area under study has values from almost nothing to 200.000 km a year, depending mainly on the kind of wagon and company exploiting it. Then so, by nation-owned companies as DB Schenker, the yearly mileage tends to be smaller than by private companies, reaching in this last case, especially in container transport, values of 150.000 yearly km per wagon on average.

Considering that in Germany there are 6600 millions of wagon-km per year (DB Netze input) and 170.000 wagons a first approximation to the average mileage should be about 40.000 km per wagon and year.
As regards as the lack of accurate data on wagon mileage distribution, a distribution has been produced for modelling purposes:



Gamma distribution from averaged values of 40.000 km/year

Furthermore, a simple calculation (amount of wagons x each averaged mileage per year) can be represented in a graph in order to see which wagons are doing the most wagon-kilometres in the German network, being:



Wagon-km performance in respect to mileage of wagons

The wagons with mileages between 20.000 and 90.000km a year are responsible of 85% of the total wagon-km on the network. Wagons below 20.000 km a year may not be retrofitted within the funding program since their natural block wear and thus replacement cycle may be more than 4 years. On the contrary, wagons with high wagon mileage will be retrofitted earlier because they get their Ci-blocks replaced more often, about two times per year for a container wagon. This fact increases the average mileage of retrofitted wagons, which has been estimated in 50.000 km a year. This value approximates from the safe side the fact that "high runners" (e.g. container wagons) may enter before in the program, the value has been proportionally extrapolated to the other countries.

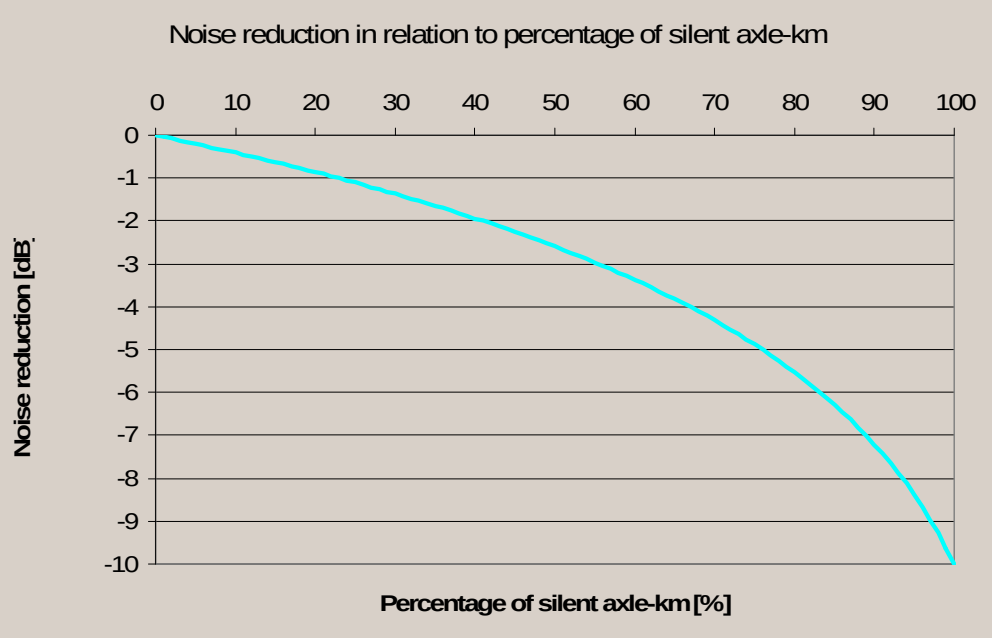
There is another fact that has been considered relevant for the results: It is that the expected increase of railway performance in the forthcoming years will make increase the averaged yearly mileage of the wagons. The expectations are that wagon-km performance should be growing at a pace of 2% in railway networks overall[Eurostat] (in the corridor Rotterdam-Genoa this pace should be around 5%, by this in year 2025 the traffic performance would double[21]). As the total amount of wagons of the fleets is decreasing or stagnating [Eurostat], the averaged yearly mileage should be growing; values from Eurostat confirm a trend of max. 4% increase of averaged mileage of wagons.

For model purposes the increase of average mileage would go from 50.000 to 60.000 in 5 years, for a safe side approach, a value of 55.000 has been taken as averaged yearly wagon mileage for cost calculations.

5.1.5 About noise reduction

The following logarithmic conversion has been employed for roughly ascertaining the noise reduction derived of an increase of silent axle-km on a given area:

[21] Source: PMO corridor A



It is assumed that organic blocks (K and LL) have a maximum noise reduction of 10 dB. The logarithmic proportion is partially based on the free publications of Mr. Kalivoda (PSIA Consulting, Austria).

The noise decrease effect in relation to amount of silent-axle-km responds to a mere mathematical expression that looks as follows:

$$N = 10 \cdot \log_{10}\left(\frac{n_n \cdot 10^{0,1 \cdot N_n} + n_s \cdot 10^{0,1 \cdot N_s}}{n_n + n_s}\right)$$

Where:

- N: noise level
- Nn: noise level of noisy wagons
- Ns: noise level of silent wagons
- nn: number of noisy wagons
- ns: number of silent wagons
- In the case the intention was to present the change of the noise level and not the overall noise level. Therefore relative values were chosen as follows:
- Nn=0
- Ns=-10

5.1.6 About the funding period

The model has been programmed to calculate different funding periods, from 3 to 10 years. In so doing, retrofitting schemes for LL-blocks will have shorter funding periods and retrofitting schemes for K-blocks larger ones.

As discussed, LL-block retrofitting rate is much higher than K-block because the retrofitting process is much easier. Therefore optimally, the retrofitting with LL-block could be completed in minimum 2 years and with K-block in minimum 5 years.

As the retrofitting process will not start at its full speed the very first day, but the supply market will have to adapt to the situation progressively, it is estimated that the minimum time for LL-blocks retrofitting is 3 years and for K-blocks 6 years. Furthermore 6 years is the averaged cycle of maintenance of freight wagons in which K-block retrofitting could take place more smoothly.

The choice of the funding period is also of crucial importance for the implication of WO in the retrofitting process. The extra LCC of the silent wagons will obviously continue after the end of the funding period, which means that the WO should have to face the LCC on their own. Optimistically, the development of the LL-blocks and maintenance processes of wagons in the future will be good enough to reduce the costs derived of their use. The funding period should be long enough to permit the LL or K-block technology evolution and short enough to make pressure on it. A cast iron-block prohibition should be introduced not very late after the completion of the program.

5.1.7 About administrative and transaction costs

The majority of stakeholders declare that a direct funding should be the best and easiest instrument for executing the funding for retrofitting, if this might be the case. The direct funding is understood in the model as direct payment from public body to cost bearer, being this wagon owner and wagon maintainer.

The direct funding is divided in two elements:

- Initial funding, to cover the costs of the initial retrofitting
- Km-dependent funding, or bonus, to cover the extra LCC derived from retrofitting

There are two more cost elements that will appear as result of the initiation of the program:

- Administrative costs: necessary costs of the public body to launch and maintain the program
- Transaction costs: necessary costs to gather the necessary information for enabling the claim of the funding

Administrative costs

The administrative costs of a NDTAC system were approximated in the study of PWC 2007 *"Impact Assessment Study on Rail Noise Abatement Measures Addressing the Existing Fleets"* as (pag. 70); in concrete 3,2 Mio€ of start-up and 3,6 Mio€/year of ongoing for 18 EU countries plus Switzerland. As there is a lack on data upon this issue for the present project and bonus scheme the figures of PWC (maximum values) are considered for an approximation. Assuming a price increase of 2% p.a. (since 2007) the costs for 2013 (est. start date of the program) would be 3,6 Mio € for start-up and 4 Mio€/year for running the system. A proportional distribution of the ongoing costs for the Netherlands, Germany, Switzerland and Italy has been done in proportion to their wagon-km performance in respect to EU18+CH, being:

	% of wagon-km in EU18+CH (From Eurostat 2010)	Administrative initial Costs	Administrative ongoing costs
The Netherlands	1,5%	>100.000€	>100.000€/year
Germany	31%	≈1.000.000€	≈1.200.00€/year
Switzerland	3%	>100.000€	>150.000€/year
Italy	6%	> 250.000	>250.000€/year

Transaction costs and technical solution

These are costs incurred by the stakeholders, mainly Railway Undertakings (RU) when processing, collecting and reporting specific wagon mileage data. In the direct funding, the wagon owners or wagon maintainers (WO) need country-specific information of their wagons' mileage in order to claim a km-dependent bonus from the pertinent public body.

In the current situation, the RU may provide the WO with information about the aggregated wagon mileage of its wagons, by this the WO could retrieve information of overall cumulated km of its wagons, with which among other things can be used to optimize the maintenance operations. Apparently this information does not contain country-specific data, so the WOs do not usually know exactly where and when their wagons have run, or at least they do not get this information cost-free or automatically. To be able to get the necessary information, the railway companies' information systems and processes should be modified in order to automate the specific data collecting. Apparently these modifications should enable the automatic account and report of wagon mileage on a country basis and should entail costs that the WO should bear.

If country specific data is not available, the WO can not demonstrate that the mileage has been actually done inside the country from which the bonus should be retrieved and therefore WO may encounter some problems to claim for a bonus.

The company DB Schenker published (Presentation of Mr. Schmidt of 29.10.09 Rome for Corridor A) a first and rough estimation of the costs for the system; case of a simple bonus system based on (NVR+ GCU-Mileage Model).

The proposed billing is done by the combination of two items:

- Information about wagons contained in the static database of the National Vehicle Register (NVR), for wagon country identification
- Information about wagon mileage to be included within the GCU (General Contract of Use for Wagons) by which the country specific mileage should be available for the WO

In so doing, DB Schenker declares:

> *"If direct funding of the wagons is not possible, DB Schenker Rail favors a simple bonus system (NVR + GCU-mileage model) with financial compensation by the member state. Preferably directly via a central funding authority, if needed via IM's billing"*

And the billing/recording procedure

> *"The wagon owner has the right (not free of charge) to query the mileage of his wagons from the custody RU – data are stored for at least one year*
>
> *The wagon owners sum up the mileage per wagon*
>
> *Once a year the wagon owner reports the aggregated mileage per wagon combined with the retrofitting status silent/ noisy (according to NVR entry) to the central funding authority"*

And the approximated transaction costs of it:

- Implementation cost 1Mio €
- Ongoing costs < 10 Mio€/year

As the reported ongoing costs refer to a total fleet of 130.000 wagons the division 10Mio/130.000 yields:77€ per wagon and year

This value, together with the implementation cost (equal for every country) has been introduced in the model.

Further reviews of this specific transaction, billing and recording amounts and procedures for bonus funding may appear as soon as ongoing work on the subject might be produced from the Pilotproject Leiser Rhein.

5.2 Results

5.2.1 Cup calculation

A cup calculation is produced in order to identify a plausible maximum for the retrofitting costs to be borne by the sector (if not funding is considered), the retrofitting achievement is considered instantaneous (all wagons are retrofitted the very first day of the program):

	NL	**DE**	**CH**	**IT**	**4 Countries**
Meaningful Fleet to retrofit in 2013	2.400	90.000	4.600 (6.700 already retrofitted*)	27.000	
Initial Cost LL	Initial cost	Initial cost	Initial cost	Initial cost	Initial cost
488€/axle	4m €	154m €	8m €	46m €	212m €
Extra Variable Cost LL	Variable per year	variable per year	variable per year	variable per year	variable per year
0,004€/axle-km	2m €	70m €	9m €	21m €	100m €
Initial Cost K	Initial cost	Initial cost	Initial cost	Initial cost	Initial cost
2091€/axle	17m €	658m €	33m €	197m €	907m €
Extra Variable Cost K	Variable per year	variable per year	Variable per year	variable per year	variable per year
0,003€/axle-km	1m €	52m €	6m €	15m €	75m €

The cup figures consider averaged cost values calculated from Leiser Rhein, an averaged wagon yearly mileage of 55.000 km and 3,5 axles per wagon.

Furthermore, the following table reports plausible maximums for different funding periods:

Maximums	Years	NL	D	CH	IT	Total
Cup LL	3	10m €	362m €	34m €	108m €	514m €
Cup LL	4	11m €	431m €	43m €	129m €	614m €
Cup LL	5	13m €	500m €	51m €	150m €	715m €
Cup K	6	26m €	970m €	73m €	291m €	1.360m €
Cup K	7	27m €	1.022m €	79m €	307m €	1.436m €
Cup K	8	29m €	1.074m €	86m €	322m €	1.511m €

The cup calculation shows the magnitude order of the amounts that might be incurred by the sector.

A minimum table is represented by only the initial costs for each technology considering a low initial retrofitting cost of 108€/axle (see costs of technology) for LL and 2091€/axle for K:

Minimums	Years	NL	D	CH	IT	Total
Cup LL	3	0,84m €	31m €	1,4m €	9,4m €	43m €
Cup LL	4	0,84m €	31m €	1,4m €	9,4m €	43m €
Cup LL	5	0,84m €	31m €	1,4m €	9,4m €	43m €
Cup K	6	17m €	659m €	34m €	197m €	907m €
Cup K	7	17m €	659m €	34m €	197m €	907m €
Cup K	8	17m €	659m €	34m €	197m €	907m €

Being possible to obtain an averaged cost for a successful retrofitting program where all targeted wagons become silent. Table result of the averaged value of maximum and minimum:

Averaged	Years	NL	D	CH	IT	Total
Cup LL	3	5.2m €	196m €	18m €	59m €	278m €
Cup LL	4	6m €	231m €	22m €	69m €	329m €
Cup LL	5	7m €	266m €	26m €	80m €	379m €
Cup K	6	22m €	814m €	53m €	244m €	1.134m €
Cup K	7	22m €	840m €	56m €	252m €	1.172m €
Cup K	8	23m €	866m €	60m €	260m €	1.209m €

Thus, this table shows an approximation to a plausible monetary effort to be borne by the sector for a silent conversion during the specified years. Obviously the sector would have extra costs after the conversion since the utilisation of silent brakes entails extra maintenance costs. This extra costs have been approximated in about 100mio€/year, however the costs are likely to decrease if technology and experience improve.

5.2.2 Scenario Analysis

Attending to the different arguments under discussion and pursuing the feasibility of the retrofitting exercise four main scenarios have been defined[22].

<table>
<tr><th>Scenario 1
nation-wide (LL)</th><th>Scenario 2
nation-wide (K)</th><th>Scenario 3
corridor (K/LL)</th><th>Scenario 4
CI-prohibition (LL)</th></tr>
<tr><td colspan="4">full harmonisation</td></tr>
<tr><td colspan="4">direct aid for initial retrofitting cost of wagon (nation-wide)</td></tr>
<tr><td colspan="3">bonus per axle-km</td><td rowspan="2">No bonus</td></tr>
<tr><td colspan="2">addressing only retrofitted wagons,
Nation-wide</td><td>addressing all silent wagons,
Limited to corridor</td></tr>
<tr><td>LL Technology (starting from the full authorisation of LL)</td><td>K Technology (LL does not achieve full authorisation)</td><td>K and LL Technology combined (LL achieves authorisation some years before starting the program)</td><td>LL Technology (starting from the full authorisation of LL)</td></tr>
<tr><td>3 years Funding period[23]</td><td>6 years Funding period</td><td>6 Years Funding period</td><td>5 Years Funding period</td></tr>
</table>

Scenario 1

This scenario is regarded by the majority of the stakeholders as the most suitable for achieving a cost-effective and satisfying retrofitting exercise. The scenario assumes that the LL-block achieves a full authorisation at a certain point in time. Expert consultations (Lloyds Rail register and DB Schenker) indicate that an optimistic date for authorisation should be by the end of 2012, so optimistically, the program could start in 2013. The starting date is important for modelling purposes because it influences the amount of fleet suitable for retrofitting, which may decrease every year at a pace of 5% (value calculated from wagon age distribution and assumptions reported in the model description). Hence scenario 1 has been calculated with values for starting date 2013, further delays on starting would cause a general decrease of costs because having fewer wagons to retrofit.

[22] Scenario 4 had been added at the very end of the study, based on the feedback from the working group and stakeholder meeting in Frankfurt on 7 April 2010. Due to this, not the complete calculations / modelling could be done for this scenario.

[23] The funding periods stated in this table are a result of the optimization process of the model.

The fleet values:

No. Freight Wagons	***Netherlands***	***Germany***	***Switzerland***	***Italy***
Total Fleet (2009) (Source)	4.600 (KCW EC Study)	170.000 (Sector, BMVBS)	21.400 (BAV)	52.800 (Eurostat)
Meaningful Fleet to retrofit in 2013 (estimation)	2.400	90.000	4000	27.000
Reported Mio w-km/year per country (questionnaire)	300	6.600	530	1.125

The scenario assumes that there is a direct aid of 100% per initial retrofitting costs and a bonus per retrofitted axle-km to be paid by the member states.

The amount for direct aid has been calculated with a safe-side value of 488€/axle for LL-blocks (Calculated from Leiser Rhein), the amounts mirror the extra costs for installing LL in comparison to a regular maintenance with Ci-blocks. However this value input has been parameterized since further cost decreases of LL-blocks are expected. As example a minimum value can be obtained as regards as the following calculation:

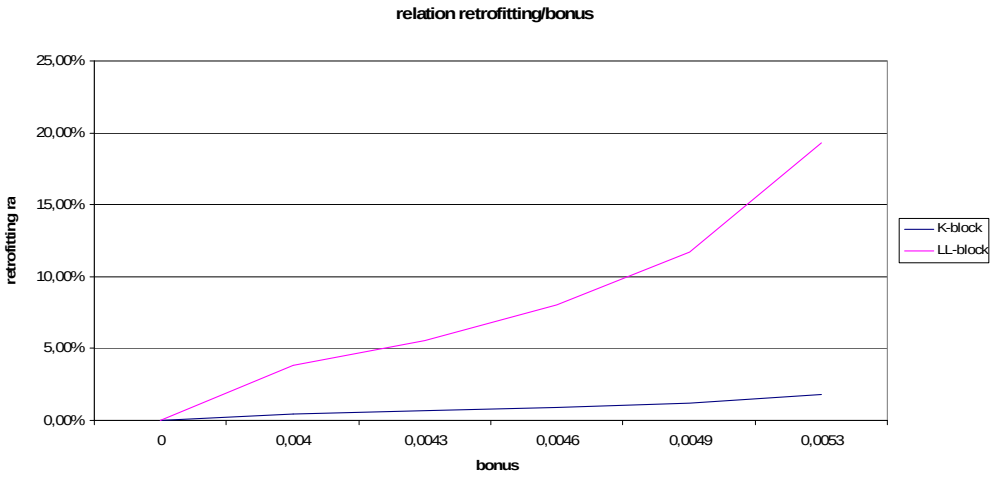
Cost of LL-block 35€ (cost assumed similar as K-block, from Leiser Rhein) – Cost of Ci-Block 8€ (Leiser Rein) = 27€; Extra cost per axle= 27x4(blocks per axle in Bg) = 108€, The extra retrofitting costs for Bgu (double block configuration) could be double, an averaged value could be 150€/axle.

The direct aid is paid directly from public body to cost bearer, billing may be based on Leiser Rhein guidelines for funding and costs from WO side to this process are considered negligible for the calculation. Costs for the public body are included within the administrative costs described below.

The value for additional maintenance costs of LL-blocks has been assumed as 0,004€/axle-km, cost reductions are possible due to improved maintenance and further development of LL-blocks. The assumption is that a mid-term minimum cost should be 0,003€/axle-km, which is the one reported by Leiser Rhein for K-blocks. This is assumed so because organic LL-blocks (the ones apparently to be favoured in detriment of sintered ones) and K-blocks are made of similar materials and show similar brake behaviours.

The current value of the LCCs has influence on the bonus necessary for incentivising the participation of the stakeholders in the program, then so, if a common accepted value for LCC is 0,004€/axle-km a higher bonus should be necessary in order to incentivise the WO participation. The bonus should cover not only the acknowledged LCCs but also the transaction costs and risks' costs the WO may have. To that aim a function has been created. It represents the retrofitting rate (% total fleet) in comparison to the funding bonus, the function is different for different accepted LCC.

Function for LCC 0,004€/axle-km:



For lower LCCs the bonus that would incentivise the retrofitting would be lower, as example the function for LCC 0,003€/axle-km.

The funding period has been set in minimum 3 years, which is considered the shortest time to retrofit the meaningful noisy fleet. The retrofitting rate (amount of retrofitted wagons per year) is estimated at 23% (see fleet discussion) of the total fleet, which in Germany is equivalent to 40.000 wagons a year. Longer funding periods lead to more payments as the wagons have longer periods to claim their mileage.

Additional costs of transaction and administration are considered as follows:

Other costs	***Administrative initial Costs***	***Administrative ongoing costs***	***Transaction implementation costs***	***Transaction ongoing costs***
The Netherlands	100.000€	100.000€/year	1.000.000	77€/ wagon-year
Germany	1.000.000€	1.200.00€/year	1.000.000	77€/ wagon-year
Switzerland	100.000€	150.000€/year	1.000.000	77€/ wagon-year
Italy	250.000	250.000€/year	1.000.000	77€/ wagon-year

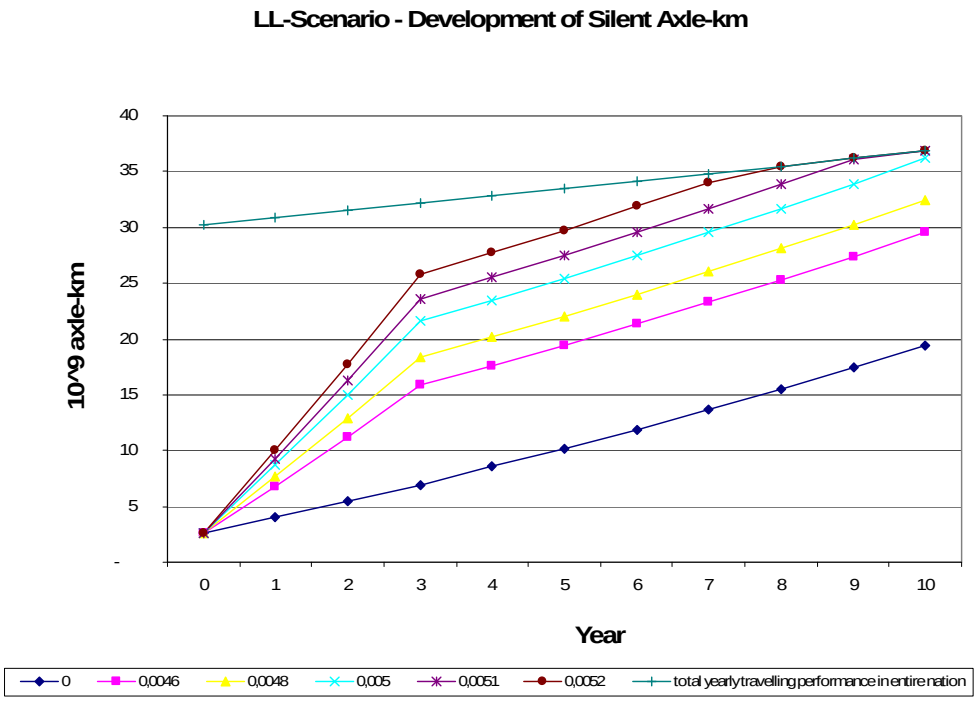
Other intermediate parameters are listed as follows:

Averaged yearly mileage of retrofitted and silent wagons	55.000
Yearly growth of overall averaged mileage	4%
Yearly growth of traffic	2%
Yearly growth of fleet	-2%
Averaged No. axles per wagon	3,54
Averaged No. wagons per train	25
Max. dB reduction of LL-blocks	10

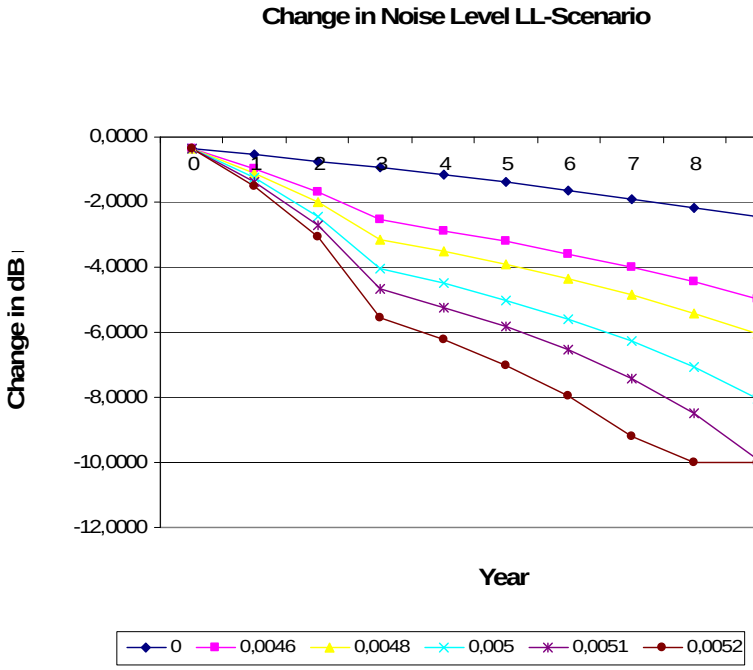
Furthermore an additional parameter has been introduced to simulate the fact that old noisy wagons may have a reduced mileage in comparison with new or retrofitted wagons. The model assumes that noisy (old) wagons do in average 10% less mileage in comparison with new or retrofitted ones. This is assumed so because as wagons get older they tend to be progressively withdrawn from operation. Besides the stakeholder consultation has shown that stakeholders with a younger fleet have a considerably higher average travelling performance for their wagons.

Scenario 1a - Cost Pessimistic [LCC=0,004€/axle-km, Initial costs 488€/axle]

Result for LCC cost of 0,004€/axle-km and initial retrofitting costs of 488€/axle and different bonuses from 0 to 0,0052 €/axle-km:



And the estimated noise reduction (logarithmic transformation):



Having the following costs estimations:

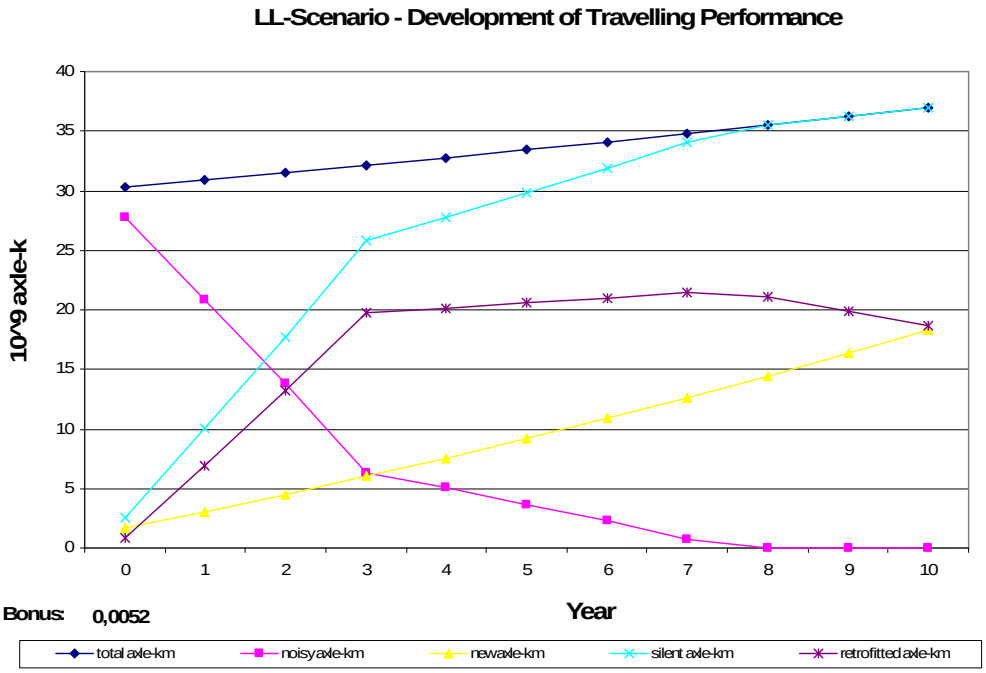
Bonus €/axle	*0*	*0,0046*	*0,0048*	*0,005*	*0,0051*	*0,0052*
Cost for MoT Germany	0	150m	193m	249m	282m	320m
Cost for MoT Italy	0	36m	46m	59m	67m	76m
Cost for MoT Netherlands	0	5m	6m	8m	9m	11m
Cost for MoT Switzerland	0	14m	16m	18m	20m	21m
TOTAL (added up)	0	206m	262m	335m	380m	429m
Years to reach fully silent performance	> 20	c.a. 16	c.a. 14	10	9	8
Noise Level in Year 10 compared to Before Program [dB]	-2,78	-5,55	-6,82	-9,30	-10,00	-10,00

(Amounts include 100% direct aid costs and administrative costs; transaction costs are not included)

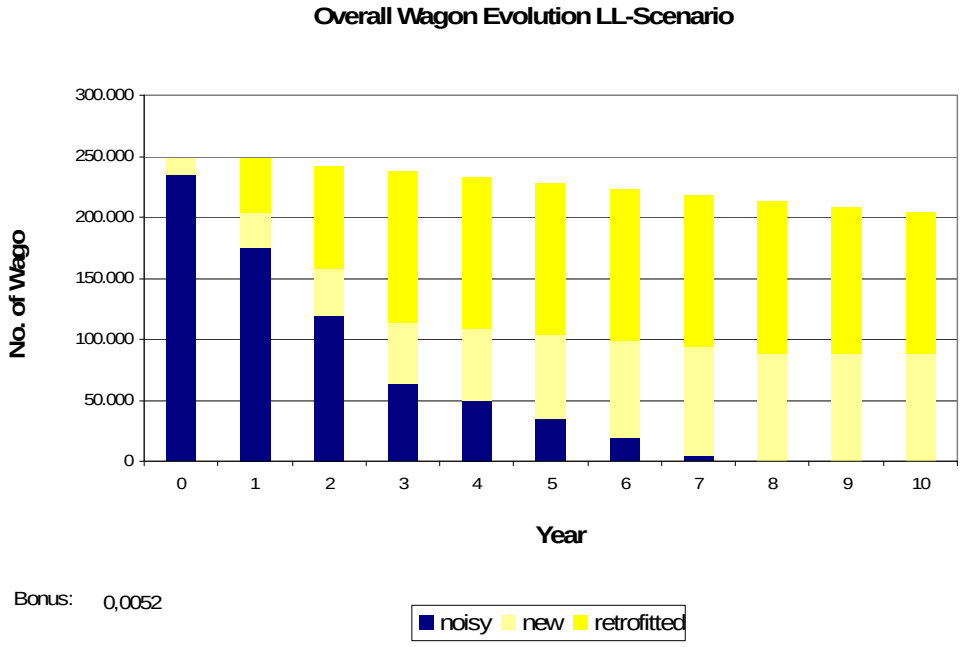
The bonus 0,0052 €/axle, equivalent to roughly 2 cents per 4-axle wagon-km, would trigger a rapid conversion of the fleet with total costs of about 430 Mio€. The following table portrays more detailed information on cost allocation:

0,0052€/axle	*DE*	*IT*	*NL*	*CH*	*Sum*
Initial Funding [EUR]	156m	48m	3m	8m	215
Bonus Payments [EUR]	160m	27m	7m	13m	208
Administrative Cost [EUR]	4,6m	1m	0,4m	0,5m	6,5
Sum as % of the TAC incomes over the funding period	16%	23%	14%	12%	15%
TAC Incomes in 3 years [Mio €]	2.059	338	79	179	2.655
Transaction Cost [EUR]	15m	5m	1m	3m	24

A graphic visualization of the travelling performance by type of axles (noisy, retrofitted, new, silent=retrofitted + new and total):

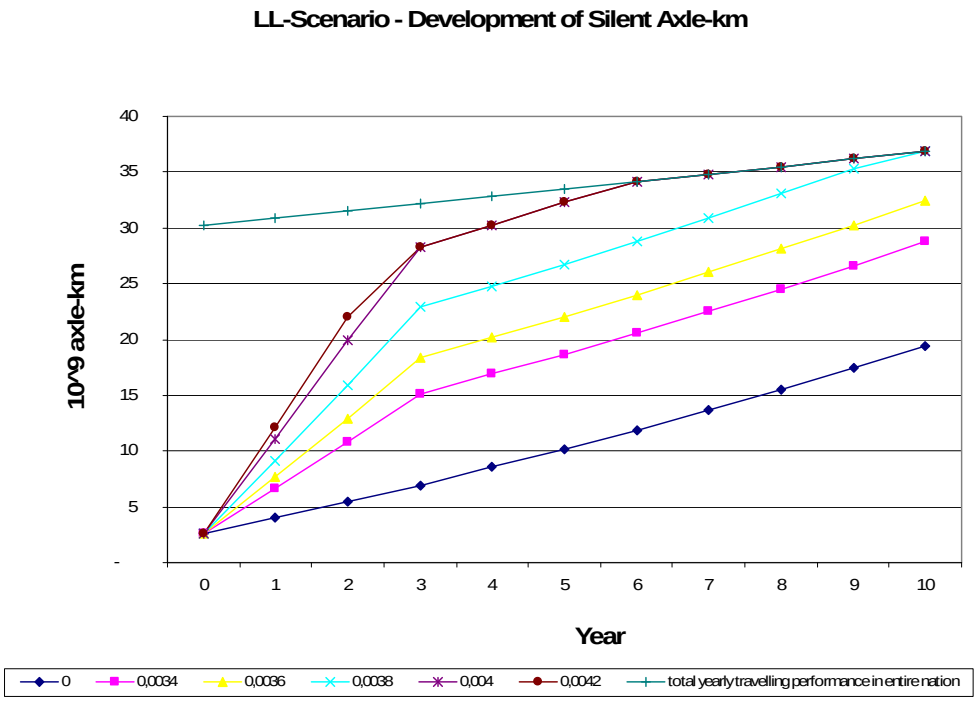


And the wagon evolution:

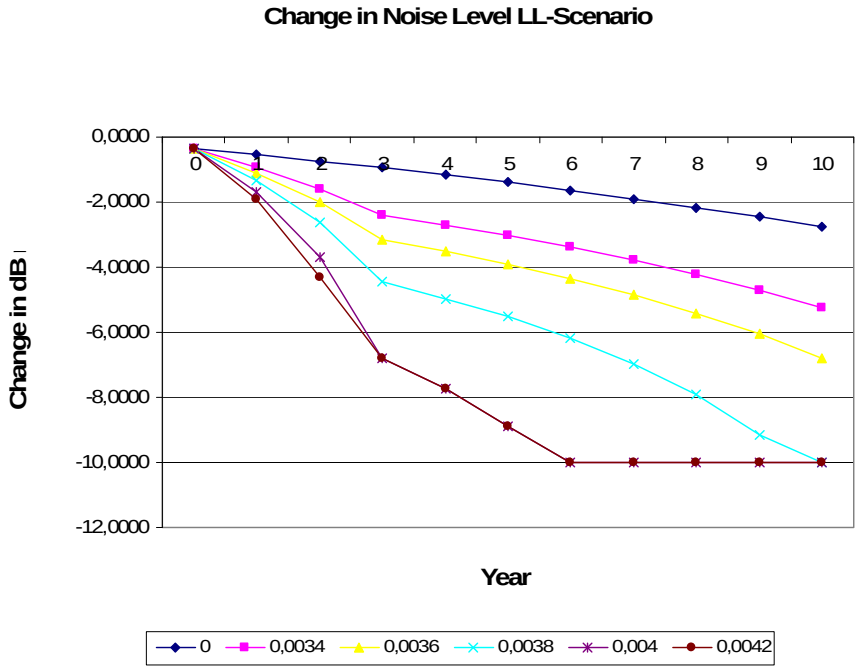


Scenario 1b-Cost Optimistic [LCC=0,003€/axle-km, Initial costs 150€/axle]

Result for LCC of 0,003€/axle-km and initial retrofitting costs of 150€/ axle and different bonuses from 0 to 0,0042 €/axle-km.



And the estimated noise reduction (logarithmic transformation):



Having the following costs estimations:

Bonus €/axle	0	0,0034	0,0036	0,0038	0,004	0,0042
Cost for MoT Germany	0	75m	104m	146m	194m	211m
Cost for MoT Italy	0	16m	22m	31m	40m	43m
Cost for MoT Netherlands	0	3m	4m	6m	8m	9m
Cost for MoT Switzerland	0	7m	9m	11m	14m	16m
TOTAL (added up)	0	101m	139m	193m	256m	278m
Years to reach full silent performance	> 20	15	13	10	6	6
Noise Level in Year 10 compared to Before Program [dB]	-2,78	-5,25	-6,82	-10,00	-10,00	-10,00

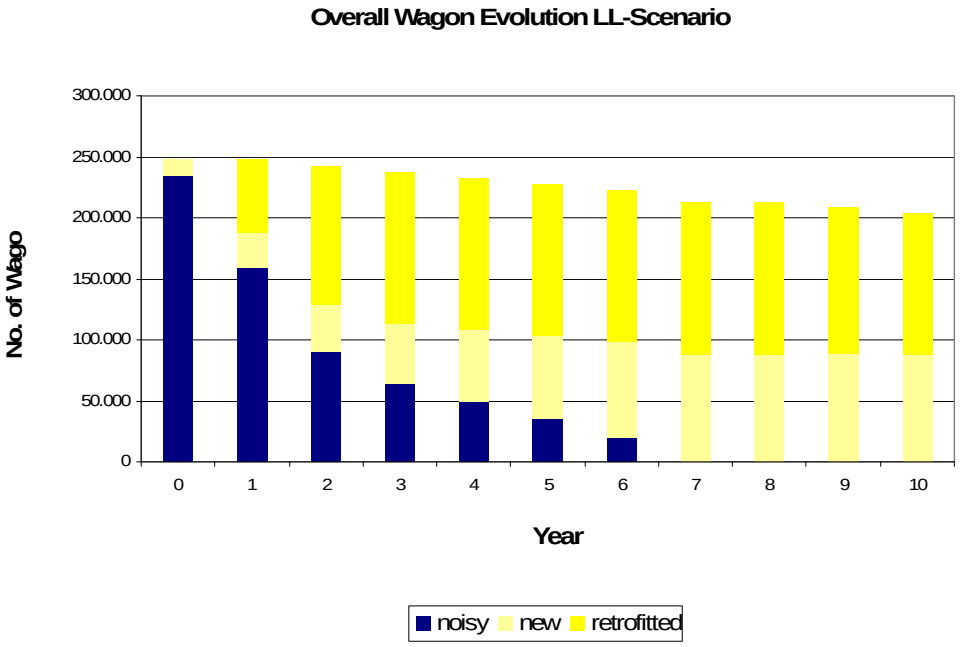
(Amounts include 100% direct aid costs and administrative costs; transaction costs are not included)

The bonus 0,004 €/axle-km, equivalent to 1,6 cents per 4-axle wagon-km, would trigger a rapid conversion of the fleet with total costs of about 232 Mio€. The following table portrays more detailed information on cost allocation:

0,004€/axle	DE	IT	NL	CH	Sum
Initial Funding [EUR]	48m	15m	1m	2m	66
Bonus Payments [EUR]	141m	24m	6m	11m	182
Administrative Cost [EUR]	4,6m	1m	0,4m	0,5m	6,5
Sum as % of the TAC incomes over the funding period	9%	12%	10%	8%	10%
TAC Incomes in 3 years [Mio €]	2.059	338	79	179	2.655
Transaction Cost [EUR]	16m	6m	1m	4m	27

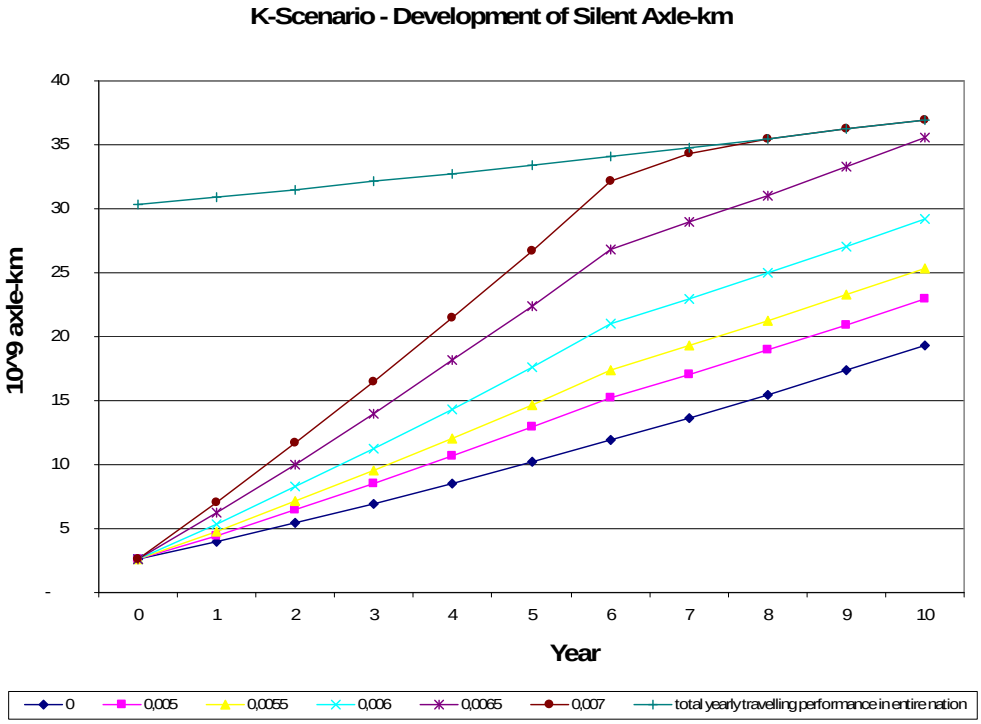
A graphic visualization of the travelling performance by type of axles (noisy, retrofitted, new, silent=retrofitted + new and total):

And the estimated wagon evolution:

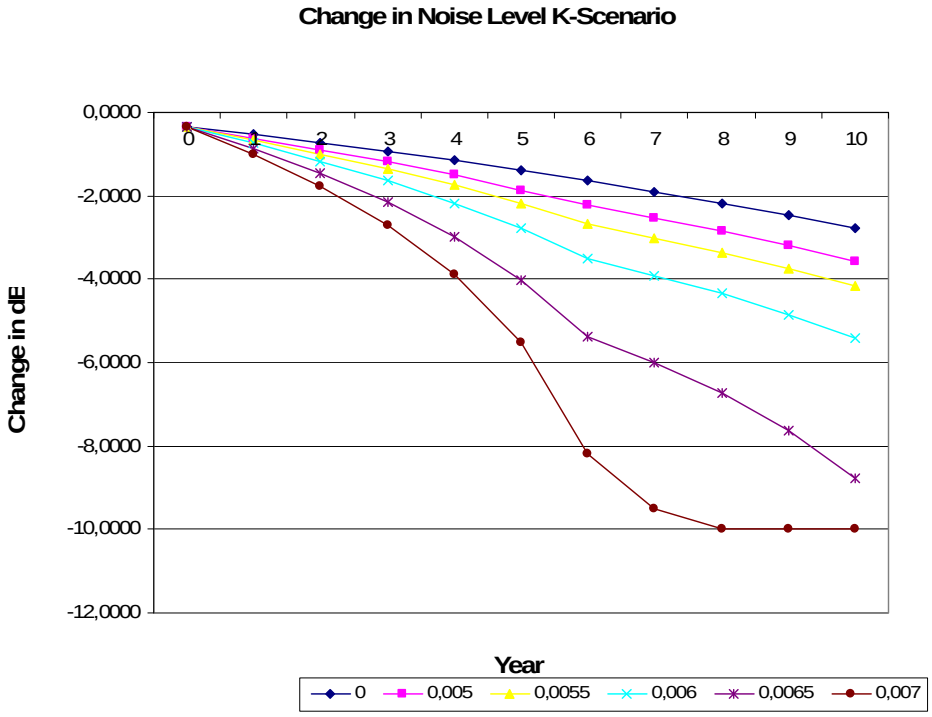


Scenario 2 [LCC=0,003€/axle-km, Initial costs 2091€/axle]

The Input parameters for Scenario 2 are basically the same as for one. Just that in this scenario the technology to be installed is K-brakes which will only have an effect in a longer funding period of at least 6 years.
Result for LCC of 0,003€/axle-km and initial retrofitting costs of 2091€/ axle and different bonuses from 0 to 0,007 €/axle-km.



And the estimated noise reduction (logarithmic transformation):



Having the following costs estimations:

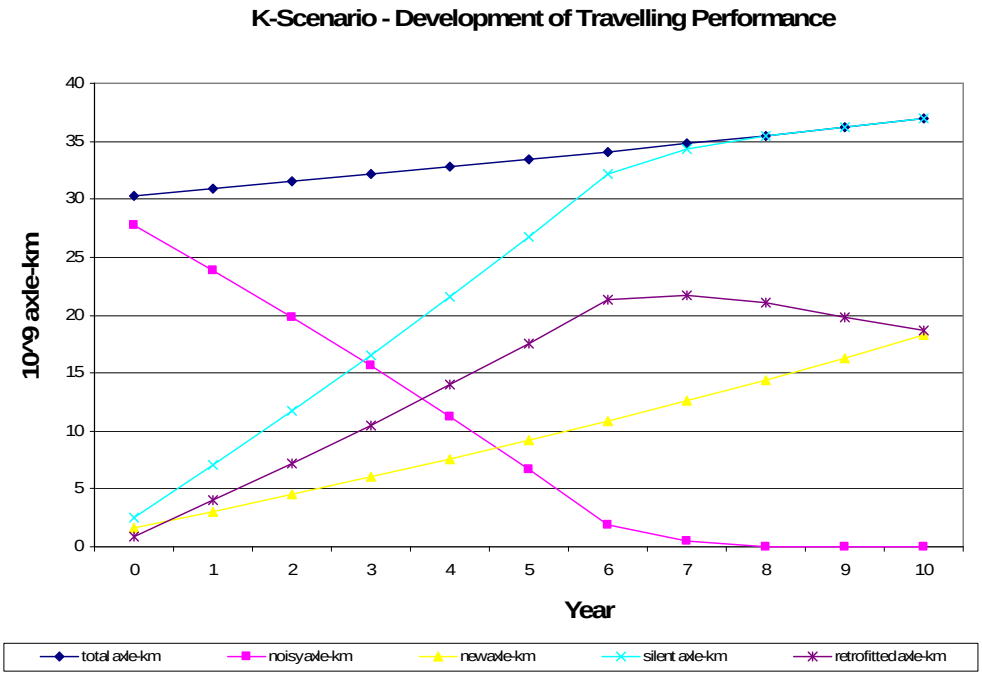
Bonus €/axle	*0*	*0,005*	*0,0055*	*0,006*	*0,0065*	*0,007*
Cost for MoT Germany	0	186m	297m	482m	794m	1077m
Cost for MoT Italy	0	48m	77m	125m	206m	277m
Cost for MoT Netherlands	0	6m	9m	15m	24m	33m
Cost for MoT Switzerland	0	20m	33m	49m	58m	68m
TOTAL (added up)	0	261m	415m	671m	1082m	1455m
Years to reach full silent performance	> 20	18	16	13	11	8
Noise Level in Year 10 compared to Before Program [dB]	-2,78	-3,57	-4,18	-5,40	-8,77	-10,00

(Amounts include 100% direct aid costs and administration costs; transaction costs are not included)

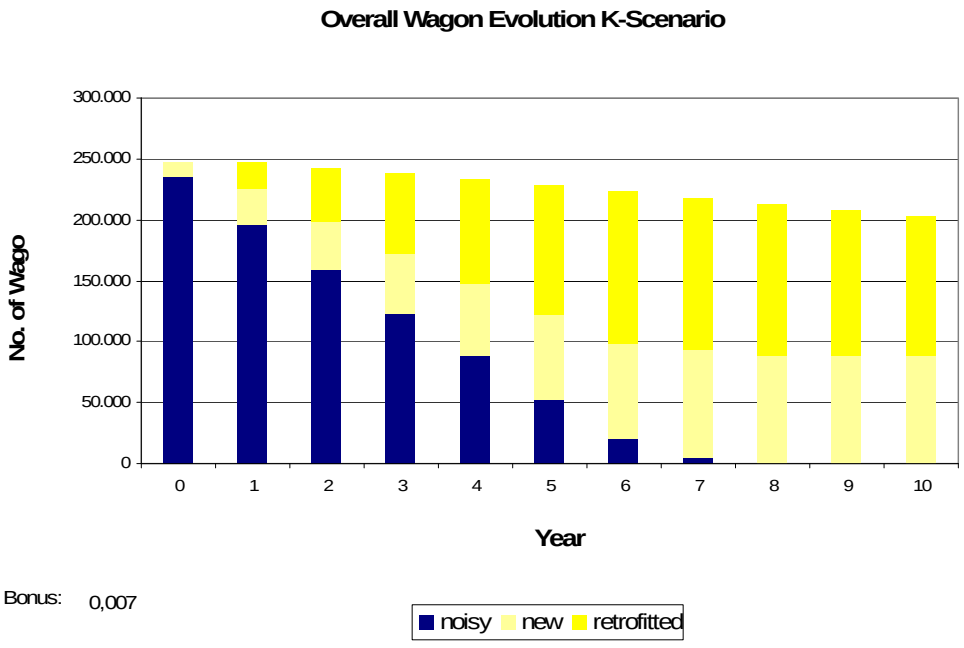
The bonus 0,007 €/axle-km, equivalent to 2,8 cents per 4-axle wagon-km, would trigger a rapid conversion of the fleet with total costs of about 400 Mio€. The following table portrays more detailed information on cost allocation:

0,007€/axle	*DE*	*IT*	*NL*	*CH*	*Sum*
Initial Funding [EUR]	667	207	14	34	922
Bonus Payments [EUR]	402	69	18	32	521
Administrative Cost [EUR]	8,2m	1,7m	0,7m	1m	12m
Sum as % of the TAC incomes over the funding period	26%	41%	21%	19%	27%
TAC Incomes in 6 years [Mio €]	4.118	675	157	358	5.308
Transaction Cost [EUR]	26	9	2	6	42

A graphic visualization of the travelling performance by type of axles (noisy, retrofitted, new, silent=retrofitted + new and total):



And the wagon evolution:

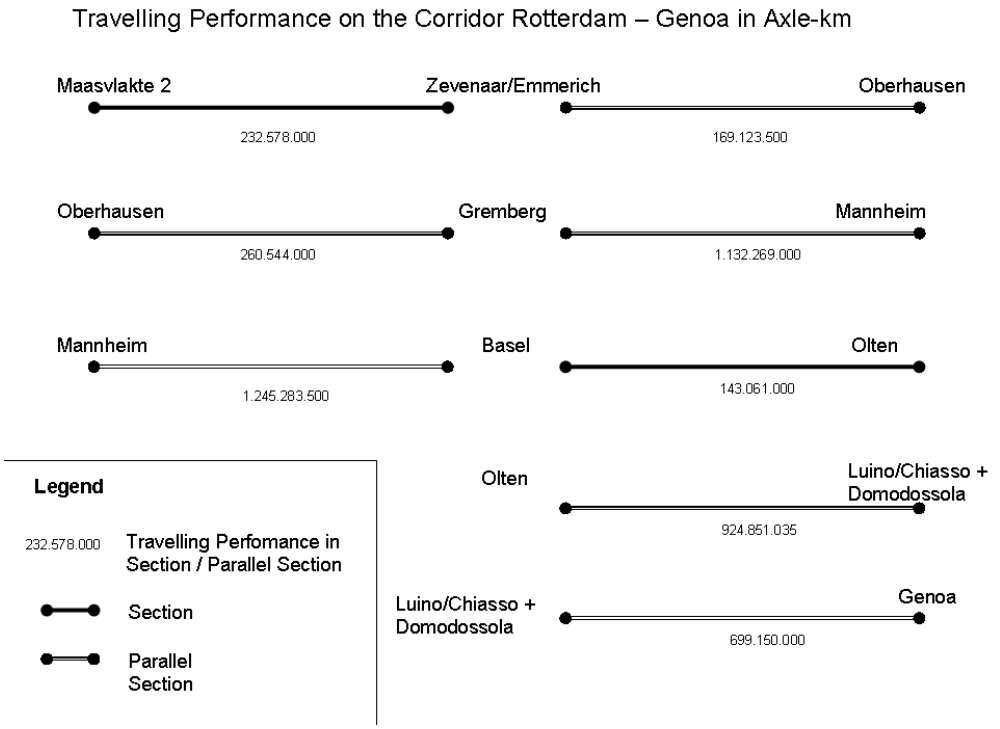


Bonus: 0,007

Scenario 3 Cost optimistic [LCC=0,003€/axle-km, Initial costs 150€/axle]

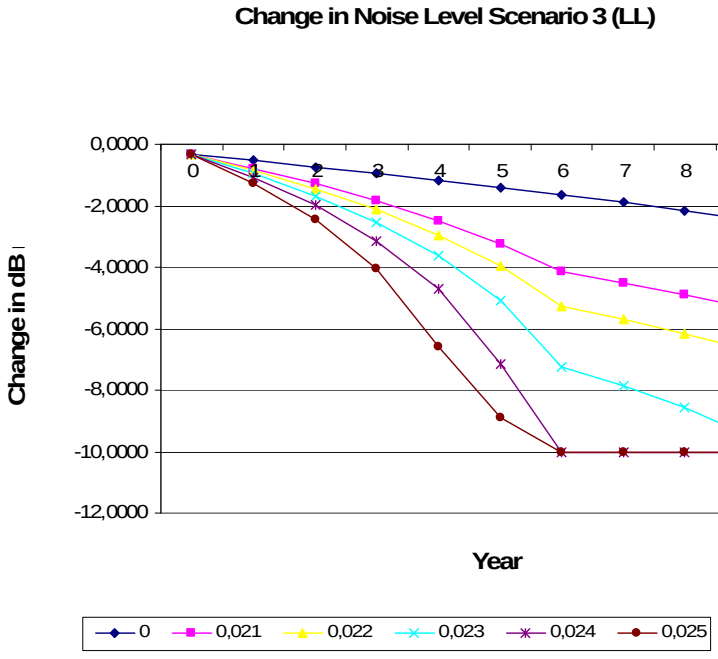
Scenario 3 is corridor based. The initial funding will still take place on the national level, the km-based bonus though will only be given for travelling on the corridor, but here for all silent wagons.

As almost no effect in the allocation of wagons is expected (see chapter 4), it can be assumed that one wagon will receive a bonus for 15% of its performance overall, which is the part on the corridor. Therefore the bonus has to be much higher in order to cover the additional LCC of the wagons done outside the corridor (85% of the mileage). The most optimistic scenario 3 is chosen with the availability of LL-blocks (K-block retrofitting is considered insignificant) funding period is set on 6 years at low additional LCC of 0,003€/axle-km and initial retrofitting costs of 150€/axle and different bonuses from 0 to 0,025 €/axle-km. The assumed tracks and traffics thereto along the corridor are shown graphically:



And the resulting development of silent axle-km for different bonuses:

And the estimated noise reduction (logarithmic transformation):



Having the following costs estimations:

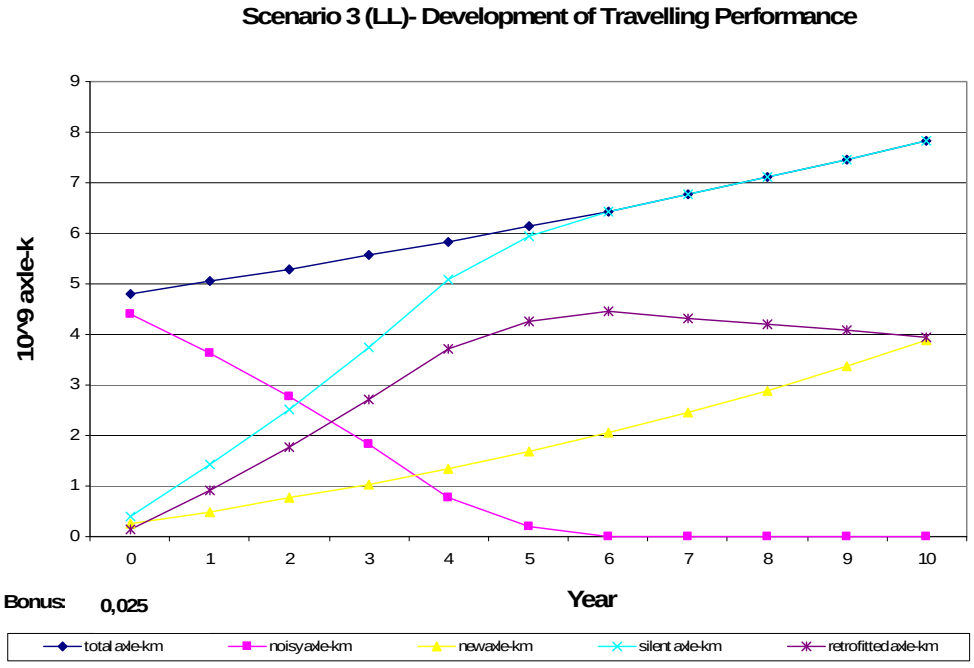
Bonus €/axle	0	0,021	0,022	0,023	0,024	0,025
Cost for MoT Germany	0	225m	267m	321m	385m	444m
Cost for MoT Italy	0	57m	68m	83m	99m	113m
Cost for MoT Netherlands	0	17m	20m	24m	29m	34m
Cost for MoT Switzerland	0	75m	88m	105m	129m	151m
TOTAL (added up)	0	374m	443m	533m	642m	742m
Years to reach fully silent performance	>20	15	13	10	6	6
Noise Level in Year 10 compared to Before Program [dB]	-2,75	-5,82	-7,32	-10,00	-10,00	-10,00

(Amounts include 100% direct aid costs for initial retrofitting and administrative costs; transaction costs are not included)

The bonus 0,025 €/axle-km, equivalent to roughly 10 cents per 4-axle wagon-km, would trigger a rapid conversion of the fleet with total costs of about 750 Mio€. The following table portrays more detailed information on cost allocation:

0,025€/axle	DE	IT	NL	CH	Sum
Initial Funding [EUR]	48m	15m	1m	2m	66
Bonus Payments [EUR]	388m	97m	32m	148m	665
Transaction Cost [EUR]	33m	11m	2m	6m	52
Sum as % of the TAC incomes over the funding period	11%	17%	22%	42%	23%
TAC Incomes in 6 years [Mio €]	4118	675	157	358	5.308
Administrative Cost [EUR]	8,2m	1,7m	0,7m	1m	12

A graphic visualization of the travelling performance by type of axles (noisy, retrofitted, new, silent=retrofitted + new and total):

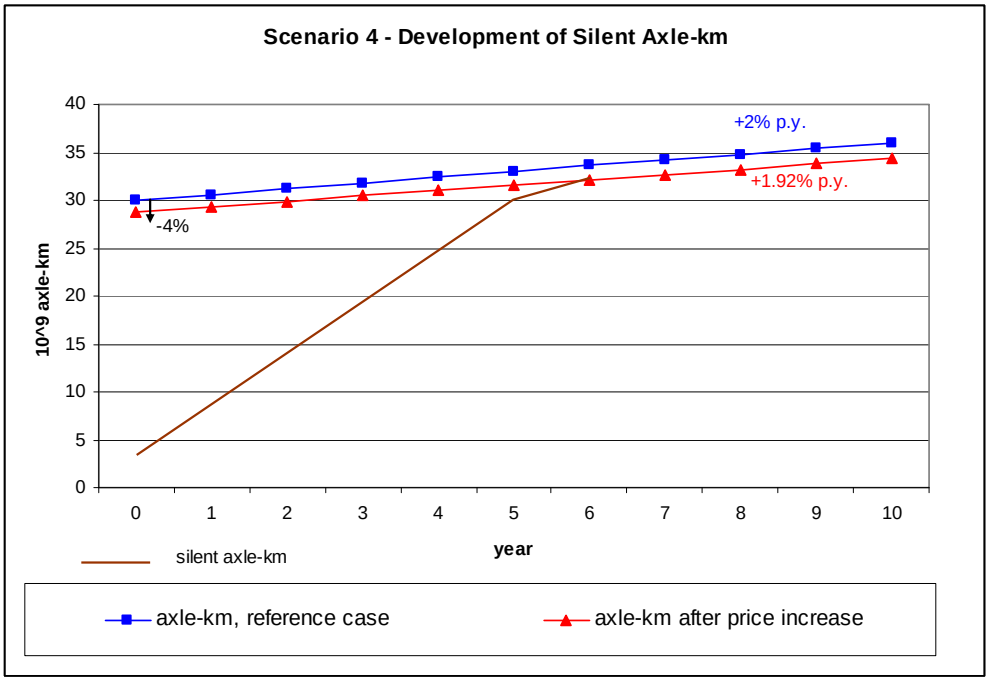


The effect of this scenario is indirectly also very important on a nation wide context where a full, or near to full, silent conversion might be achieved as well. The high costs of this scenario, in comparison to scenarios 1a and 2b, is that here also silent wagons are addressed in a longer funding period.

Scenario 4 Ci-block prohibition with direct aid for retrofitting

This last scenario investigates the impacts of a prohibition for Ci brake blocks in 5 years after the full authorisation of LL-blocks. In this case the extra maintenance costs have to be borne by the railway sector[24] and will most likely be forwarded to the client through higher fees. To show this impact on modal shift, a scenario with additional cost of only 0,003 €/axle-km for retrofitting LL-blocks is developed, initial costs to be funded by direct aid are 150€/axle. In freight transportation the impact on price changes are quite strong in most cases; exceptions might be in heavy freight transport such as coal and raw oil. Other than that an average price elasticity from rail to road transport is between -1,7 and -2[25]. The amount 0,003€/axle may lead to an increase of train price of 2%, which may result in a decrease of overall rail traffics of 4% looking at the upper limit of the price elasticity (worst case). Looking at the forecasted growth of 2% per year in the reference case and assuming a constant price elasticity of demand, this growth rate will also decrease by 4%. This leads to a reduced growth rate of 1.92% (=2% * 0.96). The difference of roughly 0.1% of growth can be assumed to be covered by road.

The result on the development of silent axle-km looks as follows:



If the public body gives direct aid for retrofitting with LL-block at a cost of 150€/axle the amounts for each country would look as follows (without administrative costs):

[24] the overall impact on the rail freight transport market has been assessed. The possible economic impact on the different (sub)sectors has not been assessed such as railway undertakings, wagon owners, workshops, infrastructure managers because that was outside the scope of the study.

[25] Mikrokonomie Grundlagen der Wirtschaftswissenschaft, Band 6 Author: Eberhard Feess 1997 Page 224. Other sources state price elasticities of down to -0.3.

	Netherlands	Germany	Switzerland	Italy	Total
Cost LL initial	1m €	48m €	2m €	15m €	66m €

To show the effect of a possible modal shift on total external costs a rough calculation has been done:

- With 8.500 million wagon-km/year in the four countries along the corridor (see chapter 3.3.2) and approx. 20 tkm/wagon-km, there are about 170 billion tkm of rail freight per year.
- The assumed price increase of 2% (worst case) leads to a reduction of 4% of rail freight, i.e. 340 million wagon-km or 6.8 billion tkm in the corridor countries.
- Values of average external costs of the freight sector according to a study by Infras/IWW are[26]:
  - for road transport: 88 Euro/1000 tkm
  - for rail freight transport: 18 Euro/1000 tkm

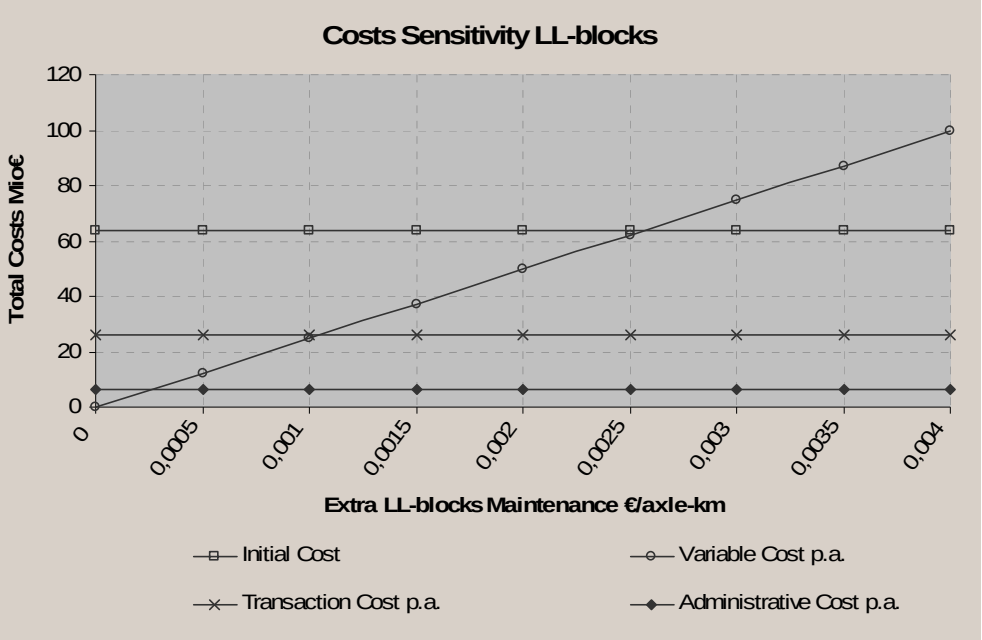
  → difference of 70 Euro/1000 tkm, i.e. average external costs for road transport is about 5 times higher than transport by rail.
- Applying these values for external costs (includes external costs for accidents, noise, air pollution, nature & landscape, upstream processes, urban effects, climate change), a shift of 6.8 billion tkm from rail to road would lead to an increase of overall external costs of 476 million Euros per year[27].
- Applying a lower price elasticity of demand of -0.4, the additional external costs would still be in the range of 100 million Euros per year.

However, if technology and experience with LL-blocks improve, lower maintenance costs may be achieved. Recent experiences and in-service tests carried out by MoT NL (Lloyds Rail register) with LL-blocks appoint to a significant reduction of such costs, in concrete a minimum value of 0,003 per 4-axle wagon and km could be reached. By this very low cost RU's would be able to lower their prices again and regain market share from road transport.

A sensitivity analysis of LL-blocks cost variation is shown in the following graph, the retrofitting is forced by a threat of Ci-blocks prohibition after 5 years of starting the program:

[26] External Costs of Transport, Update study, Infras/IWW, October 2004; values for year 2000, high scenario for climate change

[27] The effect of the reduced growth rate in rail freight transport is being neglected in these rough calculations..



In this case if extra maintenance costs for LL-blocks go below 0,001 €/axle-km the transaction system could be more expensive that the bonus grant itself, this situation should call for a direct aid without bonus.

Further economical and ecological aspects that may be derived of this measure have not been part of this study.

5.3 Interpretation / conclusions / impacts

The following table summarizes the most important results of the modelling as well as the impacts of the measures on rail traffic:

Scenario	***Minimum funding period***	***Direct aid €/axle***	***Necessary bonus €/axle-km***	***Total cost for MoTs at the end of period Million €***	***Years to achieve full silent performance***	***Freight traffic growth (estimation)***
Scenario 1a (LL Pessimistic costs)	3 years	488	0,0052	430 m	8	2%
Scenario 1b (LL Optimistic costs)	3 years	150	0,004	256 m	6	2%
Scenario 2 (K)	6 years	2.091	0,007	1.455 m	8	2%
Scenario 3 (K+LL, corridor)	6 years	150	0,025	743 m	9	5% for the Corridor
Scenario 4 (Ci - block prohibition 5 years after LL authorisation)	5 years	150	No bonus system	66 m plus administrative costs	5	ca. 1.9% (modal shift), plus 4% decrease in year 1

Looking at the results it is possible to draw some conclusions:

To launch and complete a specific and satisfactory wagon retrofitting exercise exclusively within the Rotterdam-Genoa corridor (Scenario 3) can result almost triple expensive than to launch it from the very beginning overall on the nations participating in the corridor (scenario 1b). Apparently, only if the whole nations have achieved a silent condition the corridor may be silent. According to the stakeholders there are not typical wagons captive of a corridor.

The K-block scenario needs longer periods because of the difficulty to execute retrofitting, in so doing the high initial costs lead to immense costs of the program. A full silent conversion of the fleet without 100% public aid seems unrealistic.
The LL-block optimistic scenario 1b seems achievable at a reasonable cost. However, due to the uncertainty of the transaction and administrative costs necessary to launch and monitor a proper bonus system, together with the constant LL-block technology evolution, it could happen that the eventual LL-blocks' LCCs would be lower than the costs of the transaction system itself. Hence a simplified direct aid could be a solution. To that aim, the administrations should monitor carefully the evolution of the LCCs for LL-blocks obtained in test pilots. Scenario 1b shows a possible development of (still raising) axle-km if the additional maintenance costs would be considerably lower than thought today.
Scenario 4 is easily achievable but may go in detriment of the freight railway performance if the LCCs derived from the use of LL-blocks do not improve in the future. Once again the actual developments on LL-technology, especially on the organic LL-blocks are of crucial importance. A conservative position should be to wait (or push) for further results on LL-blocks tests. A Ci-block prohibition without having LL-block authorisation and without state aid could lead to a modal shift to road. This also leads to an increase of overall external costs.

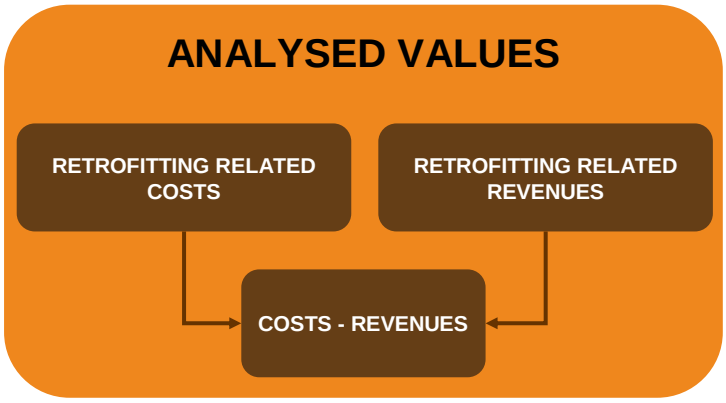
6 Business cases

The following chapter supplies a detailed description of the Business Cases (BCs) prepared by the consultancy group for the Ministries of the railway corridor Rotterdam – Genoa. In order to guarantee a description as accurately as possible, the chapter has been split up as following:

- Aim of the BCs;
- Set up and description of the BCs;
- Sources of the data used in the BCs (Input data);
- Results of the BCs
- Conclusions.

6.1 Aim

Stakeholders involved in the railway freight transportation, especially Railway Undertaking (RU) and Wagon Owners (WO), that will start a rolling stock retrofitting program related to the silent brake technology, have to face an increase of costs and revenues.
The main objective of the BCs is to analyze and to evaluate these costs and revenues increase in the different scenarios and their impact on the stakeholder's balance sheet.



All stakeholders contacted for the Questionnaire have been asked to participate in the Business Case exercise in order to ensure a very "tight to reality" significance evaluating the specific impact. Almost all stakeholders did not accept the invitation due to lack of time. Therefore the task described has been completed with a realistic but generic stakeholder modelling.

6.2 Set up, description of BC

The BCs have been prepared considering the four scenarios above mentioned (for a detailed description of the four scenarios see Chapter 5.2.2 Scenario Analysis). In other words, the BCs include the entire set of configurations of each scenario, namely:

- Level of harmonisation;

- Area;
- Bonus typology;
- Addressing retrofitted or all silent wagons;
- Technology type.

The cost items, induced by the retrofitting program, that influence directly the balance sheet, are: initial costs, transaction costs and additional LCC – Life Cycle costs.

The *initial cost* has to be paid once the stakeholder (RU or WO) retrofits its own rolling stock and it is the necessary investment in order to switch from the CI-brake technology to the K-Blocks or LL-Blocks.
The economical impact of this cost in the balance sheet is spread on the depreciation period for such an item based on the specific accounting policies.
The amount of the initial cost depends on the chosen technology. As matter of fact K-Blocks and LL-Blocks have different prices due to material and installation costs (for further information concerning the costs of each technology see Chapter 5.1 – Section: "About the costs of the technology").

The *transaction costs* can be described as an increase of yearly costs, which is directly connected with the retrofit program. These costs represent all the activities, which have to be performed by the stakeholder in order to gather all the necessary information to claim the bonus (for further information concerning the transactional costs see Chapter 5.1 – Section: "About administrative and transaction costs")

The *additional LCC (Life Cycle Costs*) are the costs directly connected to the maintenance of the retrofitted wagons. In other words, once the wagon has been retrofitted, it has to be maintained during all its life in order to guarantee the optimal functioning of the new brake system and ensure the wagon safety compliance to the standards. Like the initial cost also the Life Cycle Costs depends on the chosen technology.

The revenue components of the balance sheet directly influenced by the retrofit, considered in the BCs are: the initial funding and the axle-km dependent bonus.

At the end two BCs have been prepared, one for each technology (K-Blocks and LL-Block brake technology) to be adopted. These two BC's have been parameterized to describe all the specifics of the four main scenarios.

The model BCs have been studied from the RU point of view simulating a train service, which can be performed partially or completely within the corridor

Rotterdam-Genoa (or generally in a path within the Counties under analysis). It is important to underline that the BCs do not refer neither to the present train fleet nor to the forecasted one. As mentioned above, BC refers only to a typical train service; the BC of other stakeholders like, wagon owners, workshops, infrastructure managers, is not prepared because that was not the main target of the study.

From a general point of view, the above mentioned train service has been modelled using two different variables:

- yearly wagons mileage;
- % of path with TAC bonus;

These variables play a very important role in the BCs, because they influence directly the amount of both costs (additional LCC + transaction costs) and revenues (axle-km-dependent bonus). By the increase or the decrease of each variable's value, it is possible to study how retrofit directly connected costs and revenues change and consequently it is possible to find when:

- costs are higher than revenues, in this cases RU has little or no incentive to retrofit;
- costs are lower than revenues, in this cases RU has a significant incentive to retrofit;
- breakeven point, in this cases RU has incentive to retrofit .

This information is represented using a matrix: each cell represents a particular case. For instance, the yellow one represents the case of 100.000 km. per year with 75% of bonuses path.
In addition, the matrix shows also the impact of each result as a percentage of the service total costs (blue cell).

Yearly differential (bonus-add costs) per freight service (Values in €/000)					Total Costs of the freight service (Values in €/000)
Annual overall km per wagon	% of bonused path				
	25%	50%	75%	100%	
190.000					
150.000					
100.000	X_1	X_2	X_3	X_4	ΣC
			$X_3/\Sigma C$		
50.000					
35.000					
20.000					

The *Red Area* is where the retrofit connected costs are greater than the retrofit connected revenues. In this case the axle-km dependent bonus is not enough for RU to cover the transaction costs and additional LCC. The *Green Area* is where the RU has incentives to pursue a retrofitting program because the revenues coming from the axle-km dependent bonus are equal or greater than the retrofit costs.

The base freight service has been chosen because it mimics the impact on the overall costs of the service to the final customer, generally managed by the RU. Differently from the specialised WO, it typically has full control on its wagons fleet, it knows where its wagons are (this information is critical for the bonus claim process especially in the third scenario, the "sharp corridor") and the mileage of each of them. The WO will be affected as well, but since the initial costs will be fully covered by the incentives (all scenarios) and the additional LCC could be transferred to the RU (as premium price for the silent wagons) that in turn will claim the bonus axle-km dependent, or directly funded by the financing body, the final impact on his business will be minimal.

6.3 Input data

The two BCs have been built using the same following assumptions.

- The train service is operated for the full year (52 weeks);
- The model train composed by 25 wagons (this represents an average number of wagons, which comes from the survey results);

- On average the wagon axles are 3,54;
- The initial retrofit cost is 100% financed;
- As mentioned above the axle-km-dependent bonus has been calculated per silent wagons and depends on the technology (these values come from the model: Chapter 5.2) :
  - 0,007 €/axle-km for K-Blocks (scenario 2)
  - 0,0052 €/axle-km for LL-Blocks (scenario 1a)
  - 0,004 €/axle-km for LL-Blocks (scenario 1b)
  - 0,025 €/axle-km for LL-Blocks (scenario 3)
- % of bonuses path: 25% - 50% - 75% - 100%. The last assumption (100% of bonuses path) represents a special case (service fully in the corridor) for the scenario three and the scenarios one and two (when the wagons are running fully in the infrastructure network of the Countries involved).

- BCs consider six different yearly wagon mileages:

Approx yearly wagon mileage (km/year)	Service frequency[28] per year	Itinerary one way length (km)	Trains needed for the service (nr)
190.000	260	1.100	3
150.000	99	770	1
100.000	65	770	1
50.000	52	500	1
35.000	52	340	1
20.000	52	190	1

The BCs estimate also the percentage impact of costs and revenues variation on the total costs of the RU for the above described services, considering the following base operative cost elements[29]:

- Locomotive costs;
- Wagon costs;
- Track Access Charge – TAC;
- Energy costs;
- Labour costs;
- Overhead and other costs (20% of the total costs);

6.4 Results

K-BLOCKS (scenario 2)

The K-Blocks BC analyses impact results have been put in the following matrix. It is important to remember that the scenario assumes a full coverage of initial retrofitting costs and a bonus per axle-km.

[28] The service frequency is defined as the departure frequency of a train from station A to station B for a given itinerary and vice versa.

[29] Costs and performance of European rail freight transportation, 2008 Edition, Nea – Railrelease.com - Railistics

Yearly differential (bonus-add costs) per freight service (Values in €/000)				Total Costs of the freight service (Values in €/000)
Annual overall km per wagon	% of bonused path			
	50%	75%	100%	
190.000	20	108	**197**	7.960[30]
	0,3%	1,4%	**2,5%**	
150.000	5	28	**52**	2.190
	0,2%	1,3%	**2,4%**	
100.000	2	18	**33**	1.530
	0,1%	1,2%	**2,2%**	
50.000	0	8	**16**	990
	0,0%	0,8%	**1,6%**	
35.000	0	5	**11**	765
	0,0%	0,7%	**1,4%**	
20.000	-1	2	**5**	620
	-0,2%	0,3%	**0,8%**	

Looking at the matrix, it is possible to observe that:

- Considering scenario 2, which refers to the 100% bonuses path column, it does not matter how many kilometres a wagon runs because 100% of costs (transaction costs and additional LCC) are fully covered by the axle-km dependent bonus. There is a positive earning (over incentivised) of a range between +0,8% (20.000 km) and +2,5% (190.000 km) on the total costs.
- Even in case of freight services with just 50% within the bonuses path (in the borders of the Countries joining the incentive scheme), the freight service has a benefit from retrofitted wagons.

LL-BLOCKS (scenarios 1a, 1b, 3 and 4)

The LL-Blocks BC analyses impacts in different scenarios. The results have been summarized in the following matrices:

Scenario 1a "pessimistic" and 1b "optimistic"

It is important to remember that the scenario assumes a full coverage of initial retrofitting costs and a bonus per axle-km.

SC1A

Yearly differential (bonus-add costs) per freight service	Total Costs of the freight

[30] Total costs are much higher than at 150.000 km because 3 trains are needed under the assumptions stated in chapter 6.3 (service frequency of 260 trains a year and way length of 1.100 km).

(Values in €/000)				service (Values in €/000)
Annual overall km per wagon	% of bonused path			
	50%	75%	100%	
190.000	-76	-11	**55**	8.010[31]
	-0,9%	-0,1%	**0,7%**	
150.000	-20	-3	**14**	2.200
	-0,9%	-0,1%	**0,6%**	
100.000	-14	-3	**8**	1.540
	-0,9%	-0,2%	**0,5%**	
50.000	-8	-2	**4**	990
	-0,8%	-0,2%	**0,4%**	
35.000	-6	-2	**2**	770
	-0,8%	-0,3%	**0,3%**	
20.000	-4	-2	**0**	625
	-0,6%	-0,3%	**0,0%**	

SC1B

Yearly differential (bonus-add costs) per freight service (Values in €/000)				Total Costs of the freight service (Values in €/000)
Annual overall km per wagon	% of bonused path			
	50%	75%	100%	
190.000	-56	-5	**44**	7.960
	-0,7%	-0,1%	**0,6%**	
150.000	-15	-2	**11**	2.190
	-0,7%	-0,1%	**0,5%**	
100.000	-10	-2	**7**	1.530
	-0,7%	-0,1%	**0,5%**	
50.000	-6	-2	**2**	990
	-0,6%	-0,2%	**0,2%**	
35.000	-5	-2	**1**	765
	-0,7%	-0,3%	**0,1%**	
20.000	-3	-2	**0**	625
	-0,5%	-0,3%	**0,0%**	

[31] Total costs are much higher than at 150.000 km because 3 trains are needed under the assumptions stated in chapter 6.3 (service frequency of 260 trains a year and way length of 1.100 km).

Looking at the scenarios, it is possible to observe that:

- In both cases when the freight service would run 100% on bonuses path, regardless on how many kilometres a wagon runs yearly, all costs are compensated by the incentive scheme. There is a positive incentive ranging between +0,0% (20.000 km) and +0,6/0,7% (190.000 km) on the total costs, to retrofit wagons.
- In case the freight service would run only partially in the incentivized areas, the disadvantage is limited to an increase of the cost in the range of 0,5- 0,9% when just 50% of the miles is run in the abovementioned Nations.

Scenario 3

It is important to remember that this scenario assumes a full coverage of initial retrofitting costs and a bonus axle-km **limited to the sharp area of the corridor**. The bonus has to be substantially raised (compared to the other scenarios) in order to influence positively the wagon retrofit, since except for specific shuttle services, a majority of wagons would run just partially on the corridor.

Yearly differential (bonus-add costs) per freight service (Values in €/000)						**Total Costs of the freight service** (Values in €/000)
Annual overall km per wagon	**% of bonused path**					
	10%	**25%**	**50%**	**75%**	**100 %**	
190.000	-31	159	475	792	**1.109**	7.960
	-0,4%	2,0%	6,0%	9,9%	**13,9%**	
150.000	-9	42	125	209	**293**	2.190
	-0,4%	1,9%	5,7%	9,5%	**13,4%**	
100.000	-6	27	82	137	**192**	1.530
	-0,4%	1,8%	5,4%	9,0%	**12,5%**	
50.000	-4	13	42	71	**99**	990
	-0,4%	1,3%	4,2%	7,2%	**10,0%**	
35.000	-3	8	28	47	**67**	765
	-0,4%	1,0%	3,7%	6,1%	**8,8%**	
20.000	-3	4	15	26	**37**	625
	-0,5%	0,6%	2,4%	4,2%	**5,9%**	

Looking at the scenario, it is possible to observe that:

- When the freight service would run 100% on bonuses path, the costs are overcompensated between 5,9% to 13,9%. This high **overcompensation** would likely apply typically to the shuttle services in the corridor.
- The incentives are neutral for services running in the range around 15-20% on the corridor (average from questionnaire).

Scenario 4
It is important to remember that this is the only scenario that assumes the sector to bear all additional costs (except initial retrofit costs that would be financed by the public body). In this case since there are no incentives and no administrative/transaction costs. Based on the assumptions made in chapter 5 on initial retrofit costs and LCCs, the impact of the additional costs range from 0,8 % (20.000 km/year – total service cost 620.000 euro) to 1,9% (190.000 km/year – total freight service costs 7.955.000euro) for a train service. It's important to note that the retrofit depreciation (on 5 year period) cost accounts for (just) about 0,1% (190.000km/year) - 0,4% (20.000 km/year) of the base freight service costs.

6.5 Conclusions on the business cases

Looking at the percentages of each result on the total costs, independently from the specific BC (limiting the results of scenario 3 to the range 10-25% on the corridor), it is interesting to observe an impact which is between a positive rate barely greater than +2% and a negative one which is just -2%. It means that the retrofit connected costs and revenues, compensated by the designed incentives, have a relatively limited influence on the freight service. The effects on other stakeholders like wagon owners, workshops and IM has been out of the scope of the study and is not investigated.

Generally in the mix of services that each RU might provide, the "green area" services could compensate the "red area" services. Therefore the overall impact of the designed incentives on freight service are for sure lower than the estimated worst case of about -2%.

Considering the first and second scenario, namely the so called "country wide" scenarios, the proposed incentive policy could guarantee a good push related to the retrofit program. Looking at the matrices, the "country wide" scenarios are (when 100% within the harmonised territory) completely within the green area. This aspect could be very important from a RU point of view because the results show that its business would not be negatively impacted by a possible retrofitting program. The proposed incentives would even have a positive effect on the balance sheet because revenues result slightly greater than costs.

Considering the third scenario, namely the so called "sharp corridor" scenario, the proposed incentive policy generates three different situations which depend on the running percentage of mileage within the corridor:

- High percentage of mileage (or 100%): RU has a very high incentive to retrofit because the revenues increase is significantly greater than the costs increase, to a point that "might disturb" the competitive scenario.
- Medium percentage of mileage (50-75%): still advantageous to retrofit and significant benefit.
- Small percentage of mileage (10%- 25%): a neutral area where the incentives balances the extra costs.

It is important to remember that in the BCs the initial costs (for further information concerning the initial costs see Chapter 5.1 – Section: "About the costs of the technologies"), both for K-Blocks and LL-Blocks, are fully (100%) financed by the governments. If the retrofit financing would change, it would impact consequently the green and red areas of the matrix.

The incidence of the transaction costs incurred by the RU, has been evaluated with different underlying hypothesis on process and support systems, leading on average to less than 0,2%[32] of the overall costs for the base freight service used in all the other BC calculations.

The effect of the proposed incentives to retrofit noisy wagons on the WO are neutral for the initial investment costs (full coverage). In case the WO is responsible for the maintenance, the additional LCC associated to the retrofit, that could range form approx 2% of estimated wagon annual costs[33] for 20.000 km/year wagons, to 14% for 100.000 km/years wagons, have to be or directly funded or transferred to the RU as part of the rental price, that in turns will be compensated by the axle-km dependent bonus, as previously described.
In case there would be no incentive for the initial retrofit, the WO could incur yearly depreciation costs (for LL- blocks) in the range 1-4% (150 euro/axle – 488 euro/axle) of the wagon costs in a given freight service considered in the BCs.

The above mentioned percentage range is the result of dividing the additional LCC of a wagon by its annual costs associated to a well defined mileage.

- The costs structure of a wagon (both sggmrss and sgns wagon) has been defined in "Costs and performance of European rail freight transportation" issued in 2008 by NEA\RAILRELEASE\RALISTICS.
- The "well defined mileage" refers to same mileage used to study the BCs (20.000 – 35.000 – 50.000 – 100.000 – 150.000 – 190.000)
- Additional LCC is the result of the wagon annual mileage multiplied by the kilometre and technology dependent LCC.

In other words, the percentage range represents for a WO the impact of LCC on the entire wagon cost structures.

[32] Source for administrative transaction costs: Chapter 5.1 – Section: "About administrative and transaction costs" and other T Bridge estimate based on a hypothetical operative recording/claiming process

[33] Source: T Bridge elaboration from "Cost and performance of European rail freight transportation" 2008 edition NEA\RAILRELEASE\RAILISTICS, that includes depreciation, interests, insurance and maintenance costs (based on sggmrss and sgns wagons).

7 Management summary and recommendations to Ministries

A joint initiative of the Ministries from NL, DE, CH and IT in respect to reduction of railway noise on the corridor Rotterdam-Genoa pursues the utilisation of silent wagons in detriment of noisy ones. This measure has been proved the most cost-effective in comparison to a number of other measures, among which: absorbing walls, rail grinding for noise purposes, insulate windows and shake absorbers.

Wagons utilising cast iron (Ci) blocks as thread braking element are considered noisy wagons; they can be turn into silent if another braking system is installed (e.g. disks), or, more inexpensively, if other brake blocks' materials, namely K or LL, are employed. These solutions are not cost neutral since there are important initial investments derived from the installation of K-blocks, as well as important extra LCC costs result of the extra maintenance of wagons retrofitted with K and LL-Blocks. This entails a rejection from the sector. In spite of that, since 2007, all new produced wagons have to comply with the EC Directives TSI NOI and TSI WAG which oblige them to be manufactured silent. This guarantees that by c.a. 2035 the whole fleet in the EU should be silent because of mere renewal processes. However, the objective is to achieve this earlier by retrofitting a part of the existing noisy freight rolling stock.

The study provides an overview on the ongoing developments in the corridor countries and on EU level, a summary of the results of the stakeholder consultation, an introduction to the chosen scenarios, the result of the modelling of the scenarios and the implications for railway undertakings calculated in a business case accomplished in the management summary with the recommendations to the Ministries.

7.1 Summary of results

Policy developments at EU level and in the corridor countries

At an EU level, the EC envisages the recasting Directive 2001/14 with regard to NDTAC's. Several initiatives with regard to noise differentiated track-access charges are running in the Member States in order to combat noise. Switzerland and the Netherlands have implemented such approach, improvements could be made, though. Taking the above into account, there seems to be a good possibility to come to an integrated approach, taking the experiences of the front-runners into account. The experiences of the front-running counties indicate that:

- Experiences from the Netherlands show that it is important to set the level high enough
- A NDTAC system needs a proper incentive levels to make it work. As can be learned from the Dutch experiences, if levels are set too low the opportunities will not be used.

- Self declaration systems are based on trust and might not work with a malus system

Stakeholder consultation

The aims of the stakeholder consultation were to gather economic, financial and technical data for the impact assessment, to gather stakeholder point of view on different scenarios, to involve actively and positively stakeholders: listen to their point of view / fear / recommendations for scenarios and to get other information that will contribute to the definition of the final recommendations to the involved Ministries. The feedback from the stakeholders was following:

- Incentive level: 100%, must cover all costs (retrofitting, LCC, administrative costs)
- Almost all stakeholders prefer direct funding (easier, lower transaction costs) to a bonus
- Most stakeholders prefer direct funding only for retrofitting wagons (i.e. not for "new" wagons)
- Bonus: as a separate factor, not within TAC
- Nation-wide (Europe-wide) is widely preferred
  full harmonisation preferred
- Technology: LL-blocks would be preferred (after having passed authorisation)

Scenario Definition

Attending to the above mentioned arguments and pursuing the feasibility of the retrofitting exercise the scenarios are defined as follows:

<table>
<tr><th>Scenario 1
nation-wide (LL)</th><th>Scenario 2
nation-wide (K)</th><th>Scenario 3
corridor (K/LL)</th><th>Scenario 4
CI-prohibition (LL)</th></tr>
<tr><td colspan="4">full harmonisation</td></tr>
<tr><td colspan="4">direct aid for initial retrofitting cost of wagon (nation-wide)</td></tr>
<tr><td colspan="3">bonus per axle-km</td><td rowspan="2">No bonus</td></tr>
<tr><td colspan="2">addressing only retrofitted wagons,
Nation-wide</td><td>Addressing all silent wagons,
Limited to corridor</td></tr>
<tr><td>LL Technology (starting from the full authorisation of LL)</td><td>K Technology (LL does not achieve full authorisation)</td><td>K and LL Technology combined (LL achieves authorisation some years before starting the program)</td><td>LL Technology (starting from the full authorisation of LL)</td></tr>
<tr><td>3 years Funding period</td><td>6 Years Funding period</td><td>6 Years Funding period</td><td>5 Years Funding period</td></tr>
</table>

7.2 Impact assessment

The following table summarizes the most important results of the modelling as well as the impacts of the measures on rail traffic:

Scenario	***Minimum funding period***	***Direct aid €/axle***	***Necessary bonus €/axle-km***	***Total cost for MoTs at the end of period Million €***	***Years to achieve full silent performance***	***Freight traffic growth (estimation)***
Scenario 1a (LL Pessimistic costs)	3 years	488	0,0052	430 m	8	2%
Scenario 1b (LL Optimistic costs)	3 years	150	0,004	256 m	6	2%
Scenario 2 (K)	6 years	2.091	0,007	1.455 m	8	2%
Scenario 3 (K+LL, corridor)	6 years	150	0,025	743 m	9	5% for the Corridor
Scenario 4 (Ci-block prohibition 5 years after LL authorisation)	5 years	150	No bonus system	66 m plus administrative costs	5	ca. 1.9% (modal shift) , plus 4% decrease in year 1

Looking at the results it is possible to draw some conclusions:

To launch and complete a specific and satisfactory wagon retrofitting exercise exclusively within the Rotterdam-Genoa corridor (Scenario 3) can result almost triple expensive than to launch it from the very beginning overall on the nations participating in the corridor (scenario 1b). Apparently, only if the whole nations have achieved a silent condition the corridor may be silent. According to the stakeholders there are not typical wagons captive of a corridor.

The K-block scenario needs longer periods because of the difficulty to execute retrofitting, in so doing the high initial costs lead to immense costs of the program. A full silent conversion of the fleet without 100% public aid seems unrealistic.
The LL-block optimistic scenario 1b seems achievable at a reasonable cost. However, due to the uncertainty of the transaction and administrative costs necessary to launch and monitor a proper bonus system, together with the constant LL-block technology evolution, it could happen that the eventual LL-blocks' LCCs would be lower than the costs of the transaction system itself. Hence a simplified direct aid could be a solution. To that aim, the administrations should monitor carefully the evolution of the LCCs for LL-blocks obtained in test pilots. Scenario 4b shows a possible development of (still raising) axle-km if the additional maintenance costs would be considerably lower than thought today.

Scenario 4 is easily achievable but may go in detriment of the freight railway performance if the LCCs derived from the use of LL-blocks do not improve in the future. Once again the actual developments on LL-technology, especially on the organic LL-blocks are of crucial importance. A conservative position should be to wait (or push) for further results on LL-blocks tests. A Ci-block prohibition without having LL-block authorisation and without state aid could lead to a modal shift to road. This also leads to an increase of overall external costs.

business case

Looking at the percentages of each result on the total costs, independently from the specific BC (limiting the results of scenario 3 to the range 10-25% on the corridor), it is interesting to observe an impact which is between a positive rate barely greater than +2% and a negative one which is just -2%. It means that the retrofit connected costs and revenues, compensated by the designed incentives, have a relatively limited influence on the freight service. The effects on other stakeholders like wagon owners, workshops and IM has been out of the scope of the study and is not investigated.

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- Additional LCC is the result of the wagon annual mileage multiplied by the kilometre and technology dependent LCC.

In other words, the percentage range represents for a WO the impact of LCC on the entire wagon cost structures.

7.3 Recommendations

Based on the findings in the project the following recommendations are developed:

Harmonized solutions: Rail freight transport is international oriented. A solution which is harmonized for the four corridor countries is recommended. The existing schemes in the Netherlands and Switzerland should be changed in a harmonized solution. These changes are necessary as the scheme in the Netherlands for example is per wagon and not per axle.

Corridor: The incentives for retrofitting should cover the four countries as a whole and not only the sharp corridor.

[34] Source for administrative transaction costs: Chapter 5.1 – Section: "About administrative and transaction costs" and other T Bridge estimate based on a hypothetical operative recording/claiming process

[35] Source: T Bridge elaboration from "Cost and performance of European rail freight transportation" 2008 edition NEA\RAILRELEASE\RAILISTICS, that includes depreciation, interests, insurance and maintenance costs (based on sggmrss and sgns wagons).

The costs for retrofitting wagons for the sharp corridor are equal to the costs of retrofitting the wagons on country level and the effect is that for the same investment the whole country faces noise reduction.

Target only noisy wagons: The ministries should target only those wagons which have not been retrofitted yet; recently built wagons should not benefit from the incentives to retrofit neither should those wagons been retrofitted which are at the end of their life cycle, eg 30 years.

Initial costs: The initial costs for retrofitting should be covered by the ministries. If the additional maintenance costs (LCC) are not covered by the sector, they should be covered with a bonus per axle kilometres.

LL blocks: The LL blocks technology is preferred above the K blocks technology as the sector is much more in favour to retrofit with LL blocks and the initial costs are much cheaper.

Starting the retrofitting project: The ministries should start the programme only when the LL blocks are homologated, as the costs for the ministries are considerably lower when retrofitting LL blocks and the stakeholders are reluctant to use the K block technology. Therefore the Ministries should push the LL-authorization process.

Minimize funding period: The funding period is calculated between 3 and 8 years, depending on the funds available and the desired retrofitting speed. When the funding includes only the initial costs, the costs are fixed over the period. When the funding includes both initial costs and LCC, the funding period should be as short as possible to reduced the Ministries costs. The longer the period the longer the variable LCC costs should be compensated.

Bonus scheme: A bonus scheme for retrofitted wagons is very difficult to organize. It involves an administration of all the wagon /kilometres', administrative costs for the operator, the operator should transfer the bonus to the owner of the wagons, the IM/Ministries should check (ad random) the administration, etc. Quite some administrative costs.

Introducing a malus: a malus scheme is working contra productive. The IM/Ministries should check each wagon kilometre as operators will not announce themselves that they have to pay malus. Again quite some administrative costs.

Banning iron blocks: The introduction of a ban should be considered. Since a malus per wagon-km would lead to a complicated and costly transaction scheme, banning iron blocks is more efficient. Various possibilities could be considered, like the forbidding iron blocks after a certain period, noise tax on the sales of iron blocks, introduce a legal ban on noisy wagons by 2020 etc.

Administration process: The administration for claiming the bonus per axle/km should be very simple. Some stakeholders prefer to include the bonus directly in the initial costs to avoid extra administration and transaction costs. Other options should be explored, but separately organized from the access fees.

Moreover the bonus should be claimed by the operators, and only ad random checked. It should be avoided that each bonus- kilometre is checked.

State aid: State aid should be organized conform the state aid guidelines for railways, published 22 July 2008 (2008/C 184/07) and the guidelines for state aid for environmental matters published 3 February 2001 (2001/C 37/03). In the "Funding for measures of noise reduction for existing railway freight wagons under the framework of the pilot project 'Silent Rhein' (State Aid No N324/09)" the EC agrees upon a state aid of 50% of the additional costs for the retrofitting. Further investigation is necessary for any scenario which includes forms of direct aid taking into account the above mentioned guidelines. Any national scheme that involves a direct public support to the infrastructure managers/railway undertakings other than differentiation of track access charging compliant with directive 2001/14/EC, should be subject to a notification to the Commission and an evaluation by the competition department of the Commission on a case-by-case basis.

European scope: The effect of the proposed measurement has more effect when these are adapted at EU level as wagons are running all over Europe. There for it is advised to urge the UIC to speed up the authorization of LL blocks on European level. A prohibition of noisy wagons per e.g. 2020 / 2025 should be also considered. As already mentioned in section 2.2.1, the Commission plans to submit in July a proposal for the recast of Directive 2001/14 which will introduce the mandatory NDTAC on a EU-wide basis. There is a potential risk of divergence between national measures and requirements of EU legislation which may later on result in legal procedures. Therefore there is a need that any eventual measure taken at national or corridor level should be consistent with ongoing developments at EU level.

Compensating external costs: Running noisy wagons has are external costs to the society, not to the IM. It is therefore not logical to compensate the IM in the NDTAC for these costs. The society should be compensated. It is unclear now how these NDTAC are passed to the society and are not kept within the IM.

Consultants advise on scenarios:

If the Ministries want 100% confirmation that the modal split does not change: the MoTs are advised to cover both initial costs and additional maintenance costs of retrofitting (scenario 1).

If change of modal shift is regarded as a minor risks and knowing that the additional maintenance costs of LL blocks cover maximum 2% of the railway operators costs; the consultant advise the Ministries to subsidize only initial costs for retrofitting to minimize administration- and transaction costs and to avoid setting up a control system. (scenario 4)

In order to avoid future conflicts that could lead even to legal remedies and to maximize the efficiency of the proposed measures, it is recommended to align the national efforts on rail noise abatement in Corridor A with the ingoing EU developments, especially the recast of Directive 2001/14.