

ANALYSES OF PRECONDITIONS FOR THE IMPLEMENTATION AND HARMONISATION OF NOISE-DIFFERENTIATED TRACK ACCESS CHARGES

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1. EXECUTIVE SUMMARY

Rail freight noise has been increasingly regarded as a problem by EU Member States over the past few decades. It has now been acknowledged for several years that noise can be a serious threat to public health. An estimated 10% of people in the European Union (EU) are exposed to noise levels above the threshold of 'serious annoyance'.

The problem of noise – and more specifically of noise created by freight wagons – has long been recognised by the European Commission. Earlier studies commissioned by the European Commission have concluded that the retrofitting of freight wagons with 'silent' brake systems has proven to be the most effective method to reduce freight train noise. As a technical solution to overcome the problem of 'noisy' freight wagons, the industry developed several types of low-noise brakes which can reduce the perceived rolling noise by up to 50%. There are two types of brakes: So-called K-blocks which require the wagon to be modified and the braking system to be adjusted as well as so-called LL-blocks which require only minor adjustments to the braking system but have not received their homologation yet.

The main obstacles against retrofitting are the commercial constraints that exist in the rail freight industry. Due to the competitiveness of the freight market stakeholders (Wagon Owners – WOs, Wagon keepers – Wks, Railway Undertakings – RUs) do not have sufficient resources or incentives to finance the retrofitting of their fleets. Furthermore, national approaches cannot ensure sufficient noise reduction due to the internationality of rail freight traffic.

Therefore the European Commission favours a coordinated approach at the European level using the instrument of a Noise-Differentiated Track Access Charge (NDTAC) to incentivise the involved stakeholders to retrofit freight wagons.

Objective of the present study was to identify an NDTAC which secures retrofitting of the majority of the freight wagon fleet within the envisaged time horizon of 5-7 years by prioritising those vehicles with the highest annual mileage. At the same time, the level of complexity and administrative costs was to be kept to a minimum. Furthermore, the incentive system should neither weaken the overall market share of the freight sector nor disadvantage any freight market player.

In a first step existing academic approaches towards NDTAC were reviewed and narrowed down to two design options – 'pass-by NDTAC' and a 'TSI noise-based NDTAC'. In order to identify the preferred design option the study investigated the framework conditions under which an NDTAC will operate. This analysis was supported by interviews with key experts from the involved stakeholders. Furthermore the case studies looked at the two countries – Switzerland and the Netherlands – where NDTAC has been implemented.

To derive the preferred NDTAC the two main options 'pass-by NDTAC' and 'TSI Noise based NDTAC' were analysed with regard to the following framework conditions:

- Analysis of the rail freight market, most notably the risk of modal shift, possible impacts of a NDTAC on an intramodal and intermodal shift and the contractual relationships with special regards to the wagon renting market;
- The costs of an NDTAC, differentiated by cost-elements (e.g. retrofitting costs, costs for data entry) and possible risk of over- and undercompensation;
- Differentiations within a NDTAC by type of wagon, by route or by time;
- A short overview of systems for data entry. Main focus was set on TAF TSI and their usage for NDTAC applications in the future. Regarding a possible delay of TAF TSI and the envisaged time horizon interim solutions were included;
- The compatibility of existing 'TAC' with an upcoming NDTAC;
- A demonstration of the two main technical solutions of fast reducing rail noise: The brake block retrofitting with K-blocks or LL-blocks.

The analysis concluded that the 'TSI-noise-based NDTAC' is the most appropriate option with regard to the targets and continued with an in-depths analysis of the settings for this remaining option.

Under given constraints regarding charging processes, market situation or impacts of incentives, a qualitative analysis specified details of the charging process (bodies involved, technical system, institutional setup, sources to finance). Furthermore a quantitative model was developed setting the main parameters of the NDTAC, such as the bonus level, the length of funding period, total amount of economic costs and total cost of bonuses paid.

The findings of the study – as shown in the below figure – drafted the structure of the preferred NDTAC. It is important to note that the sector's willingness to participate is essential. This can be realised by implementing an efficient and effective NDTAC which keeps the sector's burden low and leads to high incentives regarding noise reduction.

Main elements of such a system are:

- A pure bonus system for 'silent' wagons without implementation of maluses in regard to 'noisy' wagons;
- Funding of any wagon which is homologated according to TSI Noise; while the level of bonus depends on the costs of retrofitting with either K-blocks or LL-blocks;
- In any case the ban of cast iron brake blocks should be aimed in the long run. At least a re-retrofitting of once retrofitted wagons should be prohibited;
- The bonus level should be calculated on the basis of costs of retrofitting plus additional operational and administrative costs which occur on the side of the RU and the WK. Emerging costs at the IM-side should not be part of the bonus level applied;
- The bonus should be calculated based on the number of brake blocks per axles;
- Charging of the NDTAC should base as far as possible on existing procedures of existing track access charging schemes. Due to the fact that NDTAC has to be axle-based instead of wagon- or train-based the noise related elements have to be put "on top" of the existing schemes and not to be implemented as simple factors of TAC;
- In the long run the environment of TAF TSI should be used in order to support and simplify the usage of the NDTAC. This includes the data entry and support of charging processes. Since TAF TSI is still not available an 'interim' solution had to be found. Due to effectiveness and simplicity the 'self-declaration' used and proven in Switzerland was selected to be an appropriate way to keep the system simple but functioning;
- To support the effectiveness and avoid discrimination an EU-wide implementation should be aimed for. On a national level only the implementation on the large networks is recommendable. Thus administrative costs can be lowered by ensuring sufficient predictability and reliability for the participants;
- The NDTAC could be funded either through maluses – which is not recommended, mainly due to high administrative complexity, an increase of the general TAC level or through financing by Member States. To avoid a high financial burden for the sector, without fully excluding the sector's contribution, a combination of funding – sector and Member States – might be feasible;
- The calculation of bonuses was made based on estimates of retrofitting rates and renewal rates which were ensured by consultations with stakeholders. This applies for cost estimations (initial, operational, administrative) as well.

The below figure summarises the key characteristics of the preferred NDTAC design option:

General Charging Principle Applied: TSI-Noise Approved Rolling Stock																				
General Characteristics	Charging Process (interim)	Charging Process (long term)																		
<ul style="list-style-type: none"> • Only a bonus is applied • no malus is applied • Level of bonus predefined and fixed over funding period • Wagons need to be recorded separately • Incentive level is calculated in relation to costs associated with retrofitting plus administrative costs at the RU and WK. 	<p>Institutional Set-up</p> <ul style="list-style-type: none"> • Clearing Body is the IM • RU claims for the bonus • RU allocates the received bonus to the participating WK <p>Use of Self Declaration</p> <ul style="list-style-type: none"> • IM invoices RU as part of TAC charging process • Invoice is basis for reimbursement-form listing all silent wagons per train/ day and registration number • RU passes bonus to WK • Control and Enforcement body has full access to data from the IM, RU and WK 	<p>Institutional Set-up</p> <ul style="list-style-type: none"> • Clearing Body is the IM • RU claims for the bonus • RU allocates the received bonus to the participating WK <p>Use of TAF-TSI</p> <ul style="list-style-type: none"> • Requires existence of central database including information on routing, mileage, train composition and technical characteristics of wagons 																		
Length of Funding Period	Recommended Incentive Level	Time and Route Dependent Variation																		
<ul style="list-style-type: none"> • Predefined funding period in order to secure planning reliability • Recommend are 6 years or 12 years (as a multiple of revision cycle) 	<ul style="list-style-type: none"> • For 6 year funding period <table border="1"> <thead> <tr> <th></th> <th>K-Block</th> <th>LL-Block</th> </tr> </thead> <tbody> <tr> <td>4-axle wagon</td> <td>0.032 €/km</td> <td>0.012 €/km</td> </tr> <tr> <td>2-axle wagon</td> <td>0.016 €/km</td> <td>0.005 €/km</td> </tr> </tbody> </table> <ul style="list-style-type: none"> • For 12 year funding period <table border="1"> <thead> <tr> <th></th> <th>K-Block</th> <th>LL-Block</th> </tr> </thead> <tbody> <tr> <td>4-axle wagon</td> <td>0.019 €/km</td> <td>0.009 €/km</td> </tr> <tr> <td>2-axle wagon</td> <td>0.009 €/km</td> <td>0.004 €/km</td> </tr> </tbody> </table>		K-Block	LL-Block	4-axle wagon	0.032 €/km	0.012 €/km	2-axle wagon	0.016 €/km	0.005 €/km		K-Block	LL-Block	4-axle wagon	0.019 €/km	0.009 €/km	2-axle wagon	0.009 €/km	0.004 €/km	<ul style="list-style-type: none"> • A NDTAC differentiation by time of the day is not recommended • A NDTAC differentiation by route is not recommended • Member states should consider introducing an additional bonus granted to trains, which are fully equipped with retrofitted wagons.
	K-Block	LL-Block																		
4-axle wagon	0.032 €/km	0.012 €/km																		
2-axle wagon	0.016 €/km	0.005 €/km																		
	K-Block	LL-Block																		
4-axle wagon	0.019 €/km	0.009 €/km																		
2-axle wagon	0.009 €/km	0.004 €/km																		

Source: KCW/ SDG/ TUB

2. INTRODUCTION

It has now been acknowledged for several years that noise can be a serious threat to public health. An estimated 10% of people in the European Union (EU) are exposed to noise levels above the threshold of “serious annoyance.” In the case of rail transport, studies have shown that rolling freight wagons were the most important source of noise. Since many freight trains operate at night, the noise produced is even more harmful.

The problem of noise – and more specifically of noise created by freight wagons – has long been recognised by the European Commission. Earlier studies assigned by the European Commission have concluded that the retrofitting of freight wagons with silent brakes has proven to be the most effective method to reduce freight train noise¹.

As a technical solution to overcome the problem of ‘noisy’ freight wagons, the industry developed several types of low-noise brakes which can reduce the perceived rolling noise by up to 50%. One type of such brakes is the so-called K-block which received definite homologation in early 2008. Its use is already mandatory on new wagons. K-blocks require the wagons to be modified and the braking system to be adjusted. In order to overcome this, the industry developed so-called LL-blocks which require only minor adjustments to the braking system. This makes retrofitting significantly cheaper or – as stated by several experts – even cost-neutral in some cases. So far the LL-block has not been homologated².

More recent versions of freight wagons are already equipped with low-noise brakes, since they must fulfil the requirements of the Noise Technical Specifications for Interoperability (TSI) whereby the noise created by a wagon is not allowed to exceed a certain ceiling. However, an estimated 370,000 wagons of the existing freight wagon fleet still need to be retrofitted, as the remaining lifetime of these wagons is still 20 to 30 years. Due to the long lifetime and the relatively low renewal rate – which is estimated at 2.5% p.a. – it would take decades before a reduction of overall rail freight noise levels start to show³.

The main obstacles to retrofitting are the commercial constraints that exist in the rail freight industry. Due to the competitiveness of the freight market stakeholders (Wagon Owners – WOs, Wagon keepers – WKs, Railway Undertakings – RUs) do not have sufficient resources or incentives to finance the retrofitting of their fleets. Further, 50% of rail freight transport is international. Therefore national abatement strategies – as already applied in Switzerland or the Netherlands – could have a negative impact on cross-boarder corridors and give some RUs a competitive advantage over others who are not able to receive any benefits by their respective government. Furthermore, national approaches cannot ensure sufficient EU-wide noise reduction.

Therefore the European Commission favours a coordinated approach at the European level. In preparation for this, the European Commission commissioned a study on the impact of different rail noise abatement measures. As a result, an approach which combines noise-differentiated Track Access Charges, noise emission ceilings and voluntary commitment was identified as the most appropriate solution.

As a next step, 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. In preparation for this step, the Commission has launched a study to develop preconditions for the implementation and harmonisation of important elements for such a scheme. This report presents the results from this study. The conclusions shall serve a basis for guidelines for those Member States that are willing to implement such a scheme as “first-movers”, prior to the introduction of legal requirements.

This study will therefore:

- Analyse the challenges for the practical implementation of noise-differentiated Track Access Charges,
- Develop appropriate solutions in co-operation with the stakeholders concerned,
- Explore other preconditions which must be fulfilled in order to secure a successful implementation of a noise-differentiated access charge.

3. SCOPE AND OBJECTIVE OF THE STUDY

3.1 Definition of Noise and Sources of Noise

Rail noise is increasingly perceived as a significant annoyance. Further, it has been recognised that noise can cause serious health problems. This is especially true for noise generated at night.

A complex structure such as a train consists of a plurality of noise sources. In many cases the interaction of these sources of noise leads to noise emission levels that are higher than what can be decently tolerated by people. It is impossible to exhaustively list all the components that cause rail noise. However, it is generally accepted that brake blocks are one of the main sources of rail noise.

A classification of rail freight noise by speed levels illustrates the relevance of brake blocks as a noise source. Rail freight noise can be differentiated into three main groups⁴:

- I At low speeds, **traction noise** dominates. This noise is comprised for instance of motor noise or air ventilation noise. These noises dominate during starting and low speed levels up to 50 km/hour. Therefore this noise group can be disregarded relative to the other noise groups.
- I **Aerodynamic noise** increases with speed and becomes relevant at high speed levels over 250 km/hour due to the emergence of turbulence. However, freight trains never operate at such speeds. Therefore aerodynamic noise can also be disregarded with respect to rail freight noise.
- I **Rolling noise** is predominant at speed levels between 50 and 250 km/hour. Rail freight trains usually operate within this range. The wheel-rail interaction generates the rolling noise which is caused by rough wheels and rail rolling surfaces. The contact of the rough surfaces makes the wheel and the rail vibrate. These vibrations partly radiate into airborne sound and are partly transmitted to the sleepers which in turn radiate sound.

The main cause for this wheel and rail roughness is the brake system. While disc brakes – used in most modern passenger wagons – use their own mechanical elements to get the braking energy to the axle, the wheels in the brake block system are at the same time wheel surface and immediate contact pressure elements which have to hold the braking power. When such brakes are used, the brake block frequently overheats and as a result, small particles come off the brakes and melt onto the rail and wheel surfaces. This mostly occurs when cast iron (CI) brake blocks are used. This type of brake is currently in use on the majority of freight wagons. Composite or sintered brake blocks (K- and LL-blocks) represent a possible solution to this problem. When they are used, no particles bond to the rail and wheel surfaces. Composite blocks such as the K- or LL- blocks are thus essential for the mitigation of rail noise. This explains the Commission's interest to retrofit freight wagons with innovative brakes.

Noise level reductions through the use of K- and LL-blocks have been confirmed by empirical evidence. Measurements have shown sound level differences of the pass-by-noise of up to 15 dB (A) between rough, corrugated wheel and rail surfaces and smooth wheels running on a smooth rail surface⁵.

Since rail freight noise does not only result from the rolling noise there are other opportunities to reduce noise-emissions beyond the replacement or retrofitting of brake blocks. Other solutions could be noise absorbers or bogie suspension. As long as such measures efficiently reduce noise they should be supported by Noise-Differentiated Track Access Charges (NDTAC). However, the advantage of the retrofitting of brakes is that it sets a clear and relatively risk-free framework for a relatively risk-adverse industry.

3.2 Structure of the Report and Methodology Approach

A previous study undertaken by PWC in 2007 concluded that the introduction of a NDTAC would be the most effective instrument to secure significant decrease in noise-pollution⁶. Given the relatively low annual fleet renewal rate of 2.5% and an estimated number of 370,000 wagons fitted with noisy CI brakes, the study further concluded that only an incentive system concentrating on the retrofitting of existing wagons would meet the required objectives. The replacement of existing CI brakes by composite brake

blocks was found to have the lowest cost-effectiveness ratio (i.e. the lowest cost for the highest relative effectiveness). To achieve this objective, an appropriate environment of incentives should be created in order to accelerate the process of retrofitting.

The objective of the present study is to identify an incentive system which secures retrofitting of the majority of the freight wagon fleet within a reasonable short time horizon of 5-7 years by prioritising those vehicles with the highest annual mileage. At the same time, the level of complexity and administrative costs should be kept to a minimum. Furthermore, the incentive system should neither weaken the overall market share of the freight sector nor put any freight market player to a disadvantage. In order to meet this objective the following methodology approach will be applied.

The present chapter sets out the structure of the report but also the methodology and scope of the study.

Chapter 4 provides an overview of the academic approaches and development of design options.

Chapter 5 sets out state-of-the-art examples of Member States (case studies) where approaches towards NDTAC systems have been applied or where the implementation of NDTAC is currently being discussed. The objective of these case studies is to identify and describe potential design options for an European-wide NDTAC and examine their practical feasibility. At the same time, qualitative advantages and disadvantages of the different approaches are listed. The case studies were selected based on targeted expert interviews as well as on academic literature.

Chapter 6 examines the framework conditions under which a NDTAC will be introduced. It also identifies constraints for a potential implementation. Findings from this chapter feed into the initial design options as well as the in-depth analysis of the remaining design options (chapter 7). Framework conditions and constraints are then derived from the analysis of economic, legal and technical requirements NDTAC has to meet. As these requirements cannot always be separated accurately some of the examined characteristics fall under the above mentioned requirements. All criteria must also satisfy timeframe requirements. The main characteristics of the economic constraints are:

- Risk of modal shift;
- Impacts on intramodal competition;
- Contractual relationships;
- The level of costs and risk of overcompensation;
- Differentiation of incentive;
- Data entry;
- Compatibility with national TAC and the directive 2001/14/EC;
- Technical brake block solution; and
- Measuring rail noise.

The constraints themselves form the criteria for rating the design options (**chapter 6.12**) in order to identify the preferred design option securing a rapid reduction of noise emissions.

Chapter 7 provides an in-depth analysis of the preferred design option, narrowing down the remaining variant to a practicable and target-orientated solution of a NDTAC. Analysed elements are:

- The clearing body and the claiming body of the incentive (process of charging);
- The technical systems supporting the charging process;
- Length of funding period;
- Incentive level;
- Total costs of the system; and
- Funding of the system.

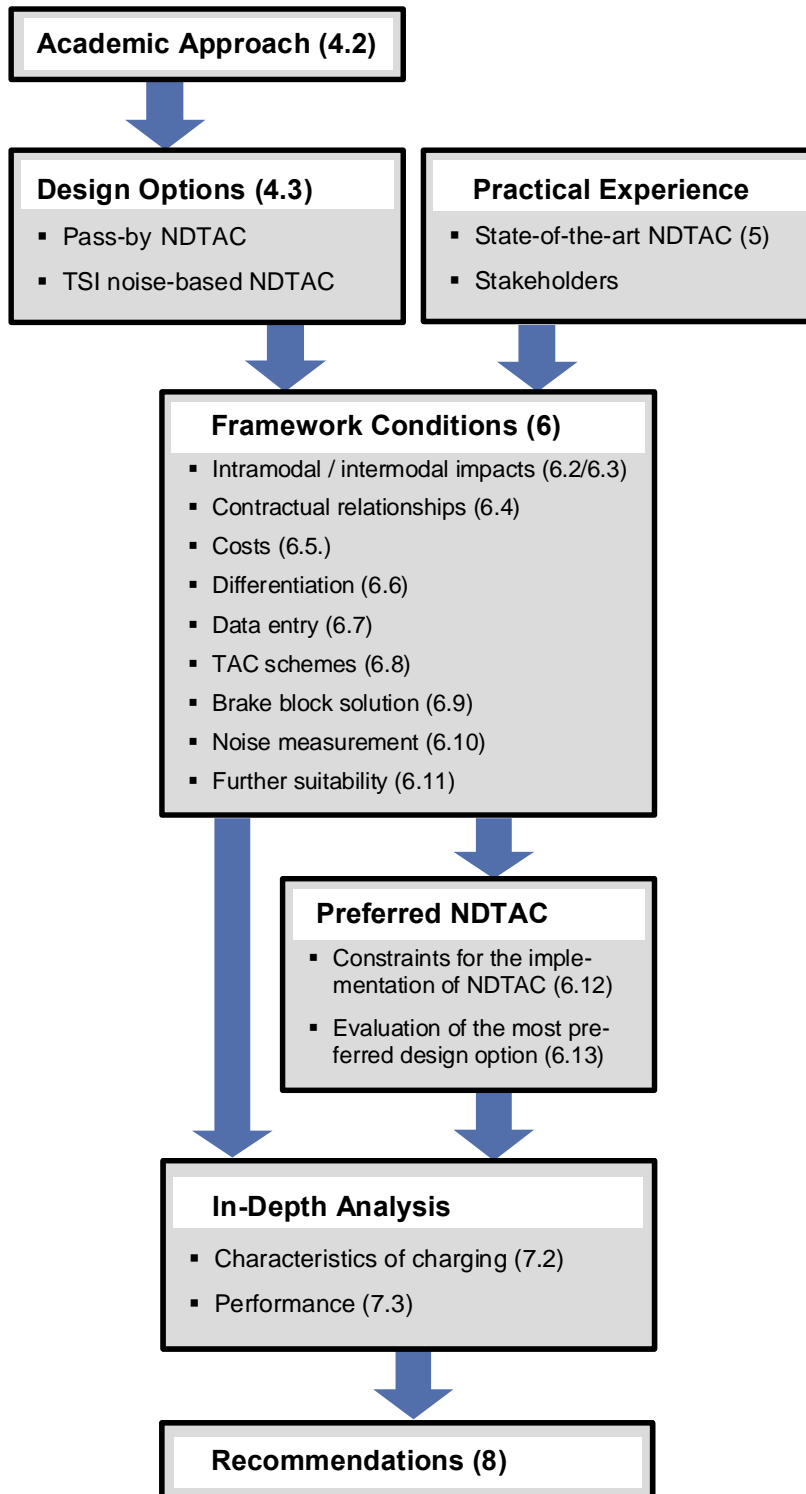
Finally, **chapter 8** provides final recommendations and outlines further steps.

The results of the analysis and research (which used information from the public domain, from literature, and from official documents) were submitted to the review of experts when applicable. Thus our analysis is coherent with the views held by the stakeholders. Furthermore, the consultants were able to sift out the opinions of experts whose opinions were influenced by their own interests since we interviewed a large panel of experts on each issue.

The following stakeholder groups were interviewed:

- RUs;
- Infrastructure Managers (IMs);
- WKs/WOs;
- Manufacturer of braking systems;
- Associations (national, international); and
- National authorities.

Figure 1: Methodology



Source: KCW/ SDG/ TUB

3.3 Scope of the Study

The scope of the study has been narrowed down with regard to the envisaged objective of the incentive system – retrofitting of existing freight wagons with composite or sintered brake blocks and with regard to the number of Member States which have been analysed.

3.3.1 Placing Emphasis on Retrofitting ‘Noisy Freight Wagons’

As demonstrated in more detail in chapter 3.1 there are various factors responsible for rail noise. CI brake blocks are one of the major sources of noise, but clearly not the sole source. However, retrofitting freight wagons would be an effective and particularly fast measure to reduce rail noise. Most industry stakeholders consulted as part of this study confirmed this assertion. Furthermore, retrofitting is a precondition for other rail noise reduction measures, such as rail-grinding.

All potential options to incentivise retrofitting must be analysed against the background of their necessary preconditions. The analysis of preconditions for NDTAC therefore has to address the issue of timeliness of the retrofitting process of ‘noisy’ wagons and of how the existing Track Access Charge Regimes can accelerate this process.

It should also be stressed that only if a significant number of freight wagons with high annual mileage are retrofitted a significant impact on noise levels can be expected. This is due to the fact that the relationship between the number of retrofitted wagons within one train set and noise-emission savings is logarithmic rather than linear. This stresses the need for a reasonably fast retrofitting of the existing fleet.

Although the study focuses on retrofitting the existing fleet, it will also consider how to incentivise the use of wagons which comply with the TSI Noise regulation.

Passenger coaches will not be considered as part of this study. They are in most instances equipped with relatively silent disc brakes⁷. Furthermore rail noise disturbance occurs mostly at night when passenger trains rarely operate.

3.3.2 Countries Analysed

In order for a NDTAC to be effective it must be implemented along the main European rail freight corridors. Thus it must be implemented in key EU Member States as well as in Switzerland⁸. This ‘trans-national scope’ can be justified by the fact that freight wagons are used trans-nationally and by the continuous increase in trans-national rail freight traffic. Furthermore, industry structures within the Member States are similar (This will be further elaborated in chapter 6). Therefore, an analysis of *all* European countries is not considered to be essential, as most of the market structure characteristics can be summarised under a few market structure regimes. It is important however to identify those market structure regimes and examine those countries which host the main European rail freight corridors with the highest freight traffic volume.

Therefore only the most relevant European countries in terms of rail freight were identified. The structures of their Track Access Charges (TAC) were analysed to find out in which framework a noise-based addition to the TAC would have to be implemented. Examples of criteria were relevant for transit of rail freight and intermodal market share of rail freight. The table below summarises the selected countries and the reasons why those countries have been chosen for the study. Generally, it is assumed that conclusions for the countries which have not been analysed can be drawn from the ones which have been analysed.

Table 1: Countries Considered in this Study According to TAC

Country	Track gauge	Reason
Countries included in the Study		
Austria	1435 mm	high proportion of rail freight traffic in the modal split; high amount of freight transit through the Alps
Czech Republic	1435 mm	high proportion of rail freight traffic in the modal split; transit country
France	1435 mm	high amount of rail freight traffic
Germany	1435 mm	highest amount of rail freight traffic in Europe; most of which is transit; freight lines going through densely populated areas
Great Britain	1435 mm	high market share of rail freight traffic; densely populated
Italy	1435 mm	high amount of rail freight traffic
The Netherlands	1435 mm	mainly port-hinterland traffic from Rotterdam (Betuwe Line); extremely densely populated; noise-differentiated Track Access Charge is applied
Poland	1435 mm	high proportion of rail freight traffic in the modal split; transit country; high percentage of private freight companies with significant market shares; great need of modernisation of rolling stock
Sweden	1435 mm	will be (together with Denmark) exemplarily analysed for the other Scandinavian countries
Switzerland	1435 mm	high amount of rail freight traffic; most of which is transit; quite densely populated; noise-differentiated Track Access Charges already exist

Source: KCW/ SDG/ TUB

3.3.3 ‘Out of Scope’ Elements

Consultations with industry stakeholders undertaken as part of this study were highly affected by the concerns of the railway sector regarding a distortion of competition. Industry stakeholders apprehend a risk of modal shift from rail transport to road transport if the NDTAC is implemented. This fear is based on the belief that the direct and hidden costs which such an implementation would impose on the rail freight sector. This would render this mode more costly and thus uncompetitive compared to road haulage.

In general, the consultants share the same point of view regarding price increase and modal shift. A distortion in competition can only be avoided if external costs and infrastructure costs are paid by all transport modes. This condition is currently not fulfilled. However, the scope of this study is not the analysis of constraints with regard to the implementation of externality charges to infrastructure users. At the same time, externalities being fully covered by all modes of transport would not tackle the problem of rail noise. Given the objective of securing a retrofitting of the majority of the freight wagon fleet within the envisaged time horizon of 5-7 years, the study foresees the existence of a cross-modal externality charge as a requirement for the introduction of NDTAC.

Furthermore, this study is *not* considering other methods to solve the problem of rail noise such as passive noise protection (e.g. noise barriers). As mentioned above, the PWC study has concluded that retrofitting brake blocks reduces rail noise most cost-effectively.

Finally the option of direct funding the retrofitting of wagons will not be taken into account in the present study. This was part of the previous PWC study which concluded that NDTAC are a better solution for incentivising retrofitting. Direct subsidies do not incentivise the WK to keep the costs for retrofitting low⁹.

4. ACADEMIC APPROACHES AND DEVELOPMENT OF DESIGN OPTIONS

4.1 Basics: Overview of TSI Noise

Since it came into effect on June 23rd 2006 the TSI Noise regulates noise-emission limits for new freight wagons in accordance with directive 2001/16/EC. For wagons put into operation before the above mentioned date, the TSI Noise does not apply. However, if the wagon is modernised or retrofitted, the TSI Noise requires homologation of the wagon. The homologation is delivered after the wagon passes a standardised noise test. There is an exception for composite brake blocks, though: If the wagon is retrofitted with this type of brake, no test is required and the wagon is automatically homologated¹⁰.

If the modification does not impact safety issues, inspection and homologation is generally not necessary (unless it is required by the Member State in which the wagon has been modified). According to WKs, which were consulted as part of this study, national authorities have not made this homologation compulsory yet.

To comply with the TSI Noise, the noise limits listed in the following table are relevant.

Table 2: TSI Noise Emission Ceilings for Freight Wagons

	Noise Level
New wagons with an average number of axles per unit length (apl) up to 0,15 m ⁻¹ at 80 km/h	≤ 82 dB(A)
Renewed or upgraded wagons according to Article 14(3) of Directive 2001/16/EC with an average number of apl up to 0,15 m ⁻¹ at 80 km/h	≤ 84 dB(A)
New wagons with an average number of apl higher than 0,15 m ⁻¹ up to 0,275 m ⁻¹ at 80 km/h	≤ 83 dB(A)
Renewed or upgraded wagons according to Article 14(3) of Directive 2001/16/EC with an average number of apl higher than 0,15 m ⁻¹ up to 0,275 m ⁻¹ at 80 km/h	≤ 85 dB(A)
New wagons with an average number of apl higher than 0,275 m ⁻¹ at 80 km/h	≤ 85 dB(A)
Renewed or upgraded wagons according to Article 14(3) of Directive 2001/16/EC with an average number of apl higher than 0,275 m ⁻¹ at 80 km/h	≤ 87 dB(A)

Source: based on the TSI Noise

In general the TSI Noise is open for any technology which reduces rail noise. Even though composite brake blocks are preferred by the TSI Noise, other technical solutions are not discouraged¹¹.

In summary, the TSI Noise applies to all new and modernised freight wagons. It is not applicable to wagons retrofitted before June 23rd, 2006 and to freight wagons which comply with the noise limit criteria of the regulation.

4.2 Theoretical Approaches Towards the Implementation of NDTAC

There are three theoretical approaches towards NDTAC currently discussed in the academic community. They form the framework from which the preferred design option will be developed. The following three options are currently being discussed¹²:

- I Rolling Stock Type Differentiated Access Charges** allow the IM to grant a bonus if the RU runs Low-Noise (LN) wagons. This concept assumes that noise emissions can be estimated as a function of the number of trains running on a network and their composition in terms of LN and non-LN wagons. This system requires the RU to classify their wagons as either LN or non-LN and the IM to verify all vehicles of a train when they pass by predefined cordons.

- I An **Emission Ceiling Bonus & Malus System** (based on measurements of real time noise emissions) works on the basis of a predefined noise ceiling, which needs to be calibrated (fixed) for each noise measurement station based on the predefined noise performance levels (e.g. noise levels with all wagons retrofitted). The fixed noise-emission measurement stations allow the measurement of noise emissions of each wagon of a train and the penalisation of the corresponding RUs which exceed the ceiling. The system requires traceability of all wagons on the network, the installation of measurement stations alongside the network and of sound propagation software which is accepted by all stakeholders. An emission ceiling based charging system also incentivises RUs to undertake noise-reduction measures which go beyond the retrofitting of wagons.
- I A **TSI Noise Bonus & Malus System** (based on measurement of a theoretical noise emission) uses the predefined noise emission ceilings defined in the TSI Noise. Indeed the TSI Noise is mandatory only for new freight wagons but its scope can be expanded to all wagons. The determination of bonus or malus is similar to that of the Emission Ceiling Bonus & Malus System. The main requirement of the Bonus & Malus System, according to the TSI Noise, is the (ex-post) certification of old wagons. This requirement is not currently necessary. Either a bonus can be granted by the IM for wagons with certifications or a malus can be charged if wagons have no certification. Additionally the concept requires the RUs to report wagon certification information in a central database.

Approach 2 is based on real noise measurement while approaches 1 and 3 are based on theoretical noise emission levels. Both approach 1 and 3 focus on the TSI Noise: The focus of approach 1 is close to a pure brake block-based system. Based simply on the types of brakes used on a wagon it is possible to classify it as 'silent' or 'noisy'. This assumption is coherent with the TSI Noise which states that the use of composite brake blocks automatically classifies a wagon as silent. Approach 3 specifically refers to the TSI Noise. This means that both approaches 1 and 3 are TSI Noise-related approaches and that they cannot be differentiated entirely one from the other. The approaches 1 and 3 will henceforth be considered as *one* design option.

4.3 Design Options

The review of academic literature, stakeholder interviews undertaken as part of this study and the analysis carried out led us to define two relevant design options for the implementation of a NDTAC. These options will be described briefly in the remainder of this section.

Pass-By NDTAC

- I The noise measured by so-called 'measuring stations' positioned alongside the route is relevant for the calculation of the bonus.
- I The basis of the charge is the entire train rather than individual wagons.
- I For the NDTAC itself, no wagon recording system is required.
- I A bonus is granted to trains which do not exceed a certain noise level.
- I No technical specifications – such as brake type or other characteristics of the wagon – are predefined as to how to keep the noise level below the limit. There is more discretion on how to achieve the target, allowing for innovation.
- I The RU, as well as the WK, has to find an agreement on how to split the bonus between the stakeholders involved.
- I Retrofitted wagons still need to be tested whether they comply with the TSI Noise or not.

TSI Noise-based Rolling Stock Differentiated NDTAC

The following characteristics are relevant for granting the bonus.

- I Wagons retrofitted with composite brake blocks get TSI Noise homologation without specific homologation process.

- The basis for the charge is the total number of axles of TSI Noise approved wagons.
- Wagons need to be recorded separately to allow for adequate allocation of the bonus.
- The clearing body is the IM.
- The RU has to allocate the received bonus to the participating WK.

The main characteristics are summarised in the table below:

Table 3: Main Characteristics of Design Options in Scope

Pass-By Noise Differentiated Track Access Charge	TSI Noise based Rolling Stock Differentiated NDTAC
Train based	Axle based
Real noise is relevant for bonus	Homologation of wagon on basis of the TSI Noise
Concerning pass-by noise no technical solution can be preferred	Design of bonus can prefer technical option by design of NDTAC
Homologation after retrofitting/modernisation mandatory	Homologation after retrofitting/modernisation mandatory
Retrofitting/modernisation of old wagons not necessary if entire train is silent	Retrofitting/modernisation of old wagons necessary, otherwise no bonus

Source: KCW/ SDG/ TUB

5. STATE OF THE ART NOISE-DIFFERENTIATED TRACK ACCESS CHARGES

This chapter sets out an overview of various national strategies towards rail noise abatement.

Currently two countries – Switzerland and the Netherlands¹³ – have already implemented approaches towards charging for rail freight noise. In both countries several stakeholder interviews were made to obtain information about the respective NDTAC. The experiences and contingent transferability of these approaches will be analysed. Furthermore, active discussion is taking place in Austria about NDTAC but at present no implementation is planned.

Additionally, a short overview of the German noise abatement programmes illustrates that most of the national approaches do not include a NDTAC, neither in theory nor in practise.

5.1 Case Study: Switzerland

5.1.1 Description of the NDTAC System

In 1986 Switzerland implemented a noise legislation that was specified for railways and enacted in 2000. The railway-specific noise abatement programme is planned to last until 2015. It is largely financed by toll road revenue. The programme consists of retrofitting all rolling stock, building noise barriers, and installing insulated windows in locations where noise thresholds are still being exceeded¹⁴.

A bonus related to the Track Access Charges was introduced in order to reward ‘silent’ wagons utilising Swiss rail infrastructure. The bonus is paid to RUs as a multiple of the number of ‘silent’ axles per kilometre. Eligible axles use K-block, disc or drum brakes; LL-blocks are still in the process of homologation and therefore are not part of the programme at the moment.

In order to be awarded the bonus, RUs first need an authorisation from the Ministry of Transportation. Then they have to send an application to the IM for the bonus. Consequently, the IM pays what is applicable to the RU which also gets an equivalent compensation through the general subsidies received from the Cantons and the State.

In addition to the Track Access Charge bonus, retrofitting Swiss freight wagons is fully covered by direct subsidies. Non-Swiss wagons are not covered by these additional subsidies though. They still benefit from the bonus by circulating on Swiss railways if they are silent.

This means the Swiss keeper/owner of ‘silent’ wagons can benefit from:

- The NDTAC bonus which can be passed on from the RU,
- The direct subsidy intended for retrofitting received from the Swiss government, and
- The willingness of the RUs to pay a higher price for ‘silent’ or less ‘noisy’ wagons.

On the other hand, the Swiss IM has recently increased the TACs. This has been interpreted by some of the consulted experts as an attempt to build a collective fund to finance the NDTAC Swiss bonus system. Alternatively, this can also be interpreted as a malus.

There is no limitation established 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 planned.

There is no mechanism to exhaustively control the bonus allocation, the bonus transferring processes, or the actual distances covered by ‘silent’ axles; this is because it would require an extensive amount of administrative effort to analyse the vast databases involved and follow up on each case individually. However, general plausibility controls of the system and punctual control actions have been announced. Both the detailed travel information of each wagon and the information on whether or not the wagon is suitable for a bonus are available from the participating stakeholders. The travel information of the RU enables a control of plausibility. Interviewed experts have declared that Swiss RUs are reliable in for-

warding 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.

The current bonus is 0.01CHF/Axle-km (~ 0.03 €/wagon-km) and will be halved for passenger trains in 2010¹⁵. The bonus represents between 5 and 8% of the access charge¹⁶ 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 2005¹⁷. 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 up until 2009 amounts 220 million CHF (~145 million €).

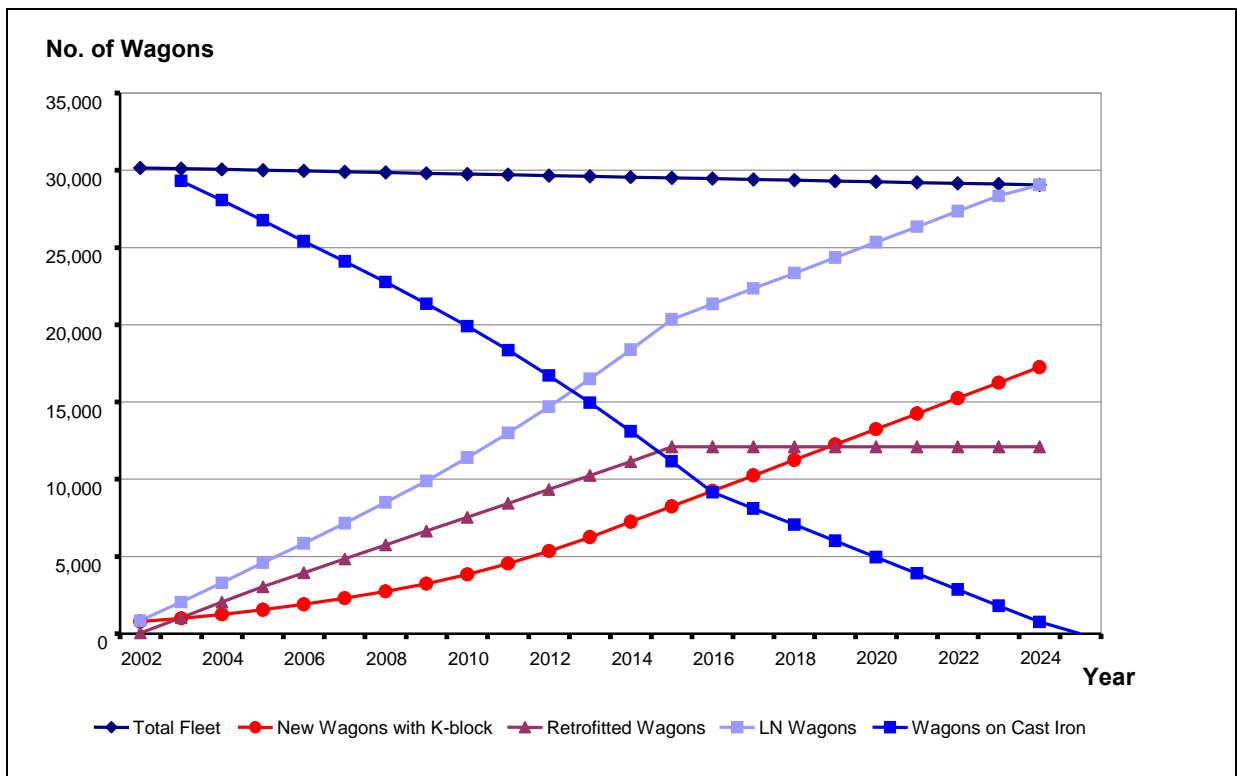
The main characteristics of the system can be summarised as follows:

- █ Direct whole subsidies for retrofitting Swiss wagons;
- █ NDTAC of 0.01 CHF per 'silent' axle (about 0.03 €/wagon) with no ceiling; paid to RU; and
- █ Self declaration (with punctual controls using information technology) of RUs which forward the bonus to WK/owner.

5.1.2 Freight Wagon Retrofitting Evolution

In early plans, 21,000 units were supposed to be retrofitted by 2015. This number was reduced for economic reasons to 12,100: 7,500 units planned for SBB and 4,600 units for private owners. The last wagon using CI brakes is estimated to be taken out of service by 2024.

Figure 2: Swiss Freight Wagon Fleet Evolution



Source: Analysis based on data of Bundesamt für Verkehr – Lärmsanierung der Eisenbahnen, Standbericht 2008 and stakeholder consultation

In Switzerland, the yearly average rail noise emission is calculated using the recordings from six measuring stations. In most cases the actual noise emission is at the level or even below the level of the emission plan for 2015. Average noise levels have been relatively stable over the years¹⁸. This can be

explained by the fact that there is a constant amount of transit traffic with 'noisy' foreign wagons or perhaps because of the increase in transport on certain routes.

5.1.3 Advantages

The main advantages of the Swiss NDTAC system are:

- Relatively low administrative costs due to self declaration and unlimited bonuses
The self declaration and the absence of limitations for noise bonuses relieve the IM from dealing with the mileage of each 'silent' axle and the calculation of the cumulative bonus it collected. An automation of this task would suppose higher administrative costs.
- Axle-based bonus
This is a more accurate measure, with respect to noise abatement, than the wagon-based one, furthermore the axle-based bonus approach can better cover retrofitting costs because it takes into account the various possibilities of the numbers of axles per wagon (2-6 axles are possible).
- Common information technology systems employed by the IM and RU
This enables easy punctual controlling for specific cases and minimises administrative costs.

5.1.4 Disadvantages

Despite the positive issues, the Swiss model includes some essential risks. The main disadvantages of the Swiss NDTAC are:

- Risk of overcompensation due to the absence of limitation for bonuses:
Although some consulted experts assure that overcompensation on wagons which are heavily used may cover the unclaimed bonuses for wagons which are not used much, the (theoretical) infinity of the bonus leads to a need for higher funding and can raise the total costs of the system.
- Administrative costs incurred by RUs for the accounting system and passing on of the bonus:
Although no precise data is available, RUs fear the administrative costs for implementing specialised accounting systems. A European wide system is perhaps not suitable for the simple system as used in Switzerland, especially for monitoring trans-national freight traffic.
The trust-based Swiss system may not be completely exportable to a wider European context
- Axle-based computation:
The automation of the system and the introduction of bonus-limits based on distances covered by axles are both relatively complex. The administrative costs would therefore increase.
- NDTAC is complemented with direct subsidies for retrofitting Swiss wagons:
This distorts the actual effect of the NDTAC on its own. The effect of the NDTAC on the Swiss system is not fully exportable to a European-wide context. Moreover direct funding only for national WOs/WKs is discriminatory and goes against the concepts defining the European market.
- 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 only.
- Level of bonus:
The data illustrates that the level of bonus is not significant. In 2005 about 2 million € of bonuses were granted for silent 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 transport¹⁹.

5.2 Case Study: The Netherlands

5.2.1 Description of the NDTAC System

In 2008, the Netherlands announced a large noise abatement programme to be carried out from 2011 until 2020. 650 million € will be invested in noise reduction programmes for road and rail. The aim is to reduce the rail noise level by 10 to 12dB²⁰.

Furthermore, since January 1, 2008, retrofitted freight wagons and retrofitted passenger coaches are eligible to receive a bonus of 0.04 €/wagon-km if they qualify as silent. This applies to all wagons and coaches that came into service before 2008 and have been retrofitted with K-blocks or equivalent technology after January 1, 2008. Newly built wagons and coaches, which are already silent, are not eligible for the bonus²¹. It is expected that LL-blocks reach homologation in about 2-3 years. At that point wagons equipped with these will be eligible for the bonus as well.

The bonus is obtained by all operating RUs after self declaring their wagons' mileage on the railway network. Thereafter, the IM reimburses the RU the corresponding bonus amount. These amounts have limitations that are stipulated as follows:

- For passenger coaches: limited to a total of 120,000km and 2 years, which makes a maximum bonus of 4,800 €/coach
- For freight wagons: limited to a total of 65,000km and 3 years (max. 25,000km of bonus per year), which makes a maximal bonus of 2,600 €/wagon (max. of 1,000 €/year and wagon)²²

The limitations to the bonus defined in distance and years forces the IM to keep a record of distances covered by wagons once the railway company has enrolled them in the programme.

Finally, the Ministry of Transportation receives a copy of the bonuses received as well as the self declarations on distances travelled. After validation, it compensates the IM with the funds from the programme.

The programme started with 15 million € of funds allocated by the government. The current plan is to replace the current bonus system with a bonus-malus-system. The malus is to be introduced 3-4 years after the homologation of LL-blocks and has not been quantified yet.

The financial flow takes place between the IM and the RU. The RU can pass on the bonus to the WO, but it is not forced to do so. The assumption in the Netherlands is that the market itself solves this problem.

Until now, there has not been a single company that has applied for the bonus due to the low incentives, and its limitations.

In the hypothetical case of a bonus application, the RU should send a self declaration of wagon mileage. In a later stage the existing information technology systems such as GOTCHA and QUO VADIS can be used for calculating the train-km. GOTCHA is used to measure the weight in motion as well as wheel defects by the maintenance company NedTrain. 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. Software for the calculation of 'silent' wagon-km and a database for the storage of the information are in development and are expected to be operational in 2011.

As a complementary measure for noise reduction, and apart from the installation of noise barriers, tuned absorbers for rails and insulated windows, a noise restriction is planned to enforce noise emission levels below the noise pollution limits. The limit will not be the same across the entire country; it will be defined for each rail line. These noise limits are not expected to be in place before 2011. At that point, noise emission levels will be monitored by several measuring stations²³.

One way of restricting the noise pollution is to decrease the speed of trains in noise-threatened sections or simply to diminish the amount of train traffic. Logically, this goes to the detriment of infrastructure capacity and it entails lower benefits for the IM. For that reason, the utilisation of 'silent' rolling stock can help maintain capacity while respecting the noise pollution limits.

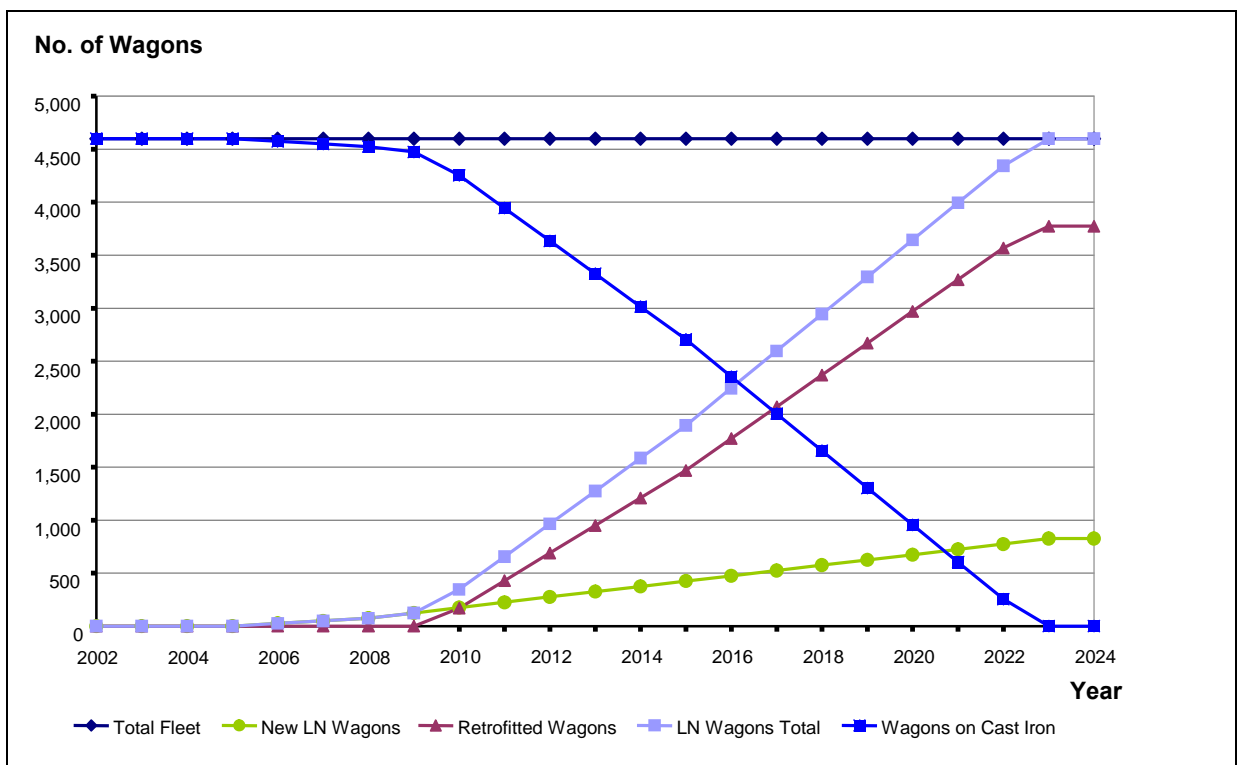
In summary, the Dutch NDTAC system's main features are:

- Only wagons which have been retrofitted after January 2008 are eligible for the bonus, not new wagons;
- The bonus level is 0.04 € per wagon and km, with limitations;
- The maximum possible bonus per freight wagon is 2,600 €;
- Self-declaration to be submitted by the RU to the IM and validated by the Ministry of Transportation;
- Possible punctual controls and authentication via information technology systems (GOTCHA / QUO VADIS);
- Malus to be introduced 3-4 years after homologation of LL-blocks but is not quantified yet; and
- Noise pollution limits controlled by measuring stations are planned. This will lead to a decrease in capacity.

5.2.2 Freight Wagon Retrofitting Evolution

The following table illustrates the evolution of the Dutch freight wagon fleet taking into account the process of retrofitting and use of new low-noise wagons. It is assumed that at first wagons are retrofitted with K-blocks and then – after the homologation of LL-blocks – with LL-blocks.

Figure 3: Dutch Freight Wagon Fleet Evolution



Source: Analysis based on data from stakeholder consultation. Please note that numbers shown in this graph comprise the fleet of former operator NS freight.

5.2.3 Advantages

The bonus payment limitation for wagons retrofitted after January 2008 makes it a pure retrofitting programme. Advantages can be summarised:

- **Bonus level:**

The amount is reasonable and in accordance with a plausible wagon performance, so that the risk of overcompensation can be reduced, although the question of overcompensation does not arise much due to the relatively high costs to supply wagons with K-blocks. But reimbursement of costs by using LL-blocks – by the time they get homologated – will likely be compensated adequately.
- **Dutch state funding:**

As the Dutch Government funds the programme completely this does not burden the railway sector and therefore an undesired modal shift is in principle avoided.
- **Self-declaration to be made by RU to IM:**

It simplifies the amount of data that needs to be processed automatically. The RU is the only party that is actually able to give detailed travel data of single wagons. The IM should keep a database of wagons and their distances travelled.
- **Possible punctual control and authentication via information technology systems (GOTCHA / QUO VADIS):**

The IM and the RU employ the same information technology platforms. With an additional software and hardware it is possible to obtain the travel distance of LN wagons.
- **Malus system announced 3–4 years after the homologation of LL-blocks, though not quantified yet**

This can trigger the rapid conversion of wagons, but details should be carefully adjusted since it could drive a modal shift in the direction opposite to what is desired by the EU.
- **Noise pollution limits are planned to be implemented. They will be controlled by measuring stations:**

The measuring stations allow the control of the real emissions and evolution of the noise. If the limits are reached this could result in a capacity restraint and create a risk of modal shift. Currently, the existing measuring stations are not linked to the NDTAC.

5.2.4 Disadvantages

Naturally, the system also contains some problems, which are listed below:

- **Limitations:**

Though the system avoids overcompensation, it has to be defined carefully in order not to be discriminatory or dissuasive. There is a risk that WOs/WKs will not retrofit their wagons if the limits are set too low. Limits do not necessarily require an automatic computation of mileage since the IM can actually continue trusting the self-declaration of RUs and keep a record of declared distances travelled to have a record when the bonus can no longer be claimed. 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.
- **Incentives too low (based on LL-blocks) and limitations for bonuses:**

The limits in the amount of the bonus given for a single wagon make the incentive for retrofitting questionable, especially for K-blocks. Even the bonuses for LL-blocks are too low. The limitation of bonuses to a maximum of 2,600 € per freight wagon is too low to create a real incentive.
- **No applications for bonus:**

Consultation with stakeholders has shown that – in some cases – the bonus is not requested by the RU due to the high administrative costs in relation to the bonus. Furthermore, an application of kilometric limitations within European territory would require communication between IMs with respect to the performance of wagons on their respective networks. This would entail high administrative costs and would be difficult to control.

I Risk of discrimination:

It is discriminatory that only wagons which were retrofitted after January 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.

I Malus:

A malus is always a financial burden to the railway sector and will benefit road transport since it is likely to divert traffic from train to trucks. The level of this malus should be set with this in mind.

I Monitoring on the basis of RFID:

The large-scale use of RFID is not economically viable. Therefore another control mechanism has to be established.

5.3 Other Noise Abatement Programmes

Beside the approaches in the Netherlands and Switzerland there are several noise abatement programmes in Europe. However, none of these programmes contain a NDTAC. Most of the programmes are regional or are focused on passive noise abatement measures. The lack of a national NDTAC in Europe simplifies a European-wide NDTAC as only two national NDTAC have to be replaced (assuming that none of them will be used as the model for the European-wide one).

There were discussions regarding a NDTAC in Austria but no decision has been made yet. If a NDTAC is implemented in Austria, the information technology system ARTIS (Austrian Rail Information System) could be used. ARTIS is a refined tool which records actual data regarding the movement of wagons in the Austrian network as well as their characteristics (e.g. brake type). Furthermore, ARCAMOS, also available in Austria, could be used for a NDTAC based on a pass-by noise monitoring system. Thus the introduction of NDTAC is achievable from a technical point of view. At the moment however, the Austrian government is not willing to pay for such a NDTAC. This means that the railway sector has to bear the costs of the system. Consequently, the risk of modal shift and disadvantages in regard to trans-alpine competition with Switzerland would increase.

Similarly, there is no NDTAC planned in Germany. There are attempts by associations of stakeholders such as “Leiser Zug auf realem Gleis” or “Leiser Rhein” to work on solutions to diminish rail noise. The first association combines Deutsche Bahn, the German government, the rail industry, and scientific institutions.

“Leiser Rhein” is an association with a specific approach focusing on the highly used north-south route through the Rhine corridor. The goal is to directly fund the retrofitting with composite brake blocks of 5,000 wagons which are using this corridor.

The main focus of German noise abatement measures consists of investments in passive noise measures. These are for instance noise barriers or insulated windows.

5.4 Summary and Conclusions

Switzerland and the Netherlands are the only countries implementing elements of NDTAC, while approaches in Austria are planned and still under discussion. Other countries have noise abatement programmes in place such as direct funding of noise barriers or direct funding for vehicle retrofitting.

The practical experience within the Netherlands and Switzerland is essential. Currently, only the Swiss system can be considered as ‘functional’ as no bonus applications have been submitted by RUs in the Netherlands yet, highlighting the deficiencies of the Dutch system. It must be noted though that these deficiencies might be overcome if a bonus were to be granted to wagons retrofitted with LL-blocks. Furthermore, the number of wagons retrofitted as a result of the incentive regime is far higher in Switzerland than in the Netherlands. In general, the incentive level seems too moderate in the Netherlands, intensified by the fact that no adjacent country is applying NDTAC. As a result RUs tend to hesitate to apply for the bonus. However, the success of the Swiss system is partly caused by the fact that the retrofitting of domestic wagons is directly funded.

Both systems are NDTACs based on a ‘construction feature’-approach regardless of any real noise measurement. The real effect of the NDTAC is therefore not clear. In some areas in Switzerland the overall rail noise level is even increasing.

Valuable information has been derived from the previous chapter with regards to the:

- Area where the bonus is granted and level of incentive;
- Application of the bonus; and
- Payment flow and impact of the incentive system in the contractual relationship between stakeholders.

Positive and negative aspects of the Swiss and Dutch systems identified as part of this chapter are summarised in the table below.

Table 4: Positive and Negative Aspects of Applied NDTAC in Switzerland and the Netherlands

Positive Aspects	Negative Aspects
‘Self Declaration’ as a simplified approach	Success partly based on direct funding of domestic wagons (Switzerland)
Focus on brake blocks; no additional technical feature considered	Overall, RUs do not submit bonus applications to the extent that they could
Bonus paid to RU, which maintains established cash flows. WK and WO are not involved	Single national solution not attractive for RU which operates only partially within the country
Axle-based bonus calculation (Switzerland)	Risk of overcompensation due to the lack of a bonus limitation (Switzerland)
Bonus available for all vehicles, regardless if they are new or retrofitted ones (Switzerland)	No bonus for new vehicles or such which were already retrofitted when NDTAC was implemented (Netherlands)
Limitation of total bonus. But: level of this total bonus has to be reviewed with regard to the incentive to retrofit (Netherlands)	

Source: KCW/ SDG/ TUB

In summary the following requirements towards a European-wide NDTAC have been derived from the findings of the present chapter:

- If possible, most of the Member States should introduce NDTAC – at the very least Germany, France, and Italy – to incentivise cross-border-operating RUs to apply for a bonus.
- The level of bonus should be high enough to incentivise RUs to apply for the bonus. The administrative costs of the bonus should not exceed the bonus itself.
- First findings from the reviewed countries suggest that funding of the LL-block may have a higher cost-effectiveness ratio than the funding of K-blocks.
- Application procedures for the bonus should be held as un-bureaucratic as possible, either through a relatively simple technical solution or through a similar system as the self-declaration in Switzerland.
- The IM and RU should be the only parties included in the payment mechanism of a NDTAC. An inclusion of further parties – such as WOs and WKs – would disproportionately increase the level of complexity of the accounting system and therefore its administrative costs.
- All wagons must be affected equally by the NDTAC or else the system will be discriminatory and will constrain noise abatement measures.

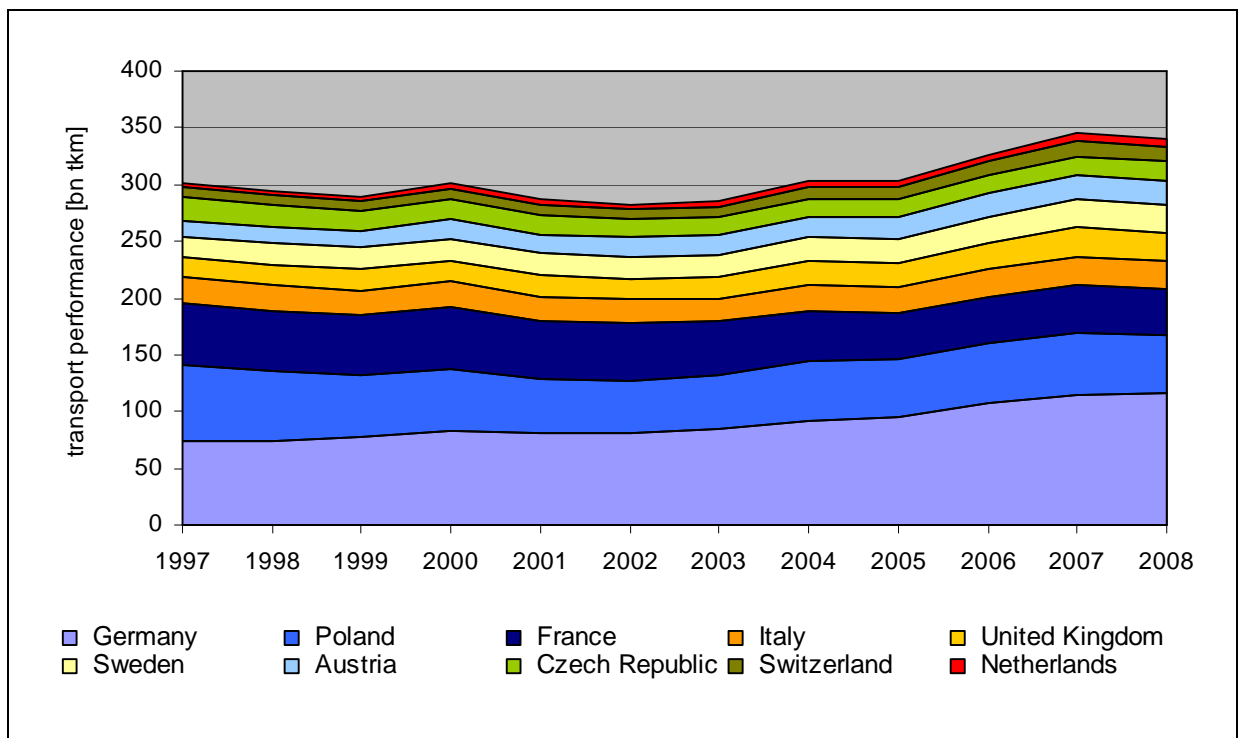
6. FRAMEWORK CONDITIONS FOR THE IMPLEMENTATION OF NOISE DIFFERENTIATED ACCESS CHARGES

The following chapter examines the framework conditions under which a NDTAC will be introduced. It also identifies constraints for a potential implementation. Findings from this chapter feed into both, the selection of an appropriate design option (6.13) as well as an in-depth analysis of the preferred design option (elaborated in chapter 7).

6.1 General Market Trends in Rail Freight

The European rail freight market has seen encouraging growth rates within the last ten years. After having lost substantial market share to road haulage in previous decades, the European rail freight market has been growing faster than road freight and regained relative market share. The figure below summarises market trends in terms of total tonne-km performance between 1997 and 2008 for the selected countries. At the end of 2008 the economic crisis caused a decline of rail freight throughout Europe. But it is expected by all economic experts that this will just be a temporary situation. Thus the trend of increasing rail freight will continue in case of recovery of the global economy. A side effect of the crisis is the high amount of idle wagons. This lowers the opportunity costs for retrofitting.

Figure 4: Rail Freight Trends in Analysed Countries



Source: German National Transport Statistics [Verkehr in Zahlen 2008/09]; European Commission, 'Energy and Transport in Figures', 2009 (for data until 2007). Data for 2008 are based on national statistical offices. Data for NL and I in 2008 are approximated by the authors using a growth rate of -4,9% (European rail transport average growth rate, calculated by UIC).

Looking at the various segments of the market, combined traffic has been one of the most growing segments, whereas bulk goods have been stagnating or have even decreased in volume. At the same time, rail services in non-bulk freight face a relatively highly elastic demand since road freight is a close substi-

tute. Bulk freight, in turn, reacts in a relatively inelastic manner to price changes. This has led to the precarious situation whereby freight has seen significant overall growth. However, this growth appeared in those segments which have the highest elasticity to changes in the market environment – most notably prices – and are therefore considered to be most vulnerable to changes in unit costs.

6.2 Substitution Risk: Risk of Modal Shift

The substitution risk relates to the potential risk for a modal shift in transport demand. It depends mainly on following aspects:

- I Type of goods;
- I Price elasticity;
- I Structure of logistics;
- I Availability of other modes of transport; and
- I Long-term relationship between customer and operator.

The **type of goods** essentially affects the preferential mode of transport. Bulk goods like coal or steel rely mostly on large shipping units. Because of this, they are typical rail freight goods, whereas groupage goods can be transported by other modes of transport.

The **price elasticity** is the measure of responsiveness of transportation demand for a given commodity using a certain transport mode as a result of a change in price for transporting the same commodity over the same mode. It indicates how a client responds to changes in prices: This could be through a change in the chosen operator, the mode of transport, or the demand altogether (which might be suppressed). The higher the price elasticity, the higher the risk of modal shift.

The **structure of logistics** relates to the transport requirements which are made by the customer. Normally customers expect reliable transport. Just-in-time production is nowadays state-of-the-art in manufacturing and it requires reliable and fast door-to-door transport solutions. It is difficult for rail to perform at this level due to the main characteristics of railway systems (for instance rail-bounding). However, customers' tendency to shift modes can be minimized, especially if railway transport is integrated as part of a transport chain.

The degree of substitution risk also depends on the **availability of other modes of transports**. This applies on the one hand to existing infrastructure and on the other hand to available operators.

Finally the **relationship between the RU and the client** also has to be considered. In some cases the RU can benefit from contractual relationships which have been established over a long period of time. It is clear however that this aspect is never the single-most important factor in the modal decision process.

The substitution risk is mainly affected by the types of goods and price elasticity. In the case of this study, price elasticity could not be established by conducting a stated preference survey with stakeholders as this would imply accessing privileged information. Thus the analysis focused on the general characteristics of goods and their impact on the substitution risk. Academic literature has often described this problem. The table below summarises the level at which there is a risk of modal shift from rail to another mode of transport based on a qualitative assessment of academic railway literature.

Table 5: Risk of Modal Shift for Selected Types of Goods

Types of good	Risk of modal shift (- = low, + = high, assumption)
Coal	(-) market dominated by single shippers, rail can offer competitive prices as unit costs are relatively low, technical affinity to rail
Steel	(-) market dominated by single shippers, technical affinity to rail
Groupage goods	(+) multiple shipper industry, rail can only offer competitive prices over long distance, rail tends to have worse area-wide coverage with terminal facilities than road haulage
Petroleum goods	(-) market dominated by single shippers, rail can offer competitive prices as unit costs are relatively low, rail benefits from road safety regulation
Chemical products	(-) market dominated by single shippers, rail can offer competitive prices as unit costs are relatively low, rail benefits from road safety regulation
Container	(+) multiple shipper industry, highly competitive market, rail tends to have worse area-wide coverage with terminal facilities than road haulage

Source: KCW/ SDG/ TUB

In cases where there is a low risk of modal shift, a price increase has a lesser effect than if it were for a type of good with a high risk of modal shift. Therefore the price elasticity as well as the types of goods have to be taken into account when analysing modal shift. A generalisation for the entire rail freight market is not feasible.

Impacts on Noise-Differentiated Track Access Charges

The overall increase in transport demand has a direct impact on the amount of railway transport supplied. However, railway transportation does not come without externalities such as noise issues. Because railway characteristics and environmental requirements both need to be taken into account, TACs attempt to solve this specific matter. This is done specifically through NDTACs. Yet, the exact impact of an implementation of a NDTAC will have to be studied by differentiating between different commodity groups. The analysis of the intermodal competition showed that an incentive system incorporating malus would make rail freight more expensive – in many cases at least for a certain time. This raises the risk of intermodal shift away from rail. A pure bonus-system could have positive effects whereas then the financing of the system needs to be examined. The general concern of stakeholders is that NDTAC could lead to higher prices for rail freight and therefore weaken the sector.

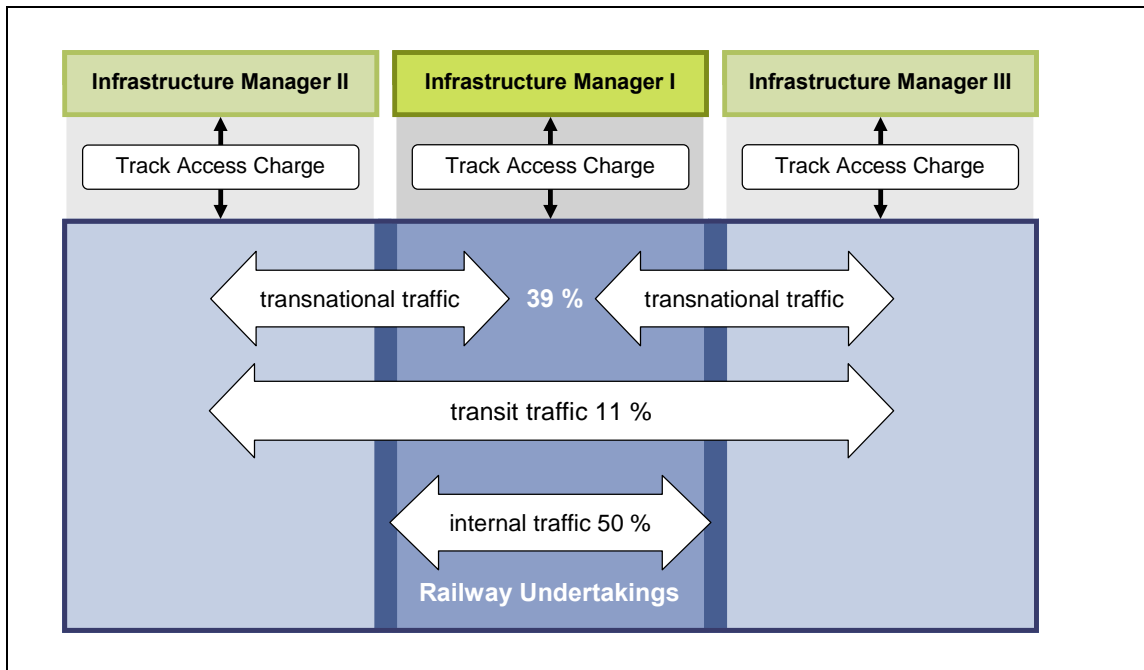
The TSI Noise-based option could theoretically allocate wagon types to commodity groups; however, this would disproportionately increase the complexity of the system and cannot be recommended. Certain commodity groups are more endangered of modal shift from rail to road than others. Hence, any noise related element of the TAC wouldn't be the proper cost element to calibrate the whole TAC to benefit such commodity groups.

In summary, it must be noted that the source of funding (Member State or rail freight industry) will have a larger impact on modal share than the choice of the design option. In addition, it has to be noted that the system, including administrative costs, must not become more expensive than it currently is. Otherwise modal shift might occur, unless other modes of transport are treated in the same manner.

6.3 Railway Undertakings: Impact on Intra-Modal Competition

Prior to the implementation of the EU Railway-Packages and the compulsory opening of national railway markets, the national rail freight markets were dominated by state-owned railway companies. Only a small amount of rail freight was transported by other RUs, mostly focused on specific areas and often operated on own railway networks. After the imposed liberalisation, the market changed: Companies expanded, newcomers appeared, and companies started to operate trans-national services. By now there are four main groups shaping the rail freight market. It is important to note that the European Railway Packages and therefore the trans-national approach of railway legislation are confirmed by division of rail freight traffic. About half of the rail freight traffic affects two or more countries. The figure below demonstrates this trend.

Figure 5: Partition of Rail Freight Traffic (Estimation)



Source: KCW/ SDG/ TUB, based on Eurostat 2008

Classification of Railway Undertakings

The Incumbent Operator

An incumbent operator is typically an already existing or former state-run railroad company. It possesses a high density railroad network and operates in nearly all market segments. For instance, in Germany the market share of the incumbent, Schenker – a subsidiary of the DB – is about 80%. The situation is similar in many European countries.

Since the last decade, after the large-scale changes in the European Railway market, the incumbents have withdrawn from some market segments, especially from unprofitable routes and/or lost market share to competitors. However, they are still the dominating market operators. This position on their domestic market is the basis for their trans-national activities. Almost all European state-owned RUs are now operating in other countries in addition to their home country. Hence, state-railroad companies have a market advantage in the sense that their offer covers a wider range of networks. Additionally it has to be noted that state-railroad companies often benefit from the advantages of a „vertical integration“ of transport and Infrastructure in one company.

Table 6: List of Selected European Formally State-Owned Railway Companies

Company	Domestic country	Freight performance (in bn tkm)
DB Schenker	Germany	113.63 (2008)
SBB Cargo	Switzerland	12.53 (2008)
Rail Cargo Austria (ÖBB)	Austria	19.43 (2007)
SNCF	France	40.92 (2006)

Source: Company Information

The Newcomers

Since the railway markets in Europe have been opened, many newcomers have entered the scene. They are sometimes private RUs with private investors or in other cases subsidiaries from foreign railway companies which are often state-railroad companies. This shows that the rail freight market has a diversity of market players.

Typically the RU does not possess any railroad network. Newcomers have focused their efforts on block train traffic and mostly on national or trans-national freight corridors, with a high proportion of container transport and transport for specialised industries such as the petroleum, chemistry or automotive industry. The risk for this group of companies lies in the fact that they are highly dependent on these clients. The customers in the industries mentioned above have traditionally strong negotiating abilities and are very price sensitive. Due to the high risk of substitution of block train traffic because of their low degree of complexity, clients can choose within a wide range of RUs.

A good example for this group is rail4chem. It was founded in 2000 by companies in the chemical industry in Germany to satisfy their rail transport needs. Since then, rail4chem expanded its activities to other countries and provides its services to clients from other industries. In 2008 it was acquired by Veolia.

The Expanding RU

Expanding RUs operate mostly on local networks and in areas with significant transport volumes or special market niches. Their focus lies on special market segments or routes. An increasing share of their business consists in regular block trains in main line traffic. They are even more dependent on individual clients as are the newcomers but they have their local network or market niche to support their business.

The Tagfrakt AB, a Swedish RU, is a typical example for this RU category. This company started as the operator of Falköping container terminal. Since 2005 it has expanded its activities to include long distance transport of containers and the operation of other terminals.

The newcomers and expanding companies cannot easily be separated into two distinct groups. Some companies will inevitably belong to both categories.

The most obvious similarities between newcomers and expanding companies are:

- Strong dependency on a specific customer or category of goods;
- Limited field of activity: geographical area and category of goods transported; and
- Weak position in comparison to incumbent.

Table 7: Selection of Significant European RUs (Newcomer and Expanding RUs)

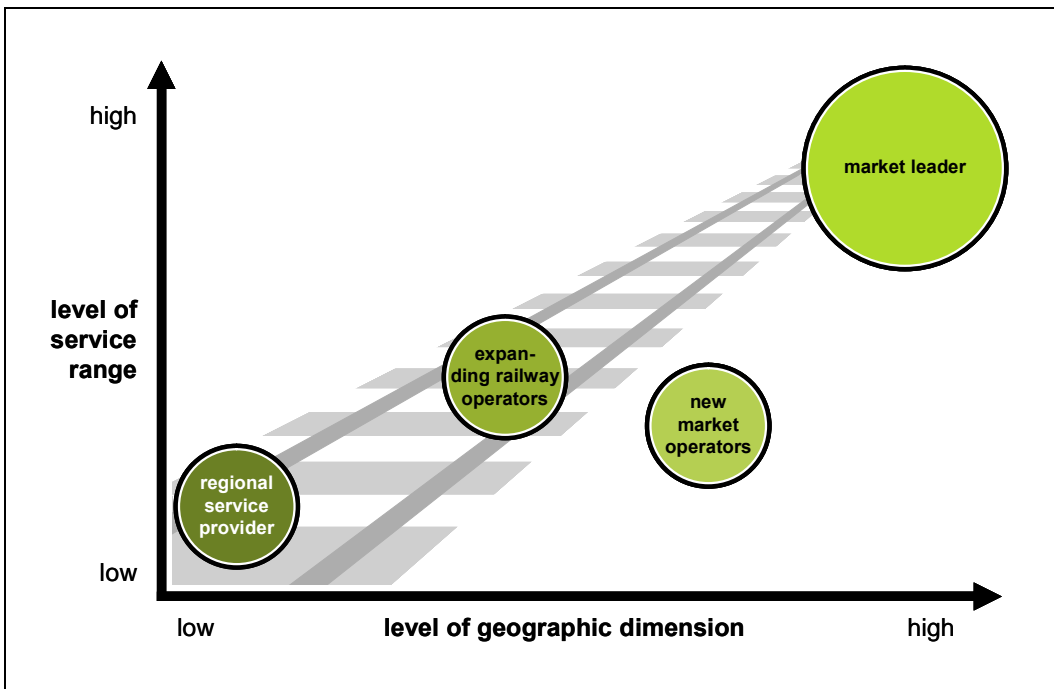
Company	Home base	Active in	Wagons	Wagon types
Freightliner Group Limited	London	UK, Poland	1750 in UK	<ul style="list-style-type: none"> • flat wagons • tank wagons • hopper wagons
CTL Logistics S.A.	Warsaw	Poland, Germany, Netherlands	5000	<ul style="list-style-type: none"> • tank wagons • hopper wagons
TX Logistik AG	Bad Honnef	Germany, Austria, Belgium, Denmark, Italy, Netherlands, Sweden, Switzerland	450	<ul style="list-style-type: none"> • flat wagons
Veolia Cargo SAS	Paris	France, Germany, Belgium, Italy, Netherlands, Poland, Switzerland	1600	<ul style="list-style-type: none"> • various

Source: KCW/ SDG/ TUB

The Local Supplier

Local Suppliers own a small regional railroad network and often locomotives and wagons, too. They focus their business on single wagon freight transport in their regional network and usually assume the role of a partner to another RU, most often incumbents that withdraw from this market segment. These companies are highly dependent on specific clients or larger RUs.

Figure 6: Typical National Rail Freight Market in Europe



Source: KCW/ SDG/ TUB based on German Federal Office of Freight Transportation 2008

This overview can be generalised for most of the European countries with significant freight railway traffic. Although there are differences in the dimension of the markets, the structure is relatively similar.

Key features are strong incumbents, local RUs with a high dependency on major RUs and newcomers and expanding RUs with a high dependency on large customers or categories of goods. The first three groups operate at a trans-national level.

The development of the rail freight market is still in progress and in some countries the liberalisation is still in its early stages. There is a possibility that the market might evolve and become more concentrated, with the emergence of big players. Small RUs can either participate in this process by letting themselves be acquired or can concentrate on a market niche where they can operate without risking having to compete against a larger RU.

Impacts on Noise-Differentiated Track Access Charges

The main risk of a NDTAC for all types of RUs is the possibility of decreasing margins if the costs for rail transport increase. As a consequence, there is a potential risk for modal shift if RUs are forced to raise their prices due to higher costs while other modes of transport are not treated in the same way. This is particularly of concern for RUs which offer services at the so-called “last mile” which usually are in highest danger of substitution by road in case of a worsen cost-benefit relationship.

Not to weaken the RU operating in this in economic terms critical field of operation, it could be an option, not to apply NDTAC for such “last mile” services or branch lines of IM with only minor importance. Low traffic volumes in combination with limited speed services aren’t serious noise problems to justify administrative costs of a NDTAC.

Any NDTAC-bonus related to mileage could also be assumed to benefit such RU mainly operating long and frequent running services, e.g. container shuttles, compared to such RU with a wider range of service and a higher proportion of less frequent and shorter services. However, in respect to the specific market segments and the intramodal competition the NDTAC seems to have the same effect for all players.

Generally, in respect to intramodal competition an increase of costs due to NDTAC could be seen as a threat for smaller RU or new entrants with a weaker commercial basis. Larger RU such as incumbents, especially state-owned RU, are more likely able to absorb losses or reduced margins temporarily due to their financial stability, their ownership structure and their wider range of business. This means that such RU could benefit from a situation in which smaller or private RU are forced to raise their prices due to burdens of NDTAC while stronger players keep their price level stable to gain market shares. Thus a risk of market concentration could occur. The current economic crisis, though probably temporary, enhances these effects. A loss of players in the market would be contrary to the aims in respect of competition of the European Railway Packages.

NDTAC schemes must be drafted to attain noise protection goals whilst in the same time negative impacts on the rail freight market are avoided.

In summary it must be noted that the impact of the design option on intramodal competition must be considered as limited.

6.4 The European Market for Freight Wagons: Contractual Relationships

As the overview over the rail freight market in Europe has shown, the landscape of RUs is fragmented. Besides large players, there are also many small RUs offering rail freight services.

These small RUs hardly have the ability to finance needed rolling stock whereas the big players can finance their rolling stock relatively easily. Additionally, companies in certain industries traditionally own freight wagons (e.g. in the chemistry or petroleum industries). Thus the market for rolling stock in Europe is also fragmented.

Generally freight wagons can be used throughout Europe if the track gauge is the same. Only operational restrictions like binding wagons to a special route constrains the use of wagons. Thus an analysis of the European freight wagon market has to be trans-national and cannot only be focused on the domestic market. The perceptions are also confirmed by the cross-border activities of many RUs as described in the previous chapter.

Since the TSI Noise has been implemented wagons must comply with the new specification and therefore must be silent. More recent versions of freight wagons are sometimes being equipped with low-noise brakes, however, an estimated 370,000 wagons of the existing freight wagon fleet still need to be retrofitted, as the remaining lifetime of these wagons is still 20 to 30 years. Therefore, to reduce noise emissions, existing freight wagons have to be modified. The most efficient way is to retrofit the wagons with special brake systems, as mentioned in previous chapters.

Structure of Ownership

Unlike the market for passenger rail coaches, the rail freight market is dominated by a more complex ownership structure. Main actors and stakeholders are listed and described below.

The Incumbent RU

Similar to the passenger rail market, the former state-railroad companies are the largest and most dominant players in the market. This group owns about 66% of the existing wagon fleet. The companies also rent their wagons to other RUs. It is important to note that the state-railroad companies' share of wagons is remarkably lower than their market share in the rail freight market. An overview of main European state-railroad companies is given in Table 6.

Private RU and Shippers / Clients

The second group of actors is comprised of private RUs and shippers, also called ‘clients’. This group holds about approximately 13% of the entire wagon fleet across Europe. Smaller RUs do not have as large a financing capability as state-railroads do to acquire large wagon fleets. Additionally they rarely conclude long-term contracts with clients. This means the risk associated with owning a large wagon fleet is too high for private RUs. Some RUs even rent wagons which are then very low utilised as they cannot afford taking the risk of buying rolling stock. Those wagons that are owned by the RU have the advantage of always being available when they are needed (and if they are not already being used).

Shippers and clients, historically more focused on the chemistry or automotive industries, allocate wagons to the RU which then only operates them. Thus, shippers and clients can easily change the train-operating RU.

Renting Companies

Renting companies form the last group of this segmentation. They are also called wagon pool companies. This category emerged because small RUs could not finance their own wagon fleets. The renting company allocates wagons to RUs or clients when demanded. About 21% of the European wagon fleet is owned by this group. Renting companies do not always own the wagons they provide to their clients as they sometimes rent the wagons for other owners and act as a facilitator²⁴. The advantage for the RU lies in the availability of wagons while keeping the flexibility associated with the fact that it does not own them. Normally renting contracts are concluded from six months up to a maximum of six years.

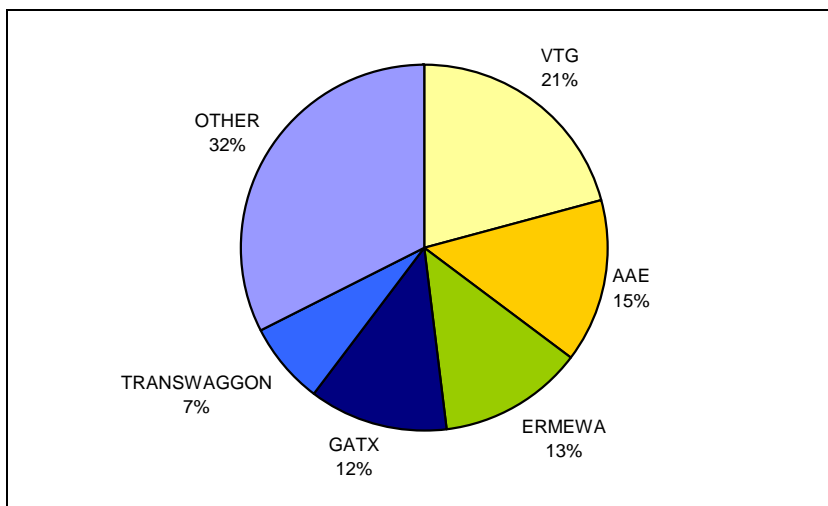
Renting companies are in most cases trans-nationally focused.

The market for renting companies can be structured into three main groups:

- Dominant companies (VTG, AAE, Transwaggon, Ermewa, GATX) each with over 10,000 wagons,
- Medium-sized companies with 1,000 -10,000 wagons, and
- Small companies, mostly focus on special types of wagons or a specific geographic area.

The following chart illustrates the dominant position of the five largest renting companies.

Figure 7: Wagon Renting Market in Europe



Source: KCW/ SDG/ TUB, based on research

The structure of the wagon renting market in general is similar in all European countries, although the market shares might vary between the countries. Even though there are some more regional players, these only have a significant market position in a few countries. Increasing liberalisation and mergers in

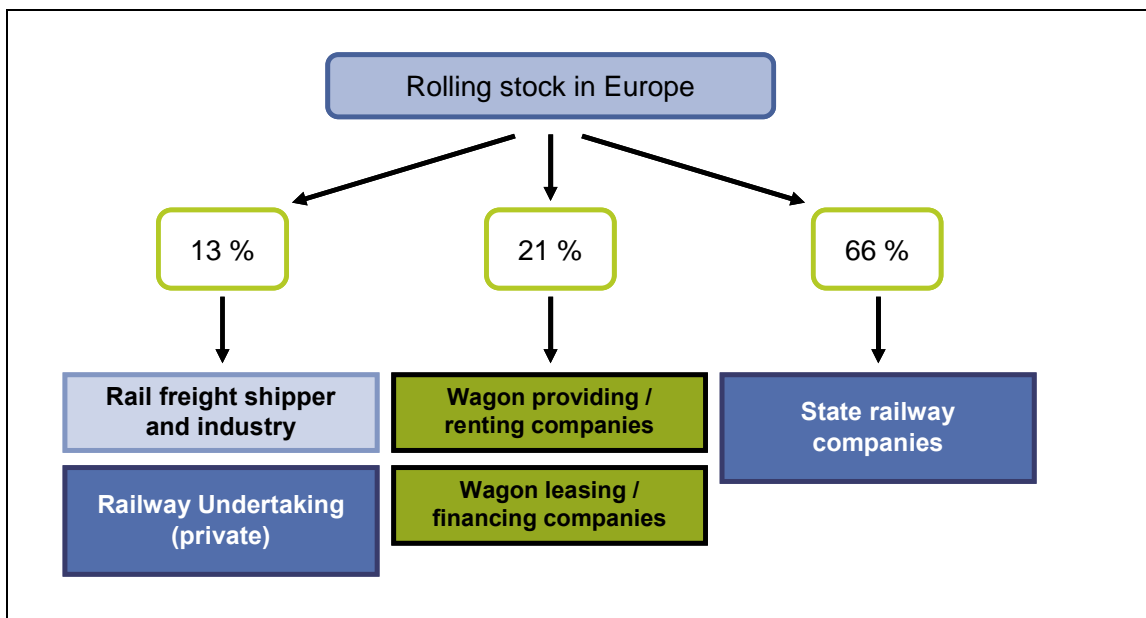
this market will make these markets across Europe more and more similar. It is also expected that due to outsourcing tendencies on the RU's side the market shares of renting companies will increase.

Today, the biggest share of wagons - about two-thirds - is owned by state railway companies, the classic incumbents. In such a case RU, WK and owner are one administrative entity. However, according to the RU's internal organisation there might be different divisions within the RU dealing with these functions but this has to be treated as an internal affair and not to be taken deeper into account.

More than a fifth of the European wagon fleet is owned by wagon renting companies, not being part of a RU and therefore owned by a third party.

The remainder, about 13%, belongs either to private RUs (which leads to a comparable structure as for the wagons owned by state owned RUs) or to rail freight shippers which supply their own wagon fleet – mostly highly specialised according to the load being shipped – to RUs as their service providers. Based on the data available a precise distinction between these two groups is not possible. However, this does not impact the general conclusion: The majority of the fleet is not directly attached to the RU which means that any NDTAC must necessarily take into consideration how incentives influence all entities responsible for retrofitting, not only the RU.

Figure 8: Rail Freight Wagons in Europe – Ownership Structure



Source: KCW/ SDG/ TUB based on analysis by HSH-Nordbank 2009

It is important to understand the distinction between WO and WK. The WK is the most relevant party concerning a freight wagon. It makes – in cooperation with the WO – all relevant commercial decisions, such as deciding whether or not to retrofit and setting rental prices. It also has to finance the investments for maintenance and retrofitting. The retrofitting can be done by the RU itself, but the decision towards this can solely be made by the WK. A renting company is always the WK, but not necessarily also the WO. The purchase of a wagon is made by the WO. The administrative handling of the wagon is made by the WK. The RU or any leaser of a wagon has to pay the rental fee to the WK.

NDTAC Impacts

The structure of the rail freight market has to be taken into account if a NDTAC is to be implemented. If not, the goals of such an incentive system will be unreachable.

TACs have to be paid by the RU to the IM. This means that bonuses or maluses as part of the NDTAC are paid between these two parties²⁵. The goal of NDTAC thus lies in incentivising the retrofitting of rail freight wagons so that their noise pollution can be significantly reduced. However the retrofitting has to be conducted by the WO or by a party who has the authority to make decisions about the wagon. If RUs

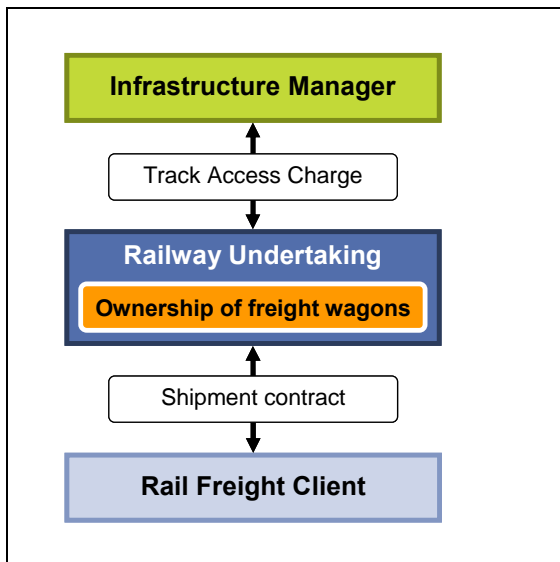
tend to be renting wagons more instead of owning them, the existing TAC relationships will be targeting the wrong entities as far as retrofitting goals are concerned.

To illustrate this, the different relationships between the IM, the RU, the client, the shipper, and/or renting company will be analysed below.

Relationship between Contractors in the Rail Freight Market

Understanding the relationship between the IM and the RU is fundamental for understanding the dynamics at play. In order to use the infrastructure, the RU has to pay a TAC to the IM. To ensure an efficient NDTAC, the various relationships between the RU, the rail freight client and the owner of the freight wagons also need to be clear. Usually, the customer (rail freight client) mandates the RU directly or indirectly via another RU or a transport logistics operator using a shipment contract. The following figures illustrate different market structures to visualise the range of different contractual agreements between relevant parties which have to be distinguished for the design of NDTAC²⁶. It has to be considered that a single train may consist of wagons which belong to several of the following types.

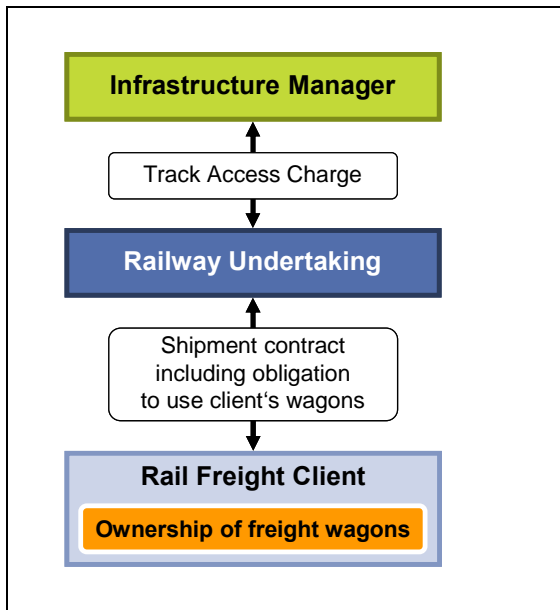
Figure 9: Market Structure Type 1 – RU Owns Wagons



Source: KCW/ SDG/ TUB

In the first type of market structure the RU uses its own wagons for its transport purposes. If bonuses for 'silent' wagons were applied in the TAC, there would be a direct incentive for the RU to retrofit its 'noisy' wagons due to direct relationship between the IM and the WO²⁷. Typical examples for this type of market structure are the transportation market for steel products and scrap, non-regular transports, automotive logistics and bulk transports.

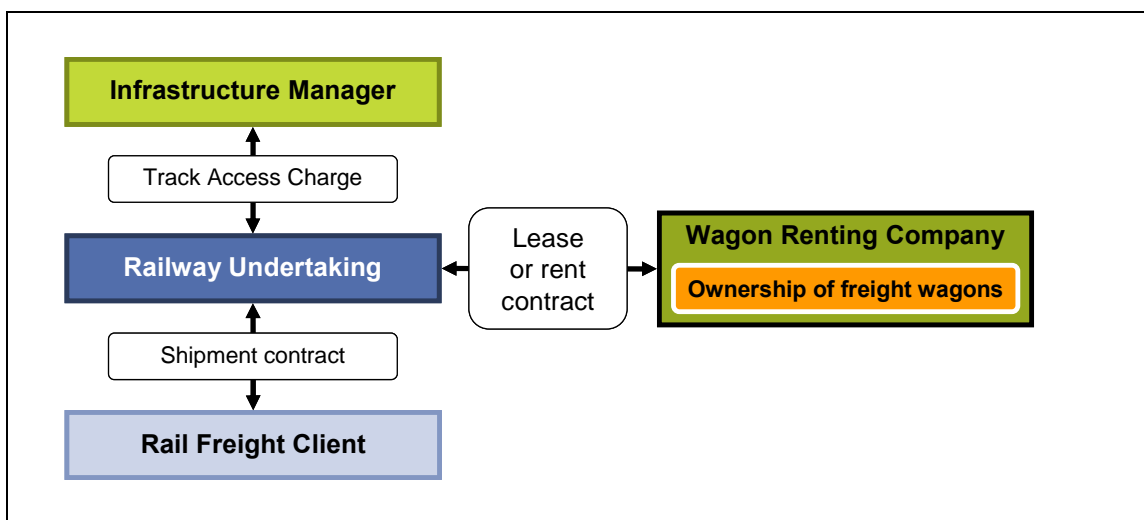
Figure 10: Market Structure Type 2 – Client Owns Wagons



Source: KCW/ SDG/ TUB

The second type of market structure describes the transport service by the RU where the customer provides the wagons which are owned by the customer itself. The RU simply acts as an operator, and not as a provider of the wagons. In the direct shipment contract between the RU and the rail freight client, the incentives for using 'silent' wagons can be considered. But it is essential that there is – in contrast to the first type – no direct relationship between the IM and the WO. This type of market structure applies predominantly for transportation in the chemical and petroleum industry where wagons tend to be owned by the petrochemical companies themselves.

Figure 11: Market Structure Type 3 – Wagon Renting Company Contracted by RU



Source: KCW/ SDG/ TUB

In the third type of market structure, the RU rents the wagons through a renting company instead of using its own wagons. Because of the direct relationship between the RU and the WO, the existence of a third party logistics operator (or another RU acting as a logistics operator) is irrelevant in this type.

Due to different accounting parameters between TAC and renting contracts and due to the lack of direct relationship between the IM and the WO the incentive for using 'silent' wagons does not fully apply. A

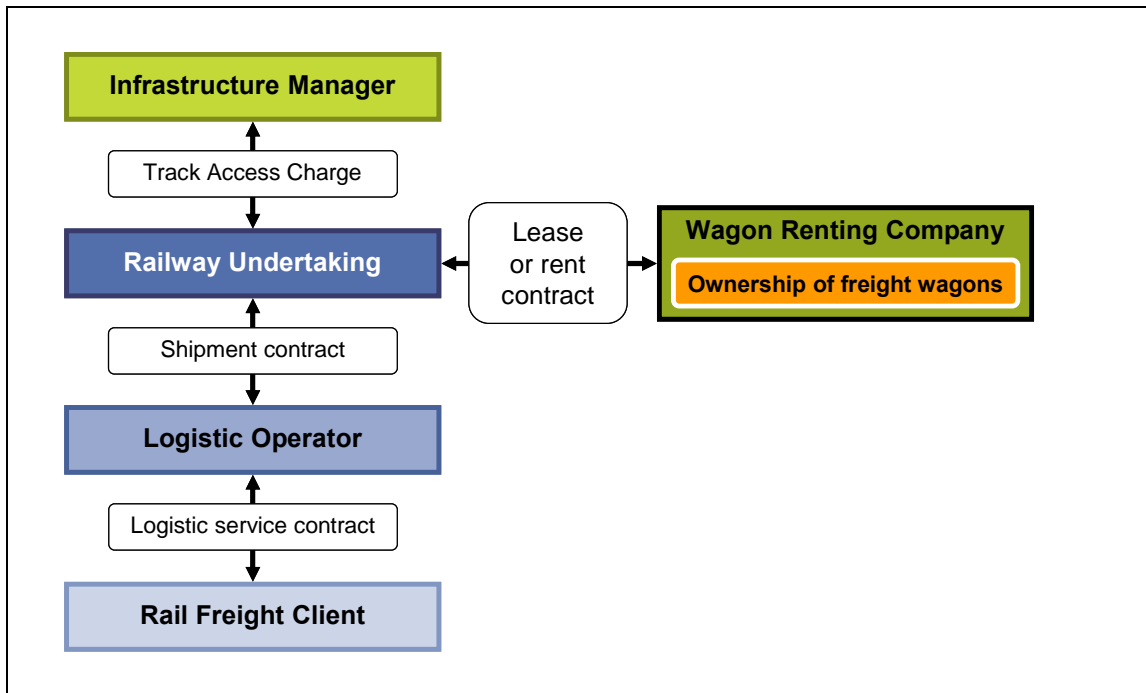
malus for 'noisy' wagons in a NDTAC will lead to lower renting charges for such wagons. For that reason a renting company will probably be inclined to retrofit its wagons with new brakes, thus complying with the goals. This means that a feasible incentive structure would require higher renting charges for low-noise wagons.

However in this type of market structure it is theoretically possible for the RU to calculate the impact of the NDTAC and take this into account to choose its rented wagon provider, based on the price proposed by each wagon renting company. But in reality this is unlikely to happen due to the increase in administrative costs and other market relationships associated with this behaviour (see type 4). This type of market applies predominately if the RU is relatively small. Other examples for this type are transport of bulk or timber.

The interposition of a logistic operator (see figure 8) can worsen the situation even more. Normally, these operators optimise the logistic chain without any preference towards a specific transport mode. This means for rail freight transport a higher risk of modal shift.

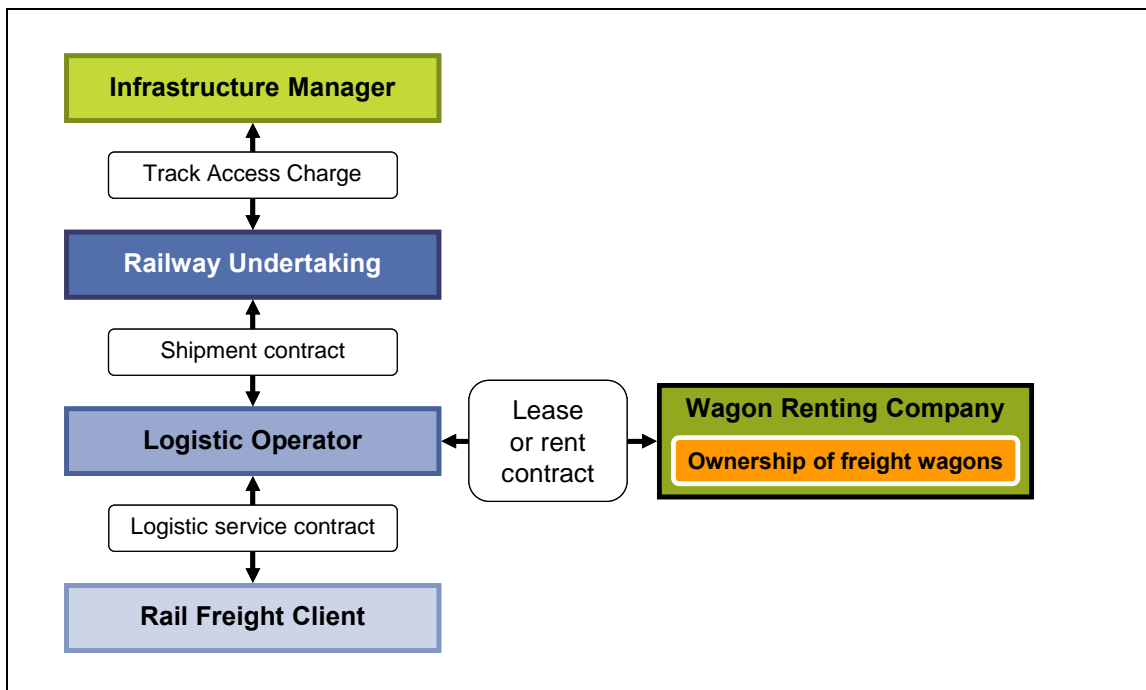
This – as well as the following types – illustrates the later discussed problem of the K-block versus the LL-brake solution. Depending on the type of retrofitting different fixed costs occur. If fixed costs are relatively low, they can be refinanced faster through a NDTAC based on kilometric performance of the wagons. However, in case the retrofitting requires substantial upfront costs, this is likely to have an influence on the price level of rents paid to the keeper, which in turn would decrease the likelihood that the RU rents 'silent' wagons.

Figure 12: Market Structure – Subset of Type 3 – Interposition of a Logistics Operator



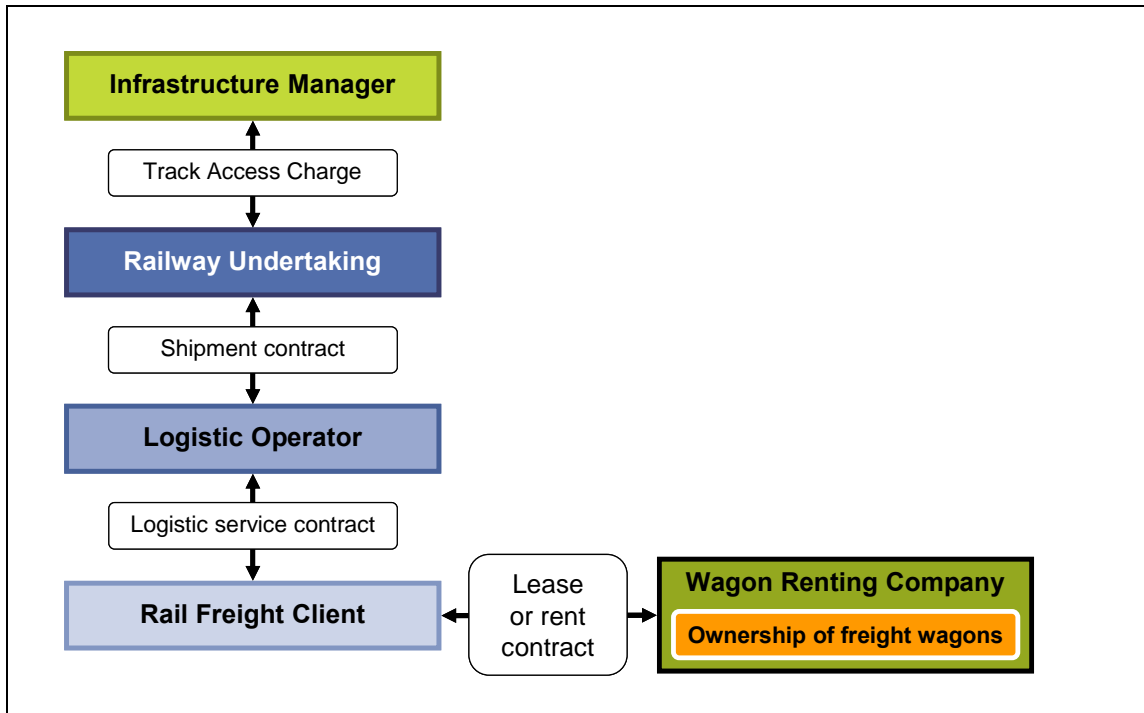
Source: KCW/ SDG/ TUB

Figure 13: Market Structure Type 4a – Wagon renting Company Contracted by Logistics Operator



Source: KCW/ SDG/ TUB

Figure 14: Market Structure Type 4b – Wagon renting Company Contracted by Client



Source: KCW/ SDG/ TUB

In these two similar types of market structures the intermediary logistics operator or the client rents the wagons and the RU (as in type 2) simply operates the train. In this type NDTAC only has a limited impact on the renting company due to the fact that there are three levels between the IM and the WO. If the wagons are rented by the client there are even four levels. It seems difficult for the incentive to be passed on over three or four contractual levels.

Overall the renting charges for wagons will differ depending on the type of brakes installed on the wagons. In this type the price differential acts as an incentive for RUs to rent less 'noisy' wagons. As discussed previously, the incentive to use non-noisy wagons does not solely depend on the relationship of the parties involved and the mechanisms in place in the wagon renting market; it also depends on the extent to which the incentive can be passed on the end party, i.e. the RU renting the wagon.

A typical example for type 4a is the market for container transport. Type 4b usually occurs in new car logistics or petroleum transport.

The more industry stakeholders involved, the higher the incentive to compensate for transaction costs and to allow for a reasonable incentive at each level²⁸. However, the level of upfront costs has been found to have the largest influence on contractual relations.

The level of incentive is slightly less important if pass-by noise measurement is applied. Wagon-specific accounting is for that design option not feasible²⁹; therefore the incentive needs to be allocated to each wagon. This will lead to free rider effects particularly for wagonload-freight.

Impacts on Noise-Differentiated Track Access Charges

Generally there are two ways NDTAC may affect contractual relationships:

- The bonus (or potential malus) is transferred to the party which finances the retrofitting. This model is applied in Switzerland.

In case of complex multi-level contractual relationships this approach might probably create too high administrative costs on each level. This would either lead to an insufficient incentive at the level, where the investment decision has to be taken. Or – on a stakeholders' point of view - it

might be seen as an argument for higher incentive levels in case of complex contractual relationships. However, it seems rather impossible to differentiate the incentive level adequately according to contractual relationships. Therefore this way of transfer seems rather suitable for simple contractual relationships with only few parties involved.

- Another model is to factor the estimated revenue of a bonus (or costs of a malus) into the rental price. This would mean that it is not necessary to transfer the specific incentive generated by operation. The contractual complexity wouldn't change and the accounting procedures of the parties would not be affected.

The study does not propose any model. It doesn't seem necessary to regulate this issue. It is likely and possible that the market actors find the way to forward the incentive in the best suitable manner in each case among each other within the industry.

6.5 Cost Elements of NDTAC: Risk of Overcompensation

Costs of an NDTAC occur on different levels of the system and are incurred by various industry stakeholders. The incentive level should be geared to those costs associated with the retrofitting of wagons, the wagon recording systems and the actual accounting system. The administrative costs of the IM should not be relevant for the level of the incentive. However, costs that occur at the IM level are important for the economic costs of the incentive system.

The following major cost-elements are associated with a NDTAC:

- Retrofitting and modernisation costs of wagons;
- Costs of homologation;
- Costs of train-data recording and data exchange; and
- Costs of the accounting systems and sample checks.

Each of the abovementioned cost elements are discussed in more detail below.

Retrofitting and Modernisation Costs of Wagons

Costs associated with retrofitting or modernisation of wagons are related to the technical method to reduce the level of noise produced by the wagon, while the cost level differs in accordance with the type of measure. The following characteristics have been identified:

- No reliable cost estimate can be made for modernised wagons as there are various options of how to reduce noise-emissions;
- The costs for retrofitting depend on whether K- or LL-brakes are chosen as a suitable option (a comprehensive overview on costs associated is given in chapter 6.9). The advantage to focus on retrofitting brakes is the fact that costs are relatively well known (to a larger extent for K-brakes and to a lesser extent for LL-brakes);
- Due to the high uncertainty associated with the costs of modernisation it is difficult to determine the incentive level. There is a risk of over or under compensation;
- In some cases additional costs based on higher wear and tear of the wheel occur. These costs have to be taken into account as well;
- There is no consideration for the opportunity costs incurred when wagons are put out of service to be retrofitted or modernised. However, retrofitting need not take wagons out of service as it can potentially be carried out during revision. Therefore no additional costs occur for the RU/keeper.

Costs of Homologation

Costs of homologation occur at the point where the wagon passes its homologation. The following characteristics of this cost element have been identified:

- Mandatory for new, modernised or retrofitted wagons;

- Whether the wagon has to pass homologation is the responsibility of the national safety regulator;
- Braking systems are always subject to pass homologation;
- No due diligence necessary for composite brake blocks; and
- Homologation costs are with the WK.

Costs of Data Recording and Data Exchange

The following characteristics have been identified for this cost element:

- Costs of data recording occur at the RU and at the RU;
- They form the basis for the calculation of bonus level or malus level respectively;
- The IM has to record train data (this is already the case at the moment);
- A new cost element which comes with NDTAC is costs for data exchange. The RU has to submit data to the IM. This requires adequate interfaces which will be secured through TAF-TSI (Telematic Applications for Freight – Technical Specification for Interoperability) at a later point; and
- Costs for data recording and data exchange are partly not relevant for the ‘pass-by Noise Measurement’ design option as the IM does not need information on the train composition.

Costs of the Accounting Systems and Sample Checks

The following characteristics have been identified:

- Costs for the accounting system occur predominantly for the IM and, if applicable, for the competent authority;
- The IM has to calculate entitlements for the incentive based on the train composition-list and has to submit this to the RU;
- Control sample checks are carried out through (manual) capture of train composition data and cross-checks with the wagon register and the RU’s declaration;
- The pass-by noise-based design option is again a special case as the bonus/malus is calculated on a train basis, and applied to the regular charge paid through the TAC.

Other Costs

There are some other costs associated with the implementation of NDTAC:

- The NDTAC needs to be implemented in the Network Statement. This process imposes costs on the IM;
- A noise-measuring station needs to be installed if the ‘pass-by noise measurement’ is chosen as an option. These costs will clearly depend on the amount of stations installed. The measuring stations would have to be operated by the IM;
- Several opportunity costs may occur. Most notably, the RU or WK may need to pay for the non-availability of wagons during the time of retrofitting. As demonstrated in the Swiss case-study, RUs could show no interest in applying for the bonus even if they are eligible. In turn, the bonus would not be granted to RUs which are eligible. This could be the case if the ‘noise measurement’ option is applied. Opportunity costs for non-availability may decrease in times of the economic crisis due to more unemployed wagons.

Conclusion

A major requirement of NDTAC is to ensure that bonus levels avoid as far as possible an over or under compensation of the RU. The bonus should therefore cover those costs associated with retrofitting and

modernisation costs of wagons, costs of homologation as well as those cost of train-data recording and data exchange. All these costs are incurred by the RU. The costs which do not occur at the RU side such as accounting costs of the IM and sample check costs, should *not* be taken into account in the bonus.

Only those costs which can be clearly allocated to NDTAC should be taken into consideration. For instance, parts of the costs for TAF-TSI implementation should not be allocated to NDTAC solely.

The pass-by noise design option imposes a high level of risk on the system, as an accurate prediction of an adequate bonus-level becomes difficult due to the high uncertainties with regard to its costs. There are no reference values for the costs of measurement points available. Furthermore, costs would heavily depend on the number of measurement points installed on the network.

There is a strong indication that the TSI Noise-based design option is more feasible, as amortisation of costs tends to be more predictable.

Interviews with stakeholders showed that their estimated costs for NDTAC are rather high, presumably because they included costs which do not directly result from the charging system itself. Moreover, costs such as those for the implementation of TAF TSI cannot be completely added to the costs of NDTAC.

6.6 Differentiation of the Incentive

The noise-related incentive paid to either the RU or the WK can be differentiated by type, time or route.

Differentiation by Type

A differentiation by type would distinguish between different types of wagons (e.g. flat container wagon, hopper car etc.) or commodity types in order to consider the different demand elasticities of freight commodities or to vary the level at which different technologies are incentivised. This option has been discussed in chapter 6.2 and has been excluded as it would increase the level of complexity too far.

Differentiation by Time

The bonus could be varied by time of day in order to reflect the higher level of social costs 'noisy' wagons impose during night hours. A differentiation by time would be easier to be implemented as part of the TSI-Noise based approach as time of day can be derived from timetable information. The problem with this is the fact that rail freight must often operate at night due to the lack of available routes during daytime³⁰. However, the difficulty has to be taken into account that a variation by time increases the complexity as it has probably to be differentiated between the planned timetable and the de facto used timetable, the length of train path sections in night and day-categories varies according to delays, even for a single train running on long distance services. Hence, a lack of predictability of amortisation of investments in retrofitting reduces the willingness to retrofit. This would have negative impact on the aimed noise reduction.

Differentiation by Route

A differentiation by route could take into account the population living in the catchment area of the noise emissions. An effect could be that RUs would bypass the high-incentivised corridors rather than retrofit their fleet. At least, this could be a contribution to reduce the noise in highly affected areas, but won't reduce noise emissions in general. If less incentivised bypasses are longer and nevertheless cheaper in case of usage of non-retrofitted wagons, the total noise emission could even grow.

A differentiation by route could be well represented by the pass-by noise-based approach as measuring points would be preferably installed only at some hot spots rather than equally distributed over the network. Furthermore, most of the stakeholders noted that routing decisions were already a very complex exercise for the IMs, besides restricted by capacity, and adding further constraints would not facilitate the process.

Conclusion

- Differentiation by type should not be implemented as it raises complexity:

- The main problem is the risk of under-compensation if the incentive is differentiated by time or by route. WK would face a relatively high risk of not recovering the initial investment as they cannot necessarily influence the routes/times their wagons will be used:
- This has a negative effect on the RU's' and WK's ability to plan ahead. Thus the incentive for retrofitting decreases. Furthermore, the structure of the NDTAC would be rather more complex and would not lead to a greater reduction in rail noise.
- If at any specific time or on any specific network section the problem of rail noise is remarkably high, the respective Member State should try to find an individual solution in collaboration with the IM. This might be more effective than adjusting the whole NDTAC to individual and confined problems. Traditional noise abatement-measures could be more effective in those individual cases.

6.7 General Framework for Wagon-specific Accounting System

For the implementation of a NDTAC – regardless what it is based on – the precise recording of the relevant data is essential. Due to the already described high proportion of transnational traffic, this has to happen consistently throughout the EU. In some way, wagons as well as their characteristics (TSI Noise homologation, brake system, owner) have to be recorded. Currently, there are a number of different designs for national registers of wagons.

The European Directive 2008/57/EC from June 17, 2008 binds every Member State to set up a register for wagons to record every vehicle (locomotive, wagon). Technical characteristics of the wagons are supposed to be stored in these registers. As can be expected, characteristics such as loud/silent are to be listed in there, too. Some of the already existing registers for wagons such as the ones in Austria or Germany include further information, e.g. on the brake system installed.

For the implementation of the NDTAC, this data has to be checked against the wagons' mileage to calculate bonuses penalties. According to the General Contract for the Use of wagons (GCU), RUs are already obliged to report data concerning the wagons' mileage to the WO or WK. WO/WK claim that this is not always how this is carried out.

In any case it would be theoretically possible to verify the data from the national register for wagons with the mileage according to the GCU and making it therefore useable for the NDTAC³¹. There is however another solution for the implementation of a NDTAC through a central interface/database: using TAF TSI.

The following paragraph will present TAF TSI as well as possibilities of its utilisation for a NDTAC. Due to the fact that this TSI will most likely be implemented only in a couple of years, intermediate solutions have to be considered additionally.

TAF – TSI (Telematic Applications for Freight – Technical Specification for Interoperability)

The term 'Telematic' comprises the technological subjects of telecommunication and computer science which can be combined in a synergic manner with the aim of obtaining profitability within a given system. When it comes to rail freight transportation, it refers to the collection, transmission and processing of data that describes the location and condition of railway vehicles and cargo on a railway network. A computer core, which serves for the control and evaluation of the incoming information, produces transformed data that can be employed for several purposes, most notably:

- Optimisation of logistic processes (car detection, delay prognosis, customer information, empty wagon trips reduction, etc.);
- Load monitoring (wagon safety system, load safety, temperature sensors etc.);
- Chassis diagnosis (derailing detectors, axle bearing diagnosis, etc.); and
- Achievement-dependant maintenance (run recording of wagon performance for proactive maintenance).

The TAF TSI is an EU law that was enforced in January 2006. It stands for a common language to be employed by the interfaces of different IT systems used by RU and IM when interchanging information

regarding freight services. This coherence on communication language enables the interoperability of information between different countries and companies. With the TAF TSI, the above appointed purposes can be achieved on a Pan-European context.

The first stage of TAF TSI (Common Interface) is meant to be accomplished by 2010. A first working group called CCG (Common Components Group) was created in March 2008 in order to pursue this objective.

Further versions of the TAF TSI will enable automatic communication processes between IM and RUs and eventually between various RUs. Total completion is scheduled for 2015.

To that aim, TAF TSI phases are³²:

- I Phase 1: Common Interface, Key Reference Files and the Wagon & Intermodal Unit Operational Database (WIMO);
- I Phase 2: Improving Data Quality, Service Quality and generating wagon ETAs (Estimated Time of Arrivals) from history. These three functional capabilities can be supported by Central Systems;
- I Phase 3: Implementation of Dialogues between IMs and RUs and using this capability to enable accurate Wagon ETAs and ETIs (Estimated Time of Interchange) to be generated from pre-determined trip plans;
- I Phase 4: It will enable the implementation of ETAs/ETIs from Dynamic Trip Plans; it represents the most challenging and risky portion of the TAF TSI. The benefits are also very significant in terms of transit time reliability, wagon fleet and infrastructure productivity.

Although TAF TSI is only a framework, and not a database or an application which can be used directly, it will be a useful environment for companies and other bodies concerned as long as they feed the system correctly with relevant data and/or meaningful messages using the guidelines appointed by TAF TSI. TAF TSI and TAF TSI developers are not building a tool that will solve all the problems of European rail freight transportation by itself, rather an environment that needs adaptation and involvement of companies -who already have their own TAF Systems- in order to achieve an integrated information system which is able to reduce rail costs and deliver higher quality customer service.

Therefore, and if no further delay is acknowledged, 2017 can be considered as a plausible starting point for TAF TSI's fully functional framework. This does not mean that the applications and functions running under TAF TSI framework should be totally developed and implemented at that point, rather that they should have the right environment to prosper and become useful for the companies using them. One of these applications could be the NDTAC identification system and corresponding charging software.

NDTAC under the TAF TSI Framework

Differentiated Track Access Charges require an automatic identification system and charging software linked to the identification system and the national vehicle registers. Noise measurements are not needed. The deployment of telematics applications for rail freight according to the relevant Technical Specification for Interoperability TAF TSI would provide the technical basis for such automatic identification³³.

Indeed, it is technically feasible to employ architectures, functions and technological platforms under the environment of TAF TSI with the purpose of automatically identifying noise characteristics of wagons and their kilometre performance on given infrastructures in order to grant bonuses to the companies using them. However, this information is currently not specified. Thus, the necessary data for noise classification and taxation of the rolling stock have to be considered in the Rolling Stock Registers and the Wagon Event Databases as well as in the Common Interface described in TAF TSI.

On the other hand, TAF TSI has a period of deployment in which some of the functions and applications are developed, among them a hypothetical noise-oriented automatic identification system and charging software which could have the right context to become operative.

A first element to look at is the **WIMO**. The WIMO-Database is the "Heart" of TAF TSI. It is of high importance for the tracking of wagons and intermodal units as a data repository accessible to all qualified stakeholders³⁴. This database stores on a trip the movement of all wagons and of all Intermodal units from departure through to final delivery at customer locations for "local" and "interline" traffic. The data-

base must be accessible via the Common Interface by authorised entities such as WK and fleet managers. WIMO database supports Tracing, Fleet management, ETAs from history, Predetermined Trip Plans, Data and Service Quality measures as well as enabling many statistical measures such as wagon mileage, Traffic flow studies etc. Therefore, a hypothetic NDTAC under the framework of TAF TSI should get its information from the elements included in WIMO.

Recently, the European Rail Freight Industry has decided to implement a purely distributed WIMO architecture to realise the TAF TSI instead of the centralised WIMO indicated during the preparation of the original SEDP (Strategic European Deployment Plan) for the implementation of the TAF TSI. One of the factors that influenced this choice was the perception that it provided greater data security; however, this has been refuted by Acklam & Horsman. In so doing, the creation of a centralised WIMO which would be able to be interfaced with local WIMOs and other local Rolling Stock Reference Databases has been recommended, this centralised WIMO should receive the name of ERVID.

ERVID is a recent initiative that stands for European Rail Vehicle Information Database. It should be an enhancement of a centralized WIMO to encompass Rolling Stock, also passenger coaches and traction units. To accomplish this enhancement, a “Harmonising Vehicle Data Interoperability Project” including the 16 TSIs and other related Initiatives, will be required. The focus of this project should be on vehicle related data requirements. If this initiative prospers, a future NDTAC under the environment of TAF TSI should be encompassed with ERVID.

As the following table shows, some of the information required for a NDTAC is already an element of WIMO. Only the information concerning the nature of the brake block is currently not part of it. To simplify data exchange between the stakeholders an implementation of this element would be feasible.

Table 8: Usable Elements of WIMO

NDTAC Necessary Information	Description	Included in TAF-TSI?
Wagon identification	Identifies freight wagon by its number	"Wagon Number Freight"
RU and IM identification	RU (Network operator) IM (operates infrastructure)	"Company"
Keeper of the wagon	is in charge for wagon	"Keeper"
Mileage	km run by the wagon on a given train path	"Kilometres" Alternative element: "KMsSince-LastOverhaul"
Noise emission of the wagon	Passing-by Noise of wagon according to the TSI Noise	"NoiseByPassLimit"
(Alternative) Nature of brake blocks	CI, disc brake, K or LL block	At present: No ³⁵

Source: KCW/ SDG/ TUB

The European Commission has shown interest in linking the European Guideline TAF TSI with the TSI Noise. In doing so, it has been suggested to employ technical platforms and applications under the environment of TAF TSI in order to identify and track down noise-related characteristics of rail vehicles – mainly freight wagons – as well as to apply automatically calculated charges, bonuses or penalties to the companies using them in a given railway network.

This context may provide the basis for the monitoring of noise-differentiated Track Access Charges: It is an element included in WIMO.

In the hypothetic case that TAF TSI could constitute the technical basis for the automatic identification, as a very first application the different phases of the automatic identification and charging system could look like this:

- I A given RU gathers and records information about noise and other characteristics of each wagon of the train the moment it is handed to it or when departure starts,
- I The RU sends the information to each IM and the later determines the noise bonus to be paid,
- I The IM executes the payment to RU,
- I IM sends information to other IMs about the mileage by the ‘silent’ wagon and if applicable the bonus received by the ‘silent’ wagon.

Although TAF TSI is already being enforced, the date of its full deployment is actually uncertain. For that reason several stakeholders are sceptical towards the possible implementation of an effective NDTAC in due time.

In any case, and until a fully effective system and application –under the TAF TSI environment- becomes feasible, an interim solution has to be produced in order to achieve results on noise abatement for the short term.

Other TAF Environments for NDTAC

Today IT environments and vehicle detecting applications exist both at a supranational and national level.

Examples of national information systems are CIS in Switzerland or GOTCHA/QUO VADIS in the Netherlands. However, neither Switzerland nor the Netherlands employ these systems for automatic detection and charging of wagons in respect to the NDTAC bonus allocation. The reason for this is economic: The costs of data processing exceeds the amount of bonus payments. In other countries there are other information technology systems which are currently employed for tracking loaded and empty wagons across each respective country.

RFID: Quo Vadis and Gotcha (Netherlands)

An utilisation of GOTCHA/QUO VADIS for the calculation and control of the ceiling in the Netherlands is planned, but unfortunately there is no experience to report on this issue since no one has applied for the bonus in the Netherlands so far. In any case the ceiling can be identified without technical support by simply counting the mileage which is, in theory, self-declared by the RU. Of course the system relies completely on trust and the use of information technology can be relegated to very sporadic punctual controls. In addition, as many wagons are running internationally they should as well be controlled in different countries separately, which would add even more complexity to a hypothetical IT implementation. More specifically, the Netherlands are running a pilot project with 200 wagons using RFID technology based on the existing QUO VADIS and GOTCHA systems. QUO VADIS is used for train weight measurement and GOTCHA is NedTrain's maintenance tool that can detect wheel defects. Forty measuring stations with optional RFID tag reader cover 95% of the Dutch Network. The costs of each station is about 100,000 € and the tag reader is worth about 5,000 €. The RFID tag that is specified in the wagon TSI costs between 20 and 40 € a piece.

In order for RFID technology to be usable for monitoring 'silent' trains, all retrofitted wagons have to be equipped with permanent magnet onboard units and measuring units on both sides of the track have to be installed.

ARTIS (Austria)

In Austria the ARTIS (Austrian Rail Transport Information System) is a widely deployed information technology system which should offer a significant platform for NDTAC allocation and control of bonus payments, yet no decision or even discussion thread, could be traced in Austria about a further implementation of NDTAC.

ARTIS collects information on actual train travelling data and is used to charge the customer the actual usage instead of the planned. The decentralized system consists of 50 computers and 153 decentralized stations. The wagons' information is interchanged between the local station and the identification points and reported to a central server where it is kept for three months. During that time the wagon can be recognized and the user can access the statistical data.

Further information on the trains' braking equipment is included in ARTIS. This is classified between disc brake, normal brake blocks and brake blocks with synthetic brake shoes. This makes ARTIS a suitable tool for charging a NDTAC.

GPS

Tracking wagons with a GPS system requires an onboard unit for wagons and a unit on the infrastructure-side to collect the information from the onboard unit. The onboard unit saves the travelling data according to the GPS Signal and can be run with a battery lasting about 6-7 years.

The costs for one single GPS onboard unit are between 800 and 1,200 €. This adds up to a total investment of at least 300 million € as the initial investment costs for onboard units. This system can realise more services for the RU and is already in use, but is too expensive to be used as a simple tracking system for a NDTAC.

Video Technology

In the video technology a camera beside the track takes single pictures of the wagons' identification number. This can be read by the system and transmitted with further information such as time and location. The maximum speed of the wagons **cannot be recorded by the camera** and the video quality in bad visual conditions is yet unknown. An interface to a database is needed in order to link the necessary information such as the wagons' braking system. A further problem is that there is no reliable information on the costs which are expected to be significantly higher than those of the RFID technology. Therefore the video technology will not be investigated further.

RAILDATA

Supra national IT systems for freight rail exist as well, e.g. ISR and ORFEUS (RAILDATA), and are currently employed for diverse purposes, namely:

- Tracking both loaded and empty freight wagons and consignments across significant parts of Europe;
- Information about actual status and position of the wagons;
- Wagon status history or freight traffic flows;
- Estimated time of arrival based on statistic of past transports;
- Exchange of the railway CIM consignment notes data between the co-operating RUs;
- Exchange of the CUV wagon notes data as well.

An automatic NDTAC could theoretically be encompassed by this IT system and would cover already a significant part of European territory, namely: Austria, Belgium, Czech Republic, the Netherlands, France, Germany, Italy, Luxembourg, Hungary, Slovakia, Slovenia, Spain, Sweden and Switzerland. However, the costs for implementing and maintaining such a system within ISR would be excessive in comparison with the expected benefit. In so doing, many adaptations are necessary, for example the transformation of certain data to calculate run km, noisy elements' creation and evaluation, establishment of information handover protocols, automatic billing etc.

Conclusion

TAF TSI is able to fulfil the requirements of a NDTAC which needs a certain amount of data, e.g. mileage, wagon characteristics or information about the WK. Primarily TAF TSI was not developed for NDTAC or charging. Anyhow it could be used for this purpose. Thus administrative costs can be lowered as TAF TSI is used by different applications.

Until TAF TSI is implemented an interim solution is needed for the purposes of an incentive system.

An automatic NDTAC implementation with current TAF systems is theoretically possible and wide ranged but economically unfeasible.

Since the IT solutions for the NDTAC are regarded with critical scepticism, the self declaration is considered as the remaining option for an effective and short-term retrofitting plan from an economic point of view without mentioning direct subsidies. This solution has already been adopted by Dutch and Swiss authorities and it apparently works efficiently in Switzerland.

6.8 European Track Access Charge Schemes – Compatibility of NDTAC with National TAC and Directive 2001/14/EC

The variety of characteristics of Track Access Charge schemes in Member States is regarded as one of the major difficulties associated with an implementation of NDTAC. An important precondition of an im-

plementation of NDTAC will therefore be the ability of each of the Member State's Track Access Charge System to incorporate a noise-dependent element.

This chapter examines the question to what extent rail infrastructure pricing currently applied within Member States is likely to be compatible with the requirements of NDTAC. The objective of this chapter is to identify potential difficulties which could occur with regard to the pricing regimes applied in each Member State. Analogue to previous chapters only selected countries will be studied.

The remainder will be structured as follows: In a first step criteria to assess the ability of national Track Access Charge schemes to implement noise-dependent elements will be derived. In a second step access charge schemes in the selected countries will be briefly described; thirdly the access charge schemes will be assessed to the developed criteria. Finally general observations and final conclusions will be outlined.

6.8.1 Derivation of Assessment Indicators

Objective of this section is to derive indicators to assess the ability of national charging systems to incorporate elements of NDTAC. Two sets of indicators will be considered: The first set of indicators helps to assess the extent to which current charging systems are inline with the requirements of Directive 2001/14/EC. The second set of indicators will be derived in order to understand the level at which national charging systems meet the requirements of a NDTAC.

The table below sets out the requirements of charging for rail infrastructure in Article 7 and 8 of the Directive 2001/14/EC, outlines the specifications set in the directive as well as their relevance for this study and derives the **first set of indicators**.

Table 9: Requirements Specified in 2001/14/EC and their Relevance for the Implementation of NDTAC

Specification in Directive 2001/14/EC	Relevance for the implementation of NDTAC
Charges are to be set at the costs which directly incurred as a result of operating the train service.	Most Member States have followed this requirement by applying at least one pricing element which is related to kilometric performance of trains. As a noise-dependent element of the charge is likely to be related to this pricing element it is therefore essential to investigate the extent to which national tariff schemes are based on kilometric performance of trains and/or wagons .
Charges to cover environmental costs are allowed. However, if they increase the revenue of the IM, they may only be charged, if competing modes of transport apply these charges on a comparable level	The noise-dependent element of NDTAC will clearly be a charge to cover environmental costs. It is therefore important to assess whether or not national access charge systems include other environmental costs and on which allocation base they are levied.
Mark-ups on the basis of efficient, transparent, and non-discriminatory principles can be applied to recover the total costs, if the market can bear this. For market segments that are not able to pay these mark-ups, the charge should only cover the costs that have directly incurred by the train run.	This specification refers to price-discrimination based on the ability of each market segment to contribute to the provision of the infrastructure. Non-bulk freight is generally considered to be more price elastic than bulk freight. A noise related surcharge for non-bulk freight therefore would have a larger impact on its cross-modal competitiveness than it would have for bulk freight. It is therefore important to analyse the level at which each national charging system considers differences in price elasticities in each freight sector .
To prevent discrimination, the charges for equivalent uses have to be comparable and comparable services in the same market segments are subject to the same charges.	The same relevance as above applies.

Source: KCW/ SDG/ TUB

A **second set of indicators** will be derived to assess whether current charging systems are compatible with the requirements of NDTAC:

The objective of a NDTAC is to accelerate the retrofitting of wagons and should therefore incentivise on the wagon – in the best case even axle-based – rather than the train level. It is therefore crucial to examine whether the **basis of the calculation of the charge** is based on wagons or based on trains (or both). For the design option pass-by noise the attribute ‘wagon’ is not needed. The existing payment basis ‘train’ is sufficient.

Beneficiary of the incentive system should be the stakeholder who makes the strategic investment decision. As demonstrated in section 6.4 this may or may not be the RU. It is therefore important to assess whether TAC is directly paid from the RU to the IM or whether other **payments are made to or from any third parties other than the RU**.

With regard to the practicability of an European-wide NDTAC it is also essential whether the TAC is charged **based on real use or based on a declared (registered) train path**.

The **level of targeted cost recovery** has a high relevance for the implementation of NDTAC. Infrastructure pricing has been debated controversially within the European Union. Different approaches towards pricing of rail infrastructure chosen by the Commission have led to a relatively broad variety of approaches chosen by each Member State with regard to the applied Track Access Charge System. The most dominant difference is the level at which the charges are intended to recover the costs of the infrastructure: While the Green Paper “Towards Fair Efficient Pricing in Transport” suggests to aim at full cost recovery, the Directive 2001/14/EC supports marginal cost pricing. The level of targeted cost recovery has a high importance for this study as it will affect the *relative* increase in charge operators will experience in Member States. Given the fact that the NDTAC will be a surcharge based on kilometric performance the relative increase in access charges will be far higher in countries which charge at marginal cost level (such as the Netherlands or most Scandinavian Countries) than in countries which aim at a high level of cost recovery (such as Poland or the Baltic States).

The presence of **price-components considering wear and tear of the track** indicates that there must be a system in place recording the certain characteristics of the wagons, such as number of axles, axle load, unsprung mass, speed of trains or the performance of wheels, bogies and wheel cases.

Table 10 summarises assessment indicators derived in the above section.

Table 10: Derived Assessment Indicators

Assessment Indicators
<ul style="list-style-type: none"> ▪ Presence of charges dependent on kilometric performance ▪ Calculation basis (train-km or wagon-km) ▪ Presence of charges regarding external costs ▪ Level of price-discrimination between different user groups (bulk/ non-bulk) ▪ Level of targeted cost recovery ▪ Charges based on real-use or declared train paths ▪ Applied Pricing Strategies (level of targeted cost recovery) ▪ Presence of charges considering abrasion of the track

Source: KCW/ SDG/ TUB

6.8.2 Description of Access Charge Systems in Selected Countries

In the following section, Track Access Charge systems applied in European countries will be briefly described and examined against the above derived criteria. Information on national TACs has been gathered from the respective Network Statements and secondary literature:

Austria

Track Access Charges in Austria consist of two major elements, a base-charge complemented by various discounts and surcharges. The base-charge is dependent on train-km run on the network and gross-weight of the train, while different track categories have been introduced to reflect different cost levels associated with the costs of maintenance of tracks. Various discounts and surcharges are applied based on qualitative performance of traction (level of abrasion imposed by traction unit on track and safety equipment such as ETCS). Unlike in most other countries charges are levied based on real use of train-paths rather than requested train paths. In Austria the Track Access Charge covers approximately 28% of its prime costs with the remainder covered by the public sector.

Czech Republic

The Access Charge levied in the Czech Republic is dependant on train-km and gross ton-km and differs for freight and passenger traffic. The following table shows the tariff components for the infrastructure use, differentiated according to railway categories, valid for 2009:

Table 11: Czech Republic – Maximum Access Charge for using the Infrastructure

base free	maintenance free
(1) 7.38 CZK (~ € 0.27) /train-km	(1) 42.37 CZK (~ €1.56) /1,000 gross ton-km
(2) 6.14 CZK (~ € 0.23) /train-km	(2) 33.67 CZK (~ €1.24) /1,000 gross ton-km
(3) 5.20 CZK (~ € 0.19) /train-km	(3) 28.54 CZK (~ €1.05) /1,000 gross ton-km

Source: KCW/ SDG/ TUB

Further adjustments to the final price are influenced by factors which depend on whether the line is electrified and if the trains have a tilting system.

Also, the maximum price access charge is abated by a multiplication factor for freight trains transporting goods which have not been transported over the Czech rail network in the past 12 months, for self-contained trains of combined (intermodal) transport, or for certain types of freight trains transporting individual complete wagon-loads (regular slow goods trains and relational trains between marshalling stations that have the majority of individual consignments with various loading or unloading sites in the Czech Republic).

In addition RUs have to pay a path reservation charge dependent on the booking horizon. RUs are invoiced each month based on requested paths.

France

France introduced an access charge system in 1997 when the new IM Réseau Ferré de France (RFF) was founded. The system is a three-part tariff: An access charge (droit d'accès), a reservation charge (droit de réservation), and a circulation charge (droit de circulation), which are all dependent on the train-km variable. The access charge in 2009 is calculated by multiplying a base kilometric factor for the track category (which ranges from A, for suburban lines, to N, for high speed lines) with the length (in km) of the allocated path. The base monthly factor ranges from € 0 for track category E (other lines), to € 0.015 per km for category A, and to € 1.051 per km for category N. The reservation charge is calculated by multiplying path length to a track category factor which varies by time-of-day and to an additional multiplication factor. Time-of-day is divided into three categories: "normal", "peak", and "off-peak" hours. The kilometric prices range from € 0 per path-km for track category E during off-peak hours, to € 15.137 per path-km for category N during peak hours. The additional multiplication factor is applied if non-high speed lines are used: It ranges from 0.6 for freight paths that are less than 300km or where speed is less than 70km/h, to 1.3 for freight paths that are longer than 300 km/h and speed is faster than 105 km/h. For freight trains, the circulation charge is charged based on the number of train-km multiplied by € 0.459. Changes for 2010 include a finer segmentation of the day for the reservation charge: A day is now split between "off-peak", "normal", "intermediary", and "peak" hours. Further, the base factor now ranges from € 0.031 per path-km for track category E during off-peak hours, to € 12.914 per path-km for track category N during peak hours.

More importantly, as of December 2009, access charges will be waived for freight trains. The circulation charge will range from € 1.881 per train-km for track category E to € 3.135 per train-km for track category N.

Germany

The access system in Germany, implemented in 1994, is one of the first charging systems introduced in Europe. Due to deficiencies regarding the accessibility of third party train operators the regulatory authority encouraged the IM [DB Netz] to change the system twice. The latest charging system [TPS 2009] is a typical representative of a linear system. The prices currently charged are estimated by a rather complex multi-level system of price-ascertainment: A base price has to be paid according to a track category and is multiplied by a product coefficient, which is set up according to the product attribute of the train path. The price generated by this procedure is again surcharged with factors dependent on characteristics of the train. The first pricing element is the **track category** [Streckenkatgorie]. These categories are divided into seven types of long distance tracks, two types of feeder tracks and three types of urban-transit tracks [S-Bahn]. The prices relevant for freight trains (long-distance and feeder tracks) vary between € 1.90 and € 8.30 per train-km. Prices are predominantly dependent on the equipment and configuration of the track, maximum speed and importance of the transport link. Those parts of the network, which have a particular importance for the network like loops or other connecting tracks, take a special role. They are classified as Fplus-type. A second element that is added is the **product coefficient** [Produktfaktor]. This coefficient considers the priority of a train path, its velocity and its flexibility within the timetable. The product coefficient is a multiplier for the track category. DB Netz distinguishes between four different kinds of products: *Express paths* are constructed with priority over other train paths when developing a timetable and are the shortest and fastest routes through the network. *Interval dependant paths* are constructed in such a way, that trains stop at the same stations with the same headway over a certain period and/ or that the pattern of train paths requires a certain allocation of the paths. This product is only available for passenger transport and its factor is 1.65. A *Standard/Economy path* has lowest priority while constructing the timetable and during actual operation. The factor is 1.0. A *feeder path* is only available for freight transport and is designated for the final distribution for wagons. The factor is 0.5. Additionally there is a *dispo path* intended to allow train operators to transfer locomotives. The product factor for freight is 1.65 for express-freight paths, 1.0 for standard speed path, 0.65 for dispo paths and 0.5 for feeder paths. A third element of DB Netz charges are **surcharges** [Sonderfaktoren] according to load, weight, characteristics of the train and regional characteristics. Some of these surcharges are multipliers while some are additive: An *exceeding gauge factor* of 1.5 is applied if a train carries out-of-gauge load. *Gross train weight supplementary charge* is applied according to additional wear and tear imposed by those trains whose gross train weight exceeds 3,000 t. This supplement is € 0.92/train-km for a gross weight >3,000 t. *Regional factors* are imposed to take different cost-levels of local track networks into consideration. They vary between 1.00 on networks with high loading factors or low costs up to 1.72 in extremely rural areas. The **final access charge** is calculated by multiplying the price for the track category with product coefficient and surcharges.

Italy

The Italian Track Access Charge comprises a base-charge, which covers reservation of the train path (the slot), access to the track and usage of electric energy. The Italian Network is subdivided into a fundamental network, a complementary network, and key nodes around major conurbations adding up to 50 different zones. The base-price varies significantly within each zone. Further parameters determine the utilisation level of the track, deviation from the average speed on the particular section of the track and axle loads of the train. The base charge varies between € 0 and approx € 70 (e.g. for Diretissima Firenze-Roma). There is also a node access charge of approximately € 1 per minute of stay. There are different formulas that calculate the charges for each type of railway infrastructure (fundamental, complementary, node). The charging framework that has been adopted attempts to disaggregate the costs of operating, maintaining and renewing the network according to the wear and tear caused by the different types of rolling stock and their characteristics. It also disaggregates the network into three types of railway infrastructure which reflects the quality of the infrastructure, the environment of the infrastructure and the amount of demand for that part of network. By providing such a structure the State has endeavoured to provide a structure where the IM can recover the incremental costs of maintaining the network, and has a mark-up on the charges to recover part of the full cost of running trains on the network through the reservation charge, thus attempting to incentivise the operators to value up to the last train*km of their service.

The Netherlands

The Track Access Charge System in the Netherlands is purely linear and based on kilometric performance. In 2009, freight trains are charged € 0.5119 per train-km for the use of infrastructure (base charge) and € 0.001750 per tonne-km. The charge for energy is € 0.028249 per kWh. The noise component of the Dutch Track Access Charge System is discussed in more detail in the case study.

Poland

The Access Charge in Poland consists of three major elements:

- I A basic charge for journeys levied according to allocated train paths. This basic charge consists of reservation charge (i.e. the right of the RU to utilise a specific train path) and realisation charge for the effective use of the railway lines (including use of devices and objects necessary for technical and commercial handling on this train path, and the use of the centenary), which is calculated as unit rate for a specific train type and railway line times train-km;
- I Additional charges as listed in the Network Statement for e.g. supply of water, compressed air, electrical energy, making availability of the PLK telecommunication network, monitoring of train journeys with dangerous goods, assistance in the operation of non-standard trains, etc.; and
- I Charges for any amendment and update to the annual timetable requested by the RU.

For RUs who orders train paths on at least 60% of railway lines managed by the IM PKP PLK and are planning to utilise at least 70% (daily average) of all train paths prepared for them in the annual timetable PKP can apply average rates (for the whole network) for the calculation of basic charges. The calculation of these average rates does not seem very transparent since weighted averages are introduced here without specifying the parameters of these weights. Any deviations from the train path allocation mechanism, e.g. allocation of individual train paths (exceptional journeys), journeys with higher than expected axle loads, lower than expected speed etc. result in predefined percentage augmentation of basic charges. These surcharges may add up (e.g. slower train with higher axle load) but the total increase cannot exceed 200% of the basic charges. The IM adds a profit margin of 5% to all basic and additional charges, thus giving the notion that calculated charges are cost-based (covering operational costs, i.e. infrastructure management and maintenance cost).

Sweden

Core element of the Swedish infrastructure charge system is the so called circulation- or **access charge** [spargift] which is € 0.0001 per train gross ton-km, while € 0.0003 is the fraction paid to the wear and tear of the track and € 250 are paid per train-crossing for refinancing the Öresundbridge. The costs for traffic management [trafikantinformationsavgift] depend on the brutto-ton-km of the train movement. They account for € 0.0002 for passenger services. Freight services do not have to pay this fraction. A price of € 0.4 for freight services that use freight terminals or marshalling yard [rangerbangsavgift] is charged in accordance with the number of wagons. An **environmental charge** is imposed either dependent on the number of litres of fuel consumed by the engine (charge varies from € 0.016- € 0.14 dependent on type of engine) or, in case of electric traction, dependent on train km (€ 0.12/km for passenger services and € 0.06/km for freight operations). These prices do not include the used energy *itself*. Diesel has to be provided by the train operators themselves, electricity for the overhead wire has to be purchased from the IM and is accounted in accordance with consumed kWh. An **accident externality charge** is levied according to train-km irrespective of the train's length and weight. It is equivalent to € 0.118 / train-km for passenger transport and € 0.059 / train-km for freight transport. These costs are fully distributed average costs and estimated over a ten-year period.

Switzerland

The access charge in Switzerland consists of two components. Firstly the three IMs Schweizerische Bundesbahn AG (SBB), Bern-Lötschberg-Simplonbahn AG (BLS) and Regionalverkehr Mittelland (RM) charge a **minimum charge** [Grundpreis]. This charge is supposed to cover the costs of wear and tear of the track per kilometre and labour costs for operating track and signalling. The minimum charge varies in accordance with the cost-structure of the specific track. Combined Freight Trains pay € 0.0006568 per tonne-km while all other trains pay € 0.0016 per tonne-km. All trains pay € 0.00065 for traffic management costs. Energy is charged dependent on characteristics of the train. A supplementary charge of € 2 or € 3.3 per train is charged if trains pass through or stop at one of the major railway hubs. Furthermore

the IM charges a **contribution margin** [Deckungsbeitrag]: Concessioned passenger service pays a proportion of its revenue. It is defined for each franchise by the rail regulator [Bundesamt für Verkehr]. Non-concessioned passenger services pay € 0.0017 per train km. Freight services pay € 0.0034 per netto-ton-train-km on the SBB and RM Network and € 0.0023 on the BLS Network.

United Kingdom

The UK track access charging regime and rates are determined by the Office of Rail Regulation (ORR) in its periodic review of Track Access Charges the new version takes effect from 1st April 2009. The UK track access charging regime is based on a framework of Fixed Track Access Charges (FTAC) and Variable Track Access Charges (VTAC or utilisation charge). Fixed Track Access Charges are paid by franchised passenger train operating companies only, and they include their costs in the franchise bids to the Department for Transport (with the effect that FTAC is paid by the government). If franchised train operators wish to run more trains than their track access contract stipulates, they will have to pay the variable Track Access Charge, which notionally represents the incremental damage caused to the track by the passage of the vehicle. In addition, where electric traction is used, the operator also has to pay what is known as an EC4T rate to purchase electricity from Network Rail (operator of the infrastructure), on a per mile and per traction type basis. Reductions are offered if the rolling stock is equipped with regenerative braking. Open access passenger operators and freight operators only have to pay the variable Track Access Charges, which are calculated per track mile and according to the type of vehicle (locomotive, carriage, wagon). Because the government – via the franchised passenger operators – pays a substantial part of Network Rail’s operations, maintenance and renewal expenditure through the fixed Track Access Charge, open access passenger and freight operators do not cover the total costs of their operation on Network Rail’s infrastructure. This is one of the means by which the government provides an incentive to new entrants and freight operators. VTAC rates vary widely, but can be classified as follows (2009):

- Class 66 – standard diesel freight locomotive 2.2p/tonne track mile;
- Class 92 – electric freight locomotive 3.2p/tonne track mile;
- Freight wagons vary enormously, but are approximately 1.5p/tonne track mile.

Therefore a precise understanding of the weight of the freight train and the number of wagons is essential in determining the price to be paid to Network Rail. Passenger vehicles are charged on a per vehicle mile basis, according to type, and are not subject to a calculation of their weight. Electric traction charges also vary, from 0.05p per kilogram track mile for freight DC to 1.13p/vehicle mile for passenger AC.

It is important to note that in addition to the existing TAC the so called “Possessions and Performance regime governs the relationship between Network Rail and the passenger or freight train operator. It applies in case the infrastructure owner has to close part of the line for work; or if delays are imposed on the operator by another operator or by Network Rail. These cases are stipulated in the track access contract between the two parties. However, although the Performance Regime has an important influence on the level of the actual charge paid it is not an access charge.

6.8.3 Presence of Charges in European TAC and their Impact on the Introduction of a NDTAC

In the following the findings of the above analysis will be assessed against the criteria developed in section 6.8.1.

Presence of Other Charges Dependent on Kilometric Performance of Trains

Almost all systems have some pricing elements dependent on train-kilometres. The Czech system charges based on train km in both, the base-charges as well as the variable charge. Similar applies to the Dutch system which is purely based on train kilometres operated. The German system charges dependent on train-km on the base-price and the surcharge level. The Swiss system charges dependent on train-km on marginal cost level (minimum charge) but not on the contribution margin level. In France all charges are set in accordance to train-km, except the access charge, which is set per month and track-km while in Sweden and the UK all charges are related to train-km. Most critical are Poland and Italy as no element of the access charge has a clear link to mileage performance.

Presence of Other Charges Dependent on Kilometric Performance of Wagons

None of the studied systems except the UK has set charges based on kilometric performance of wagons. Charges are imposed on entire trains and not on a wagon basis. Therefore the TAC accounting systems do not necessarily allow an allocation to wagon-kilometres. However, all RUs have evidence regarding train composition for every train number and therefore the mileage of 'noisy' as well as 'silent' wagons can be derived by the RU. The wagon register permits the identification of the single wagon and the number of axles respectively. Thus an axle-based accounting is possibly feasible for a bonus system which refers to the retrofitting of brake blocks.

Impact on NDTAC: A wagon based accounting system would have to be introduced in almost all Member States in order to allocate bonus and/or penalties to respective Wks or RUs.

Presence of Charges Regarding External Costs

Although the Commission's efforts to allow IMs to charge for external costs, there is only one IM that considers external costs – Swedish Banverket: The diesel charge accounts for NO_x/emissions determined by the type of the engine. For electric trains the charge correlates with train-km. Furthermore there is a charge on accident externalities, although they do not reflect any social costs of accidents. It should be noted that some countries cover external costs through taxes on energy. There is no obligation to charge for external cost (cf. 2001/14/EC, 2006/38/EC), However, if they increase the revenue of the IM, they may only be charged, if competing modes of transport apply. The Swedish example demonstrates that there are indeed tracking and accounting systems in place which allow charging for externalities.

Impact on NDTAC: Although the Commission's efforts to allow IMs to charge for external costs, almost no IM considers external costs as part of its TAC. Hence, NDTAC can not build on existing approaches and charging technologies.

Level of Price-discrimination Between Different User Groups (bulk/ non-bulk)

The analysis of the examined countries shows that there is no price-discrimination between bulk and non-bulk trains which is based on the ability of each market segment to contribute to the provision of the infrastructure. However, the level at which the axle load or the weight of the train respectively determines the access charge varies significantly between the examined countries, as some countries – such as the Czech Republic, Germany and Switzerland – charge relatively higher charges per gross ton-km than other countries – such as Sweden. The differences in those charging elements are far more pronounced than the differences in marginal cost levels imposed by a freight train may justify them. Rather, they reflect the different national policies towards the level of cost recovery as well as the level at which freight is cross-subsidised by the passenger market. Only those countries which experience a high level of transit traffic such as Switzerland and some eastern European states levy relatively higher charges dependent on tonnes which could be interpreted as an "implicit" discrimination of bulk freight. Switzerland is the only country which discriminates explicitly – namely between piggyback trains [Rollende Landstraße] and all other freight trains.

Impact on NDTAC: There is almost no explicit price discrimination in place which distinguishes between different commodity groups. Hence, any price discrimination applied by NDTAC would have to be applied on top of conventional Track Access Charges.

Applied Pricing Strategies (level of targeted cost recovery)

Three major charging regimes can be identified among the examined countries with regard to the level of targeted cost recovery: Sweden charges at social marginal cost level targeting to cover only 5% of its costs through Track Access Charges. Social marginal costs only cover environmental and accident costs. The Netherlands charge at a marginal cost level with a targeted 12% of all costs to be covered by the access charge. In a marginal cost regime users are only charged for those costs imposed by any additional train run on the IM's network (wear and tear costs, congestion and scarcity costs). All other examined countries charge significantly above marginal cost but also below full cost recovery. The Swiss IMs SBB/ BLS /RM price slightly above marginal costs targeting to cover 30% of the total costs, the Czech Republic charges significantly above marginal costs and covers approximately 60% of its costs through access charges. So does the German IM DB-Netz, while France targets a cost recovery level of 65% and Poland even a level above 90%.

Impact on NDTAC: Any noise-dependent component added to the conventional TAC should not be a percentage of existing charges. The range of charging levels in the analysed countries is too wide. NDTAC incentive levels should be consistent in all Member States.

Presence of Charges Considering Abrasion of the Track

In all train access charge regimes, train-km and gross-ton-km are the predominant activating variables. The only exception is the UK, where the charge is based on characteristics of each wagon. Charges are levied in accordance to a ‘price list’ for each vehicle type which reflects the level at which the vehicle imposes damage to the track and the superstructure. Freight wagons with track friendly bogies for instance pay less Variable Track Access Charge than other wagons do.

Impact on NDTAC: None of the investigated Member States except for the UK charges for the level of stress imposed by a single vehicle on the track. A NDTAC approach which requires tracking singular wagons cannot be reproduced through an existing TAC.

The table below summarises the findings of the previous sections including total charges levied per kilometre for an average 960 gross-tonne train as well as a 2000 gross-tonne train.

Table 12: Characteristics of National Track Access Charge Systems

	Selected Member States									
	AT	CZ	FR	DE	IT	NL	PL	SE	CH	UK
Charges based on train-kilometres	X	X	X	X	-	X	X	X	X	X
Charges based on wagon-km	-	-	-	-	-	-	-	-	-	X
Charges based on gross-tonnes	X	X	X	X	-	X	X	X	X	-
Charges based on axle load and unsprung mass	-	-	-	-	-	-	-	-	-	X
Charges consider external costs	-	-	-	-	-	-	-	X	-	-
Charges based on registered train-paths	-	X	X	X	X	X	X	X	X	X
Charges based on ‘real’ – train paths	X	-	-	-	-	-	-	-	-	-
Total access charge for a 960 tonne freight train [-€/train-km]	2.6	4.1	2.0	2.5	2.4	2.1	3.5	0.3	2.6	3.1
Total access charge for a 2000 tonne freight train [-€/train-km]	3.8	6.6	2.0	2.2	2.4	3.9	6.0	0.7	5.2	6.2
Level of targeted cost recovery [-%]	28	60	62	60	15	12	92	5	30	50

Source: Summary of TACs of Member States (cf. section 6.8.2)

Conclusion

The following conclusions have been derived from the analysis of European Track Access Charges:

- A wagon based accounting system would have to be introduced in almost all Member States in order to allocate bonus and/or malus to respective WKs or RUs. Any wagon-based incentive within a NDTAC would have to be applied on top of conventional Track Access Charges.
- Although the Commission’s efforts to allow IMs to charge for external costs, almost no IM considers external costs as part of its TAC yet. Hence, NDTAC can not build on existing approaches and charging technologies.
- Any noise-related component added to the conventional TAC should not be an EU-wide percentage of existing charges. The range of charging levels has found to be too wide. As costs for retrofitting do not differ significantly between Member States, the incentive level for the RU’s and WK’s calculations should be consistent in all Member States.
- As a consequence of the previous conclusion, the relative change of TAC after implementation of noise-related incentives will be higher and therefore probably more noticeable in such Member States with a relatively low level of TAC. On the other hand in such Member States with a

comparably high level of TAC, the effect of noise-related incentives will be less noticeable for RU and WK. Hence, despite the absolute incentive might be the same in economic terms, the need to react might vary between the RU/WK in the Member States according to the level of TAC as the relative risk / chance of noise-related incentives for the decision takers' margins depends on the core TAC level. However, the more important effect of such a setting in the European rail freight market is the calculability of investments for retrofitting since they are independent from the country of wagon operation.

- I None of the investigated Member States except for the UK charges for the level of stress imposed by a single vehicle on the track. A NDTAC approach which requires tracking singular wagons cannot be reproduced through an existing NDTAC.
- I A NDTAC scheme based on the 'pass-by noise measurement' approach (whole train's noise emission) would be easier to be implemented into the current Track Access Charges as it does not require a breakdown per wagon. Although more difficult – also a 'TSI Noise-based feature'-approach could be applied by synchronising data between actual or registered train movements and train-composition lists.

6.9 Technical Solution: The Preferred Brake Block Solution

The choice of the preferred braking system is crucial for a successful implementation of NDTAC. As discussed at an earlier point of this study the European Commission prefers a quick implementation of NDTAC. It is likely that a 'known technology' at 'known prices' will be chosen.

First of all, any NDTAC scheme which intends noise reduction through retrofitting brake blocks has to agree upon a technical brake block solution which should be the focus of the system. On the assumption that CI brake blocks are making rail freight unacceptably loud, a substitution by more silent brake blocks is necessary. Basically there are three possible technical options to substitute CI brake blocks:

- I Disc brakes;
- I K-blocks;
- I LL-blocks.

Disc Brakes Solution

Disc brakes, meanwhile standard for passenger coaches, are not a suitable option for retrofitting due to their technical demands. Rail freight is usually a rough kind of transport therefore technical solutions like brake blocks should not be too sophisticated. There are indeed singular cases, especially freight wagons constructed for speeds until 160 km/h, in which these types of brakes are used, but a general retrofitting of freight wagons with this technology is not practicable. Therefore a NDTAC that would focus on retrofitting with disc brakes is not feasible. However, if freight wagons with disc brakes are certified for TSI Noise, these wagons could nevertheless benefit from noise related incentives as they also contribute to a lower noise level, provided that certified vehicles are included in such a scheme.

K- and LL-blocks

As the main focus is the retrofitting of the big fleet of older wagons, the technical solution must be feasible for a large-scale application. Thus two solutions remain: K-blocks and LL-blocks, both consist either of *composite or sintered brake blocks*. The mentioned study of PWC examined both solutions. Currently only K-blocks are available and in use. At present LL-blocks do not have any homologation yet, therefore their usage is currently not possible except for test runs.

TSI Noise prefers retrofitting with composite brake blocks, as noise-emissions do not need to be tested. However, this does not apply to sintered brake blocks, which have to pass the entire approval process.

K-block Solution

K-blocks are the brake block solution which is used in practice and already contributes to the abatement of noise. But the usage of K-blocks requires a complex technical modification of the single wagon and, if applicable, for wheels. For using K-blocks the whole pneumatic braking system has to be changed and recalibrated. Depending on the type of wagon there are several options for doing this – all of them in-

involve relatively high up-front costs. Additional costs are generated by new homologation of the whole wagon after the retrofitting. Stakeholders criticise this process stipulated by the responsible authority due to producing unneeded additional costs. One homologation of a brake block for a specific wagon type should be enough. Besides, the fixed up-front costs – as for any brake block – variable costs due to wear and tear occur. In total, the LCC of K-blocks are higher than the ones for CI brakes. Currently, K-blocks are state-of-the-art for new wagons which are certified for TSI Noise. The relatively high up-front costs lead to higher uncertainty with regard to the return on investment and might cause Wks to refrain from retrofitting their wagons. Any incentive has to take the relation between fixed and operational costs into account: In case of K-blocks the incentive should be higher at the beginning to have an impact on the Wks decision to retrofit.

Additionally opportunity costs occur if the wagon cannot be used during the retrofitting process. These costs can be lowered if retrofitting is done during revision of the wagons (at average every 6-7 years)

LL-block Solution

LL brake blocks are composite or sintered brake blocks, too. However, apart from that they differ essentially from K-blocks. LL brake blocks do not require technical modifications on the wagon. This implies a comparatively simple retrofitting with LL brake blocks. Only in some cases additional modifications on the wagons are necessary. For some wagons an additional specific valve is needed. In principle there are no fixed retrofitting costs apart from time and effort plus opportunity costs. The costs of retrofitting with LL-blocks consist therefore mainly of variable (material) costs.

Risk of calculation: Due to higher wear and tear the LCC of LL-blocks are higher than for CI brake blocks. However, LL-blocks are not homologated yet; valid LCC data are not available. The consultations with stakeholders showed disagreement among the experts. Some experts expect higher costs for LL-blocks compared to K-blocks (as discussed above), but other experts have doubts on this assumption. Some of them even estimate nearly the same costs as for CI brakes.

The uncertain variables for LL-blocks – and hence the reason for uncertain predictions – enfold the development of prices in the future and the use in practice. It can be estimated, that the prices for LL-blocks will change if they are ordered on a larger scale. Consultations with experts from the railway industry have shown that a price increase can actually not be assumed: The market for brake blocks is not monopolistic; there are currently three manufacturers who are able to produce LL-blocks. It is likely that further manufacturers will enter the market if the LL-block homologation has passed.

Despite the uncertainty of LL-block homologation, pilot studies with LL-blocks suggest, they have a longer live time, but impose higher wear and tear costs on the wheels. Overall costs per axle-km are higher for LL- blocks.

Risk of variable costs: The existence of almost exclusively variable costs results – in theory – in claims for unlimited incentive payments due to continuously higher costs. This circumstance is intensified by the technical feasibility of re-retrofitting from LL brake blocks to CI brakes. Initially this is also an argument against direct funding: A company could get a one-time bonus for the retrofitting and after the wear of the new brake block it can use cheaper – and louder – CI brake blocks. By setting incentives depending on performance or time of usage, the use of silent LL-blocks could be extended. Hence to avoid re-retrofitting the bonus theoretically has to be paid for the remaining service life of the wagon. This would lead to incalculable costs. These considerations would apply less if the future costs for LL-blocks adjust to the costs of CI blocks.

Ban of CI brake blocks: Anyway, a decision for the NDTAC to support retrofitting wagons with LL-blocks should go along with additional measures. For retrofitted wagons a re-retrofitting must be prohibited. Alongside the mandatory registration at the registration papers, an extra mark has to be made on the wagon. In the long run the authors advise a ban of CI brake blocks, especially if a LL-block based solution is preferred in order to prevent an 'endless' incentive system.

Conclusion

In general, the consultants advocate focusing on LL-blocks, as it increases the effectiveness of the incentive system: Overall costs are lower and the incentive structure imposes less risk on the WK and there is less risk of over- or undercompensation. As the introduction of NDTAC requires an amendment of Network Statements it would not be implemented with immediate effect anyway. This would leave some time for the finalisation of the homologation process of LL-blocks.

However, there is an uncertainty that the homologation of LL-blocks might face further delays. Therefore we will consider K-blocks as well within the in-depth analysis (chapter 7).

A more detailed analysis on costs of LL-blocks and K-blocks is given in chapter 7.4.

6.10 Methods of Measuring Rail Noise

One of the investigated options – the pass-by NDTAC – is based on real noise measurement.

A direct measurement of rail noise is performed by using calibrated microphones or sound level meters in a defined setting. Specifications as to how exactly measurements should be conducted are specified in ISO 3095. The main benefit of this way of measuring is that noise is measured during the actual operation of individual trains using fixed measuring points throughout the rail network. A direct reference to the Track Access Charges for individual trains is thus feasible. But the area-wide usage of noise measurement is limited due to the costs of the measurement stations. Thus either trains are incentivised for the whole route even though their 'real noise' is only measured on a few measurement stations. Or the incentive is restricted to a limited area, which is equipped with several measurement stations. Trains which do not pass a measurement station are not incentivised under such a regime.

On the other hand, the noise generated by individual wagons cannot be measured separately. Additionally, measuring rail noise during operation also leads to certain inadequacies. Whereas licensing measurements are subject to TSI-standards, monitoring measurements reflect real life factors such as wind, rain, extreme temperatures, as well as different running speeds, types of wagons, environmental noise, and rail conditions. These influences need to be understood in greater detail and correction factors have to be found so that different monitoring measuring results can be better compared with each other. Moreover the rolling noise might change due to factors other than rail roughness, for instance change of superstructure type, reflections from platform sidewalls etc. Hence, the results of different measurements are not comparable depending on the particular conditions at the measuring points.

Hence, for the consideration of individual wagons a different setup is necessary. During operation the correlation between measurement readings and individual wagons is difficult when an entire train is passing by.

The determination of rail noise originating from individual wagons can also be estimated indirectly using the correlation of rail noise with wheel/rail roughness. With these indirect measurement methods it is easier to determine the influence of individual wagons on the noise level of the train. The separation of wheel and rail roughness is possible when roughness of one of the components is either well-known or very low. It is also possible to gauge the roughness using a derived quantity such as the measured vibration level.

It is important to note, that a NDTAC based on 'pass-by noise'-measurement will only allow for charging an entire train but not single wagons. Indeed, there are efforts to enable wagon-specific recording in the Netherlands and Austria but without satisfying results so far³⁶.

Noise measurement at the tracks is essential for the design option based on pass-by noise. However, if required noise measurement is also needed for the TSI homologation process. These measurements are done at a test laboratory.

6.11 Suitability of the system for other Differentiated TAC

Despite the fact that noise emissions from rail freight are a significant problem, the implementation of a charging system purely for the purpose of solving noise issues seems to be inadequate. Hence, the use of a system which can be used to charge for other elements should be considered. The demand for such a differentiating system is expected to increase in the future, due to the political will to internalise external effects. Beside rail noise, other external effects like for example CO₂ emissions could be taken into account. The directive 2001/14/EC allows factoring these emission costs into the TAC. In Sweden emission related TAC is already in force.

In addition to the pricing of external effects like noise or emissions, the infrastructure established for NDTAC might be used for pricing according to wagons' special characteristics. The cost for maintenance of the track depends in certain cases on the used rolling stock's quality. Therefore it should be in

the IM's interest to differentiate the TAC in order to reflect these effects. Such pricing elements are for instance used in the UK.

Stakeholders will most likely disapprove such approaches due to their concerns regarding increasing burdens for the sector. However, differentiated TAC should not just increase total TAC but reflect different stress imposed on tracks. Such schemes could be cost neutral by applying both, bonuses and penalties (maluses) and hence not put any additional burden on the rail-freight sector as a whole.

It has to be taken into account that specific additional elements of a differentiated TAC applying to individual rolling stock characteristics, cannot be implemented as an incentive factor within 'ordinary' TAC (applying to entire trains). As illustrated in chapter 6.8. a NDTAC scheme and other differentiated TAC as well have to be wagon-specific at least. Therefore, they would function rather as an 'add-on' charging system in the environment of the existing TAC-structure.

6.12 Conclusion: Constraints for the Implementation of a Noise Differentiated Track Access Charge

The previous chapter identified various framework conditions in which a NDTAC needs to be embedded (this will be further elaborated in chapter 7). Based on this, the two design options 'pass-by NDTAC' and 'TSI Noise-based NDTAC' will be evaluated in respect to their applicability for NDTAC. Main aspects and key results were:

Table 13: Rating Matrix to Identify the Preferred Design Option

	TSI noise-based rolling stock NDTAC	Pass-by NDTAC
Risk of Modal Shift	<ul style="list-style-type: none"> Depends predominantly on the funding of NDTAC, not on preferred design option (question is whether costs are allocated to the freight sector or covered by Member State's Governments) Differentiation between types of wagons in theory possible but not recommended 	<ul style="list-style-type: none"> Depends predominantly on the funding of NDTAC, not on preferred design option No differentiation between types of wagons possible
Impact on intra-modal competition	Depends predominantly on the funding of NDTAC, not on preferred design option	Depends predominantly on the funding of NDTAC, not on preferred design option
Contractual relationships	<ul style="list-style-type: none"> Relatively simple; current relationships detained Complexity increases with rising up-front costs for modernisation/retrofitting Good calculability if applied on large parts of the network 	<ul style="list-style-type: none"> relation between RU and WK regarding incentive payment is complex due to passing-by of the whole train at measuring station (bonus is paid for entire train rather than the wagon) Lack of calculability for RU/WK as only applied on routes equipped with measuring stations
Costs and Risk of over-compensation	<ul style="list-style-type: none"> Relatively certain costs for brake block solution Amortisation of costs more predictable 	<ul style="list-style-type: none"> Relatively high and uncertain costs for measurement portals Amortisation of costs not predictable due to limited usage of measurement stations
Differentiation	<ul style="list-style-type: none"> Differentiation by time and region feasible but increases the complexity 	<ul style="list-style-type: none"> Regional differentiation complex – new measuring stations necessary
Data entry	<ul style="list-style-type: none"> Self declaration feasible as interim solution TAF TSI feasible at a later point Data exchange between IM and RU 	<ul style="list-style-type: none"> Measuring stations necessary, large upfront investment at the side of the IM Additional Exchange between IM and RU not necessary Data exchange between RU and keeper complex, but inalienable
Compatibility with TAC and directive 2001/14/EC	<ul style="list-style-type: none"> Currently TAC accounting on train basis However, link between train composition and train possible NDTAC in accordance with 2001/14/EC 	<ul style="list-style-type: none"> Both, national TACs and noise measurement both apply on train basis NDTAC in accordance with 2001/14/EC (external costs)

	TSI noise-based rolling stock NDTAC	Pass-by NDTAC
	(external costs)	
Ability to use system for other differentiated TAC	<ul style="list-style-type: none"> ▪ Environment of the design option can be used for other differentiated TAC, e.g. to charge for CO2 emissions 	<ul style="list-style-type: none"> ▪ Option restricted on noise measurement due to measurement stations and vehicle-based accounting
Technical solution	<ul style="list-style-type: none"> ▪ LL-blocks preferred ▪ K brake blocks as alternative if LL brake blocks are further delayed ▪ Ban of CI should be taken into consideration 	<ul style="list-style-type: none"> ▪ No preferred technical solution, certain degree of freedom for RU/WK on how to reduce noise ▪ Ban of CI should be taken into consideration
Measuring Rail Noise	<ul style="list-style-type: none"> ▪ Only as test for certification 	<ul style="list-style-type: none"> ▪ Main attribute of the system ▪ Only feasible on train basis

Source: KCW/ SDG/ TUB

6.13 Evaluation of the Most Preferred Design Option

Comparing both design options, disadvantages of both become visible. Nevertheless, the design option based on TSI Noise has been considered as the preferred solution.

Most of all, this model is quickly realisable because it builds on already available technical solutions. TSI Noise prefers composite brake blocks. In the case of the TSI Noise based design option, incentives can be applied according to the brake block equipment.

In addition to that, the pass-by noise design option requires at first expensive measurement stations to be installed along the tracks, where NDTAC is applied. This causes the system to be inflexible when new routes need to be included in the NDTAC. Further problems occur because the measurement results are not 100% accurate. Due to this RU and WK have a lack of reliability for their incentive calculation because this requires a high amount of security, to which extent the wagons will run on incentivised lines after retrofitting.

The TSI Noise-based design option with focus on brake technology builds on existent specifications (TSI Noise – preference of brake technology) and accounting procedures (accounting process between IM and RU) and therefore also has to be considered under the aspect of preferably minimal administrative costs. Until moreover a Europe-wide standardized accounting regime based on a central database can be implemented, in this option – unlike in the pass-by noise design option – a simplified interim solution in form of self-declaration is possible.

All together, there are convincing criteria in favour of the TSI Noise-based design option:

- Acceleration of the retrofitting process;
- Preference of known technical solution (composite brake blocks);
- Simplification of the administrative process possible (self declaration).

On top of that there are exclusion elements for the pass-by noise design option:

- Uncertainty of technical solutions produces unknown costs for the noise abatement;
- Difficulties concerning noise measurement (limited area, inaccuracy, no recording of single wagons).

Therefore, in principle, a TSI Noise-based NDTAC is being evaluated as the preferred design option. This model will be presented in depth in the following chapter.

7. DEVELOPMENT OF THE PREFERRED NDTAC

The previous chapter identified the 'TSI Noise-based Rolling Stock NDTAC' as the preferred option for a NDTAC. Based on this, the current chapter provides more specific settings for NDTAC. In a first step initial targets are reiterated and findings from chapter 6 are summarised as constraints for the further development of a NDTAC (chapter 7.1). Based on that a practicable and target-orientated solution for NDTAC is narrowed down by shaping the various elements which are:

- General characteristics of charging of NDTAC;
- Functionality and institutional setup of the charging process; and
- The level of incentive (bonus-level).

Secondly this chapter provides an analysis of the performance of NDTAC with regard to an estimate of the likely fleet evolution and economic costs. Furthermore it suggests options how the system can be funded.

7.1 Practical Constraints for NDTAC

The target of the NDTAC is to secure a relatively fast retrofitting of the majority of the fleet by prioritising those vehicles with the highest annual mileage. At the same time the level of complexity and administrative costs should be held to a minimum. Furthermore the incentive system should neither weaken the overall market share of the freight sector nor disadvantage any market participants in the freight sector.

First of all, the essential "constraints" will be defined briefly. These limit the freedom of design and have been derived from the previous chapter, stakeholder consultations and the analysis of state-of-the-art NDTAC.

- The procedures and elements of the NDTAC are built on existing (charging procedures) or planned processes (TAF TSI), therefore causing only minor additional implementation costs (cf. chapter 6.7.).
- Only the fixed and additional variable costs associated to retrofitting, mileage and accounting regime (RU+WK) should be the basis for the incentive. Overcompensation for these costs should be avoided. Gradually, possibilities for overcompensation as well as a lack of incentives will need to be accepted to a certain extent to keep the system functioning and avoid over-bureaucratisation (cf. chapter 6.5).
- Wagons need to be recorded separately to allow for an adequate incentive. This would not be achieved if the incentive is granted only to entire trains. A train-based bonus can only be an additional feature of the system (cf. chapter 6.8).
- Retrofitting costs and higher operational costs after retrofitting correlate with the number of brake blocks and axles. Therefore the calculation basis for the bonus needs to be number of axles per wagon.
- Given relatively low margins and relatively high uncertainty on future revenue streams in the market, Wks act relatively risk adverse and will avoid investments unless pay-off is secure. The incentive system must therefore guarantee planning reliability and a relatively short refinancing period (cf. chapter 6.1 and 6.2).
- If the incentive system would apply maluses for 'noisy' wagons as well as bonuses for 'silent' wagons, self declaration would have to be obligatory because all wagons have to be reported – irrespective of their noise level (c.f. chapter 6.7.). A mandatory participation of all RU would be the consequence. This huge flow of data is difficult to manage until TAF TSI is implemented. Furthermore, the rail freight sector is fragile in terms of cost increases. A malus would weaken the sector (cf. chapter 6.1 – 6.3).
- Objective of the system is not that all wagons on all rail corridors become 'silent' but that frequently used wagons and track sections with heavy traffic reduce their noise level, preferably at

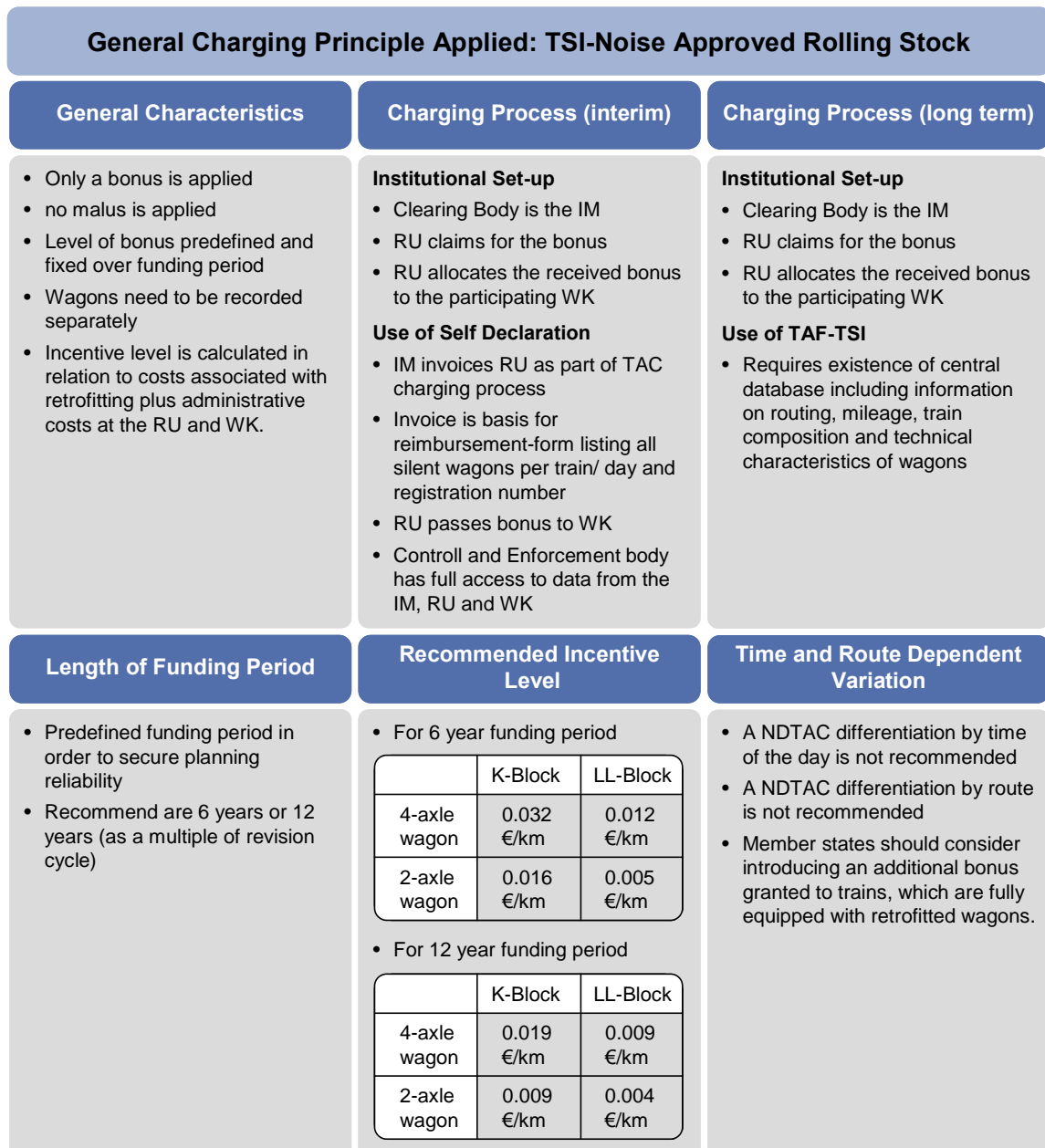
places where most people are affected by noise. Therefore, the NDTAC needs to be applied on major national networks only. The proportion of administrative costs would be disproportionately high for minor feeder lines. Therefore, small IMs with regional and/or small networks should not charge NDTAC (see chapter 6.3).

7.2 General Characteristics of Charging

In the following sections design options of further elements of NDTAC will be set out: At a first step the process of charging is illustrated – for the case of self declaration as well as for TAF TSI. Supported by a quantitative model the optimum level of incentive (bonus level) will be calculated - based on the estimates on costs for retrofitting, operational costs associated with retrofitting as well as administrative costs.

The below figure presents the core results of chapter 7.2, which will be described in detail in the sub-sections of this chapter.

Figure 15: Charging Elements of the Preferred NDTAC Design Option



7.2.1 Process of Charging

This section sets out the recommended process of charging a NDTAC, including the most suitable Clearing Body and Claiming Body and describes the charging and payment processes. Two options will be considered, option 1 describes charging using TAF TSI, option 2 describes the charging using self declaration.

The contractual structure between WO, WK and RUs or even other parties is considered to be adequate to allow for a transfer of the bonus and/or penalty payments either as a specific forward or factoring within the renting prices. The primary charging relationship between IM and RU will be described in the following.

The **Clearing Body** for a NDTAC remains – as for ‘ordinary’ TAC - the IM, as it is the only stakeholder with all the necessary information. In all relevant countries the IM is already in charge for clearing access charges and most administrative preconditions to manage this task are available.

Furthermore it is most likely that the NDTAC scheme will receive substantial financial support by the Member State which requires a state owned or at least a state-regulated company to be in charge.

Finally, the IM and the regulator respectively should be the entity with the greatest interest to add further pricing elements to its conventional TAC at a later point of time if required: Such further pricing elements could consist of other social marginal cost elements or allowing for the IM to incentivise the use of vehicles which put less stress on track superstructure. The structure of NDTAC is generally usable for other differentiated TAC. Besides this the NDTAC can be suspended after a successful noise reduction at the end of the funding period, but be reactivated in case of future improvements in noise reduction technologies. For all such purposes the IM is seen to be the proper player.

The **body claiming the charge** should be the RU. As our analysis and stakeholder consultation has concluded, the RUs have indeed all the necessary data available. Neither the WK nor the WO currently has sufficient information on route and kilometric performance of their vehicles. Even if this would be the case, it cannot be recommended to implement a new additional flow of data including WK/WO. This would cause more administrative costs.

Therefore, the recommended approach is the preferred one, because:

- It builds on existing contractual relations and payment flows between the relevant stakeholders;
- The IM (used or registered train paths) or the RU (train-composition) respectively have all relevant data at their disposal; and
- It is a bilateral transaction between the IM and the RU and no complicated trilateral transaction with direct accounting procedures between the IM and WO/WK.

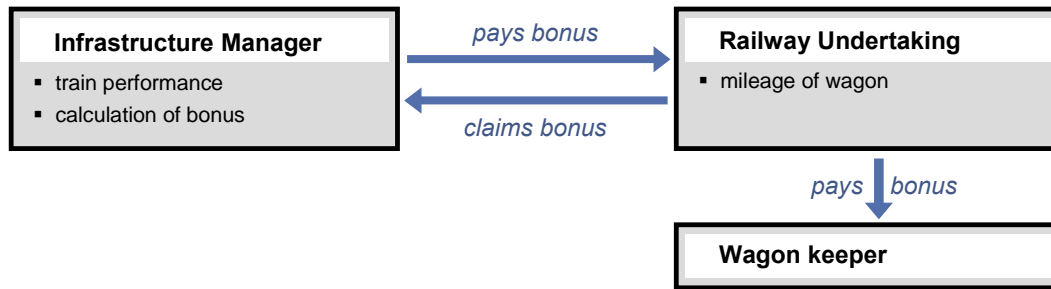
The disadvantages which will be encountered while using this approach are:

The ‘leakage effect’ which may occur if the bonus has to be passed from the IM to the WK via the RU, in which case the RU might either not pass the bonus to the WK at all or retain a certain proportion of the bonus to cover its administrative costs. This disadvantage could be mitigated by setting up a ‘control and enforcement body’ which allows the WK access to information on bonus payments from the IM to the RU. In the short term, this task could be located within the national regulatory bodies. In the mid and long term this function could be simplified by using TAF TSI environment which allows every stakeholder access to the relevant data anyway. TAF TSI WIMO would also allow the passing of all information relevant to mileage without giving away confidential information such as exact timing and routing. Alternatively the WK may factor in the retrofitting costs in the renting price for the amortisation of these costs.

The alternative to this would be an approach where the WK addresses the IM directly and the bonus is paid directly from the IM to the WK. However, this approach has been rejected, as:

- All stakeholders have opposed against opening a new ‘transaction channel’ between IM and WK (there is neither a contractual nor a financial relationship between IMs and WKs at the moment).
- The wagon specific data required from the RU would increase the administrative costs even further. It is likely that these additional administrative costs will balance out the disadvantages of the ‘leakage effect’ described above.

Figure 16: Process of Charging



Source: KCW/ SDG/ TUB

Option 1: Process of Charging under TAF TSI

The following recommendations revert to the findings of chapter 6.7. Charging and payment using TAF TSI should be conducted as follows:

All relevant data necessary to calculate the bonus are provided through TAF TSI interfaces and attached applications. Each party feeds the relevant data into the databases.

- Based on this information the bonus is calculated by the RU. The RU applies for the bonus at the IM and the bonus is cleared through regular TAC payments. This requires a link between the NDTAC database and the regular TAC schemes. With the implementation of TAF TSI such a link should be established at least.

The RU may pass the eligible share of the bonus to the WK on an annual or semi-annual basis in order to reduce administrative costs. Alternatively, the bonus may not be transferred specifically to the WK, but generally factored into the renting price.

Charging and payment through TAF TSI requires the existence of a 'Central Database' collating all necessary data to process charging. This database should be accessible by the IM for the following data records:

- Routing and mileage of trains and train composition of all trains (information provided by RU),
- Train-path of train (information provided by RU), and
- Technical characteristics of the wagon: brake-system, TSI Noise certified information (provided by the WK).

Option 2: Process of Charging using Self Declaration

As outlined in chapter 6.7 a 'Self Declaration' should be chosen to implement a NDTAC in the short term before TAF TSI is in place. A distinct precondition for self declaration is that the NDTAC contains no wagon-related maluses. A pure bonus-orientated self declaration has proven its feasibility in Switzerland, however self declaration of maluses are less likely to be implemented successfully as the system loses its quality of being voluntarily. Self declaration of maluses would increase the level of mistrust between stakeholders and therefore the administrative costs.

Based on the findings of chapter 6.7 charging and payment using self declaration should be implemented in the following way:

- The IM invoices the RU based on the number of trains, day of travel, train-km, and track-category. It is thus irrelevant whether this invoice is based on the registered train-path or the 'real-use' train path.
- This invoice is the basis for a 'reimbursement form' which lists all of the 'silent' wagons per train and per day based on class-identification and registration number (aa/a/-;ss/s/-)³⁷.
- Based on this information the RU derives the train composition and fills in a 'bonus application form' (presenting either the complete train composition or 'silent wagons' only). If an extra bonus

is paid for entire trains operated with ‘silent’ wagons the submission of the entire train composition would be required).

- The bonus is calculated based on axle mileage and class-identification (aa/a/-;ss/s/-) by the RU.
- The IM pays the RU the calculated bonus. The charging interval should a year be on an annual or semi-annual basis to minimise the administrative costs associated. Furthermore, it would incentivise smaller RUs to apply for the bonus even if their annual mileage is relatively small.
- The RU passes the bonus to the WK on an annual or semi-annual basis. As mentioned above, a control and enforcement body which acts as an arbiter and has full access to data from the IM, the RU and the WK should be created. Alternatively: The bonus is not transferred to the WK, but factored into the renting price.
- Self declaration is based on mutual trust. Therefore sample checks by a state authority are necessary. If a stakeholder betrays or tries to betray, a rigorous penalty should be imposed.

7.2.2 The Incentive Level (Level of Bonus)

A calculation model has been developed to evaluate the main parameters, most notably the bonus level. The model considers two funding period scenarios: 6 years and 12 years. These periods have been chosen, because they correspond to applied inspection cycles of freight wagons. As outlined in chapter 6.5 - and in order to avoid overcompensation of the recipient – the bonus should not exceed costs of retrofitting and administrative costs of the RU and WK. Therefore the bonus will be closely associated to those costs. The following section therefore investigates the likely cost levels associated with retrofitting wagons and operating administrative systems to secure charging and payment of the bonus.

Figure 17 below visualises inputs and outputs of the calculation model as well as the scenarios used.

Figure 17: Model Inputs / Outputs and used Scenarios

Model Inputs	Model Scenarios	Model Outputs
Costs of Retrofitting <ul style="list-style-type: none"> • Upfront costs LL blocks • Upfront costs K blocks • Vehicle mileage related costs LL blocks • Vehicle mileage related costs LL blocks 	Length of Funding Period <ul style="list-style-type: none"> • Scenario 1: funding period over 6 years • Scenario 2: funding period over 12 years 	Incentive Level <ul style="list-style-type: none"> • Bonus level K-Blocks • Bonus Level LL-Blocks
Fleet Configuration <ul style="list-style-type: none"> • Fleet size • Annual change in fleet size • Age distribution • Annual mileage distribution 	Annual Retrofitting Rate <ul style="list-style-type: none"> • low case: 30,000 wagons per year • central case: 60,000 wagons per year • high case: 90,000 wagons per year 	Fleet Evolution <ul style="list-style-type: none"> • Evolution of retrofitted wagons over funding period • Evolution of retrofitted wagons over funding period
Administrative Costs <ul style="list-style-type: none"> • Costs at RU • Costs at WK/WO • Costs at IM 		Economic Costs <ul style="list-style-type: none"> • Total bonus payments over funding period

Source: KCW/ SDG/ TUB

So-

Costs of Retrofitting

The costs associated with retrofitting freight wagons can be divided into three cost categories:

- Initial upfront costs of retrofitting (fixed costs, independent on operational performance);
- Vehicle-mileage related costs (operational costs); and
- Administrative costs of the RU and/or WK.

Cost estimates given by literature and the various stakeholders consulted differed significantly. Therefore, a *band* of costs has been derived, limited by a minimum value and a maximum value (cf. table below).

Initial Upfront Costs (Fixed Costs) comprise the initial investment a wagon requires in order to be made 'silent.' The retrofitting with LL-blocks is much less complicated than with K-blocks. Initial costs for retrofitting with LL-blocks include the following elements:

- Extra costs of purchasing LL-blocks (in relation to CI blocks);
- Costs for block substitution at the workshops;
- Lost amortization because premature substitution of CI-blocks; and
- Management costs for launching a retrofitting plan.

The same cost elements occur when retrofitting with K-blocks. However, significant changes have to be made to the wagon as well, increasing up-front costs further.

As a result of the expert interviews, stakeholder consultations and literature research carried out, it is recommended to work with the following costs (with respect to CI blocks). All estimates given represent 2008 real values in EUR. The table below summarises the cost range encountered for different types of wagons.

Table 14: Estimated Cost Range for Retrofitting Freight Wagons with K or LL Blocks (Initial Upfront Costs)

K blocks	Min Value	Recommended Value	Max Value
Initial investment for a 4-axle wagon	€ 6,000	€ 8,000	€ 10,000
Initial investment for a 2-axle wagon	€ 3,000	€ 4,000	€ 6,000
LL-blocks			
Initial investment for a 4-axle wagon (s-traffic)	€ 500	€ 1,000	€ 1,600
Initial investment for a 4-axle wagon (ss-traffic)	€ 2,500	€ 4,500	€ 6,600
Averaged investment 4-axle (ss/s=20/80%)	€ 900	€ 1,700	€ 2,600
Initial investment for a 2-axle wagon (s-traffic)	€ 250	€ 500	€ 800
Initial investment for a 2-axle wagon (ss-traffic)	€ 2,250	€ 3,500	€ 4,800
Averaged investment 2-axle (ss/s=5/95%)	€ 350	€ 650	€ 1,000

Source: KCW/ SDG/ TUB Analysis

(Vehicle) Mileage Related Costs (Operational) Costs of Retrofitting with K-blocks

Operational costs (mileage related costs) associated with retrofitting are still characterised by some uncertainties. The variability of operational costs depends on various factors. The utilisation of the wagon determines the rate of wear and tear of the components related to new brake systems and is therefore a central variable in the calculation of operational cost.

K-blocks' behaviour and LCC have been studied in several pilot projects (for instance the Dolomite Shuttle project³⁸) and through commercial experience/field-tested, since they are homologated for commercial use. After analysis of pilot projects and stakeholder consultations the extra value of 4€/1000km (4-axle wagon) can be recommended for further calculations³⁹.

However, this does not include all cost associated with the operational cost of K-block retrofitted wagons: a sensible problem derived from the utilisation of K-blocks, is the hollow wear and increased wheel diameter difference which occurs on the wheels. As a result, an increase of the equivalent conicity - exceeding 0.4- appears on the wheel set, which threatens the stability of the vehicles on the track. The likelihood of derailment, the uneven wear of wheels and the degradation of infrastructure singularities (junctions) increases. There are no internationally recognised limit values for these parameters and in any case their inspection cannot be carried out with ordinary means. The cost appraisal of this problem can be formulated by considering shorter reprofiling intervals. The mentioned Dolomite Shuttle LCC Study proposes that the reprofiling should be done every 150,000 km, instead of 230,000 km as is currently the case.

This results in operational costs, which are presented below.

K-blocks Operating Costs for 4-axle Wagon:
€ 5.3/1000 km

The above figure is only a reference value and should be reviewed as more studies on the subject are published.

(Vehicle) Mileage Related (Operational) Costs of Retrofitting with LL- blocks

LL-blocks have not been homologated yet and therefore the achieved results on their LCC are obtained from pilot trials which do not guarantee full reliability of LCC results. The consortium has examined recent literature and project results and assumes that 4.1 €/1000km are reasonable costs that can be used to calculate the extra costs of using LL-blocks⁴⁰.

The increase in equivalent conicity of wheelsets due to the use of LL-blocks is also taken into account in this value. Due to the unavailability of further studies on hollow wear and diameter difference increase related to LL-block usage, it is necessary to assume, that organic LL-blocks, which are cheaper than sintered LL-blocks, should be similar to the above described organic K-blocks with similar effects on costs.

Considering that the reprofiling period decreases from 230,000 km to 150,000 km an increase in the extra costs of the wheel sets is expected, making the operational costs for a 4-axle wagon as follows:

LL-blocks Operating Costs for 4-axle Wagon:
€ 5.4/1000 km

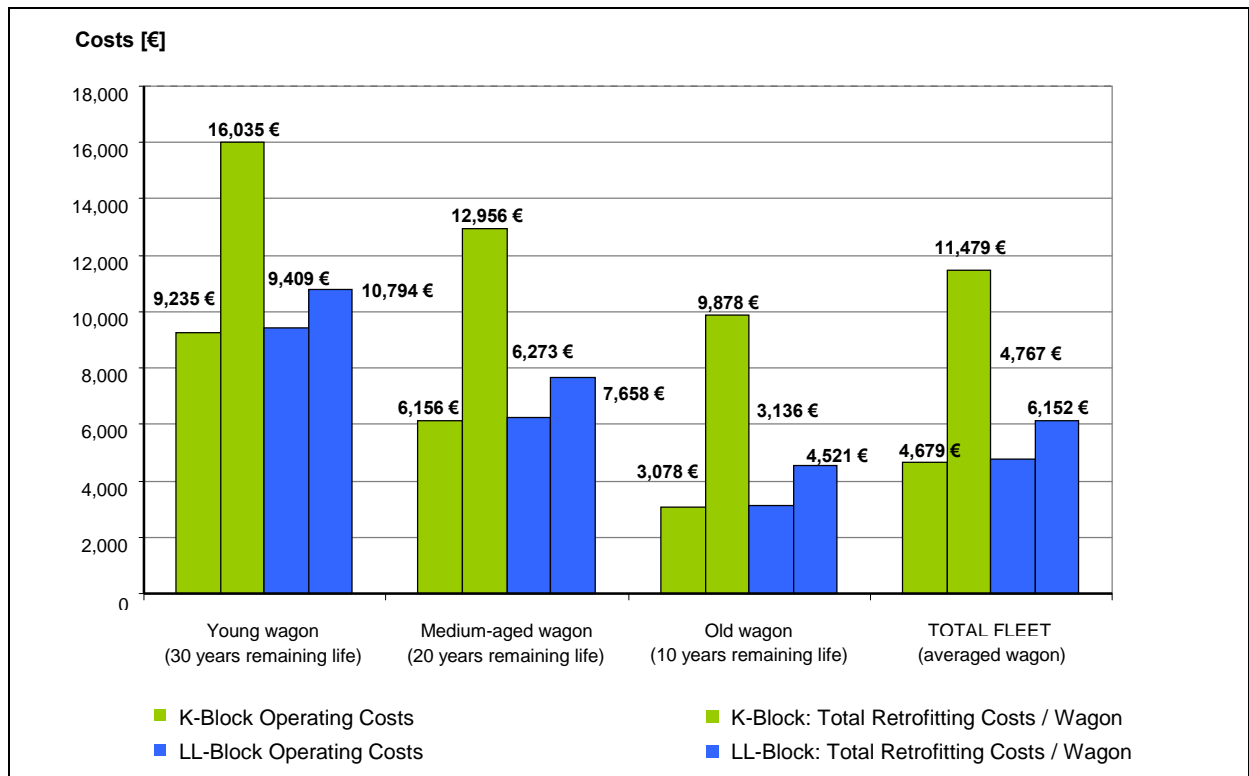
As for the previous cost figure, we recommend the revision of the above estimate in accordance with up-to-date LL-blocks brake performance experience. Figure 17 below demonstrates retrofitting costs per wagon for both, K-blocks and LL-blocks, exemplarily distinguishing between wagons with different remaining lifetimes (and therefore different remaining mileage) and distinguishing between operational and total costs of retrofitting. The figure also visualises some of the earlier findings set out in chapter 6, namely:

- The strong impact the remaining lifetime of wagons has on the total costs associated with retrofitting;
- The significant difference between costs of retrofitting freight wagons with K-blocks as opposed to costs of retrofitting freight wagons with LL-blocks; and

- █ The significant difference between total costs and operational costs for K-block retrofitting (caused by the relatively high upfront costs) as opposed to costs associated with retrofitting wagons with LL-blocks which are highly dependent on operational performance (indicated by the relatively small difference between operational and absolute costs for LL-blocks).

Please note that all numbers shown in figure 18 are calculated based on the 'recommended' upfront values given in table 14, the vehicle mileage related costs derived in the above section and fleet composition characteristics.

Figure 18: Retrofitting Costs per Wagon Dependent on Remaining Lifetime and Brake Type



Source: KCW/ SDG/ TUB

Administrative Costs of the Charging System

All stakeholders have to bear administrative costs for gathering, processing and organising the necessary information to submit a declaration that enables them to receive the bonus from the IM. The transfer of the bonus to the WK involves also administrative costs. This includes – as discussed in chapter 6.5. – mainly costs for data recording and data exchange, homologation processes (if needed for NDTAC), charging and accounting.

There are significant differences of the cost estimates given by stakeholders and other parties, therefore they could not be considered for this study. Rather, it is assumed that stakeholders opposing against NDTAC included elements in their administrative cost-estimates which did not necessarily need to be allocated to NDTAC. This applies particularly to IMs.

An UIC study published in July 2009 estimates the administrative costs for all involved parties at € 0.2 per wagon-km for self declaration and €1.8-2.0 per wagon-km for a TAF-TSI solution (these estimates have been undertaken by the German IM DB-Netz and apply for their network, no estimates of other European IMs have been stated as part of the UIC study).

However, the present study recommends that the bonus should only consider those administrative costs incurred to the RU and the WK. Administrative costs for those entities have been estimated on the basis of an earlier study undertaken by ETH Zurich as well as on the estimates of the stakeholders who were

relatively indifferent towards the NDTAC. These stakeholders cited administrative costs in the range of 10% to 20% of the actual bonus. The relevant drivers to calculate administrative costs are:

- Fleet size operated by RU,
- Ownership structure of operated fleet and amount of contractual parties involved,
- Amount of IMs involved in the charging process, and
- Applied accounting system (TAF TSI or Self Declaration).

In the table below values will therefore comprise a 15% surcharge for administrative costs on the 'recommended value', a 10% surcharge on the minimum value, and a 20% surcharge on the maximum value. The estimated administrative costs include the costs for transfers of the bonus at least between the levels of IM and RU (minimum) and between the levels of IM, RU and external WK (maximum).

Calculation of the Incentive Level

The range of the recommended bonus has been calculated for two scenarios. The first scenario assumes a six-year funding period, the second scenario assumes a twelve-year funding period. In both scenarios the recommended bonus is based on costs per estimated axle-km. Fixed costs are distributed over a six year period in scenario one and over a twelve year period in scenario two assuming an average annual mileage of 60,000 km⁴¹ for each wagon (and assuming that the RU/WK receives a bonus for all these 60,000 km). All estimates presented are 2008, real values. The two tables below summarise the minimum, recommended and maximum level of bonus that should be granted for 4-axle and 2-axle wagon per 1000km.

Table 15: Derivation of Incentive Level / Scenario 1: 6 Year Funding Period

Type of wagon	Type of cost [unit]	K- block			LL- block		
		Min	recommended	max	min	recommended	max
4 axle-wagon	Fixed costs distributed over 360,000 km [€/1000km]	16.7	22.2	27.8	2.5	4.7	7.2
	Operational costs [€/1000km]	5.3	5.3	5.3	5.4	5.4	5.4
	Administrative Costs [€/1000km]	2.2	4.1	6.6	0.8	1.5	2.5
	Total [€/1000km]	24.2	31.7	39.7	8.7	11.6	15.1
2 axle-wagon	Fixed costs distributed over 360,000 km [€/1000km]	8.3	11.1	16.7	1.0	1.8	2.8
	Operational costs [€/1000km]	2.7	2.7	2.7	2.7	2.7	2.7
	Administrative Costs [€/1000km]	1.1	2.1	3.9	0.4	0.7	1.1
	Total [€/1000km]	12.1	15.8	23.2	4.0	5.2	6.6

Source: KCW/ SDG/ TUB

Table 16: Derivation of Incentive Level / Scenario 2: 12 Year Funding Period

Type of wagon	Type of cost [unit]	K- block			LL- block		
		min	recommended	max	min	recommended	max
4 axle-wagon	Fixed costs distributed over 720,000 km [€/1000km]	8.3	11.1	13.9	1.3	2.4	3.6

Type of wagon	Type of cost [unit]	K- block			LL- block		
		min	recommended	max	min	recommended	max
	Operational costs [€/1000km]	5.3	5.3	5.3	5.4	5.4	5.4
	Administrative Costs [€/1000km]	1.4	2.5	3.8	0.7	1.2	1.8
	Total [€/1000km]	15.0	18.9	23.0	7.3	8.9	10.8
2 axle-wagon	Fixed costs distribute over 720,000 km [€/1000km]	4.2	5.6	8.3	0.5	0.9	1.4
	Operational costs [€/1000km]	2.7	2.7	2.7	2.7	2.7	2.7
	Administrative Costs [€/1000km]	0.7	1.2	2.2	0.3	0.5	0.8
	Total [€/1000km]	6.4	7.8	10.7	3.4	3.9	4.5

Source: KCW/ SDG/ TUB

Finally, the table below summarises the results and itemises the derived bonus values into a “per kilometre base. The stakeholder consultation concluded that a 70% / 30% split between 2-axle and 4-axle wagons is an appropriate proportion between these wagon types. In order to calculate an average bonus per axle this split is calculated in the last row of the table (ignoring wagons with 6 or more axles at this point).

Table 17: Derivation of Incentive Level: Bonus per wagon-km and axle-km

Type of wagon	Type of cost [unit]	K- block			LL- block		
		min	Recommended	max	min	recommended	max
4 axle-wagon	6 yr funding [€/km]	0.024	0.032	0.040	0.009	0.012	0.015
	12 yr funding [€/km]	0.015	0.019	0.023	0.007	0.009	0.011
2 axle-wagon	6 yr funding [€/km]	0.012	0.016	0.023	0.004	0.005	0.007
	12 yr funding [€/km]	0.007	0.009	0.013	0.004	0.004	0.005
Average per axle	6 yr funding [€/axle km]	0.0060	0.0079	0.0111	0.0021	0.0027	0.0034
	12 yr funding [€/axle km]	0.0036	0.0046	0.0063	0.0019	0.0021	0.0026

Source: KCW/ SDG/ TUB

7.2.3 Additional Bonus for Entire Train with Retrofitted Wagons

Member States should consider introducing an additional bonus granted to those trains, which are fully equipped with retrofitted wagons. This bonus should be granted to the RU only, as it is the RU, which has to spend resources on the set up of trains in order to achieve this target. This could be an incentive for the RU to use more ‘silent’ wagons within the trains it uses. The bonus could be calculated based on a logarithmic scale, matching the evolution of noise reduction when the share of ‘noisy’ wagons decreases⁴². Although it may disadvantage wagonload traffic and advantage block trains, this bonus is effective with respect to noise reduction. Such an additional bonus would not increase the complexity of the system as only the RU and IM are involved in this charging process.

7.3 Performance of the NDTAC

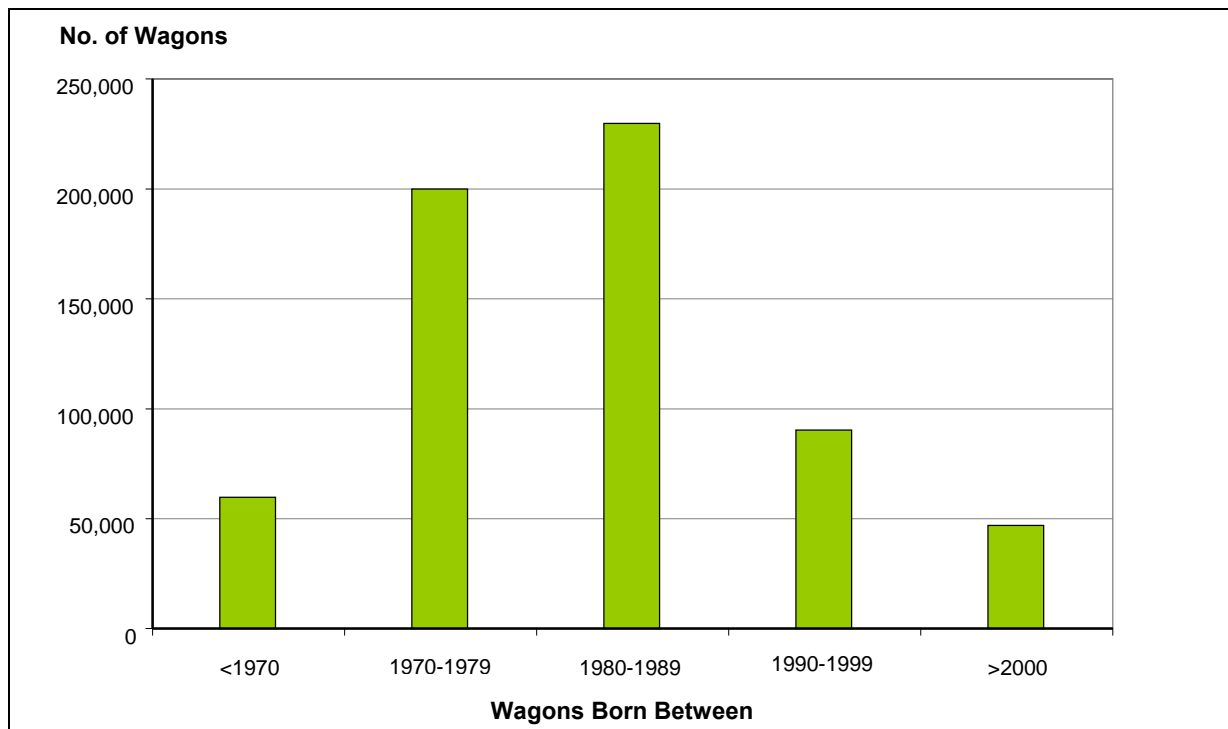
The following section sets out key performance indicators of such a NDTAC, built on the calculation model developed as part of this study.

- In a first step current fleet characteristics are considered;
- Secondly different estimates for a likely retrofitting fleet evolution will be made;
- Finally the total economic costs of NDTAC will be calculated assuming different retrofitting rates; Furthermore estimations of yearly bonus payments that depend on the different retrofitting rates are established.

7.3.1 Estimate of a Likely Fleet Retrofitting Evolution

The calculation model starts with the given fleet size in 2005 (623,000 units)⁴³. Slight modifications to the assumptions regarding age distribution of freight wagons in 2010 were made. It was assumed that the new wagons procured from 2007 onwards would be fitted with silent brake blocks and therefore would not need to be retrofitted. As mentioned in the previous chapter, the European-wide TSI Noise standard which specifies noise limits for new freight wagons came into force in June 2006 across Europe.

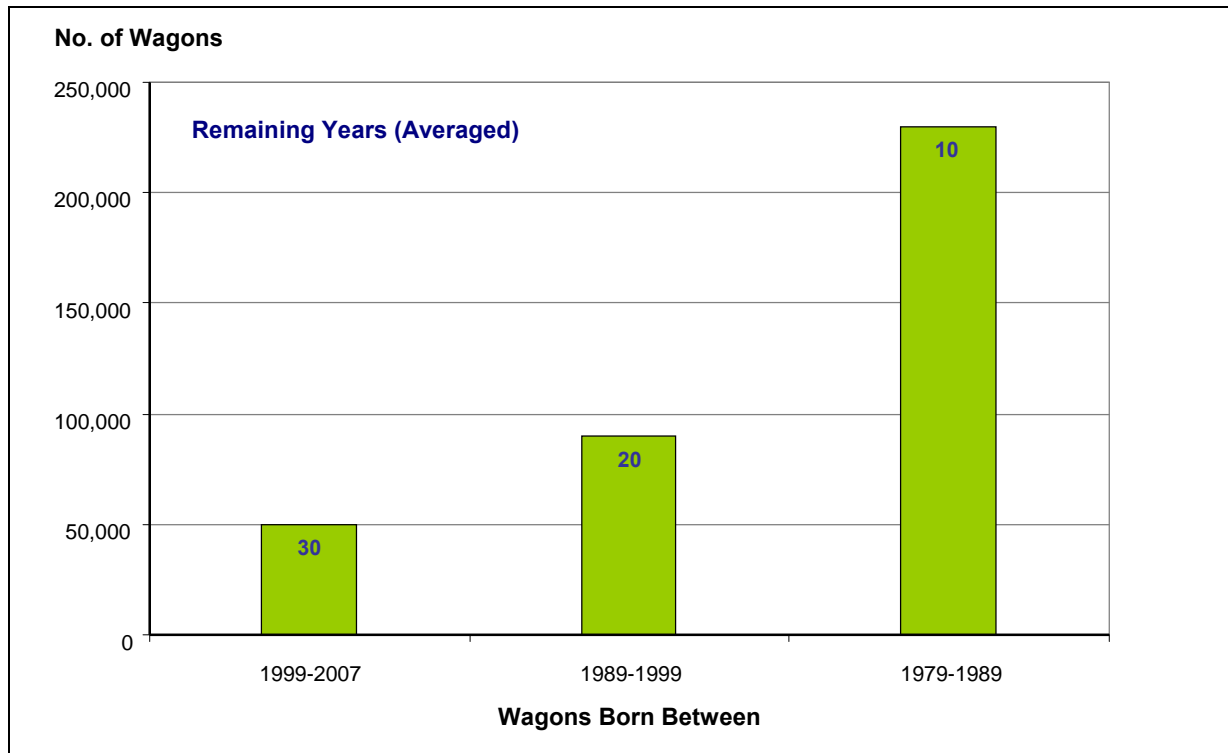
Figure 19: Age Distribution of the Fleet (2005)



Source: KCW/ SDG/ TUB elaboration based on PWC 2005

The amount of wagons with a remaining life of five years in 2010 has been subtracted from the calculation, because they probably will not be retrofitted as they are approaching the end of their lifespan (assumed to be 35 years). Under these assumptions the averaged remaining life of a given European wagon is 15.2 years. Furthermore it is assumed that there is a 'natural' annual decrease of 5,000 wagons per year. This assumption has been made based on the stakeholder interviews and is caused by trends towards more efficiency in circulation, growing average wagon capacity and a general declining willingness of WK to storage wagons without sufficiently calculable service opportunities.

Figure 20: Number of Wagons and Remaining life (Est. 2010)



Source: KCW/ SDG/ TUB Track and Railway Operations Chair

Hence, from 2010 on the total amount of wagons to be retrofitted will be about 370,000 of which:

- 14% will last at least 30 years,
- 24% will last at least 20 years, and
- 62% will last at least 10 years.

Fleet Composition

The first important characteristics of freight wagons for retrofitting purposes are the **number of axles**. In general, wagons can either have 2 or 4 axles, there are indeed wagons with 3 and 6 axles as well as other rare axle configurations but they do not represent a large amount within the whole axle-per-wagon spectrum and will therefore be neglected in this calculation model. The assumptions derived from the stakeholder conversations are:

- Amount of wagons with 2 axles: 30%
- Amount of axles with 4 axles: 70%
- Average number of axles per wagon (for averaging purposes): 3,4

Second important characteristic is the **authorised maximum speed**. Usually freight wagons do not run at more than 100km/h (s-traffic), however there are freight wagons able to 120 km/h (ss-traffic) and even more. The following assumptions have been made in the model:

- Amount of wagons with 2 axles and ss-traffic enabled: 5%
- Amount of wagons with 4 axles and ss-traffic enabled: 20%

Annual Mileage Distribution

When setting a noise dependant bonus system that allocates bonuses to wagons depending on the distances they covered, it is crucial to consider for calculation purposes an average yearly km amount representing the entire wagon mileage spectrum. Not all wagons cover the same distances. A typical ex-

ample of a wagon with a high utilisation is a container wagon on a medium-distance - 700km - shuttle operation, which can reach up to 250,000 km/year. On the other hand a typical example of a wagon which is not highly utilised is a wagon for the transportation of long steel profiles or rail which covers 10,000km/year or less. Within this range any distance value is possible and depends on the owner, the type of traffic, the production system, the repositioning of trips, etc.

As a result of consultation held with stakeholders, the following bands have been chosen as reasonable model inputs.

Table 18: Average Annual Mileage Band European Freight Wagons

Mileage Band	% of total Fleet
0-40,000 km/a	25%
40,000-90,000 km/a	55%
> 90,000 km/a	20%

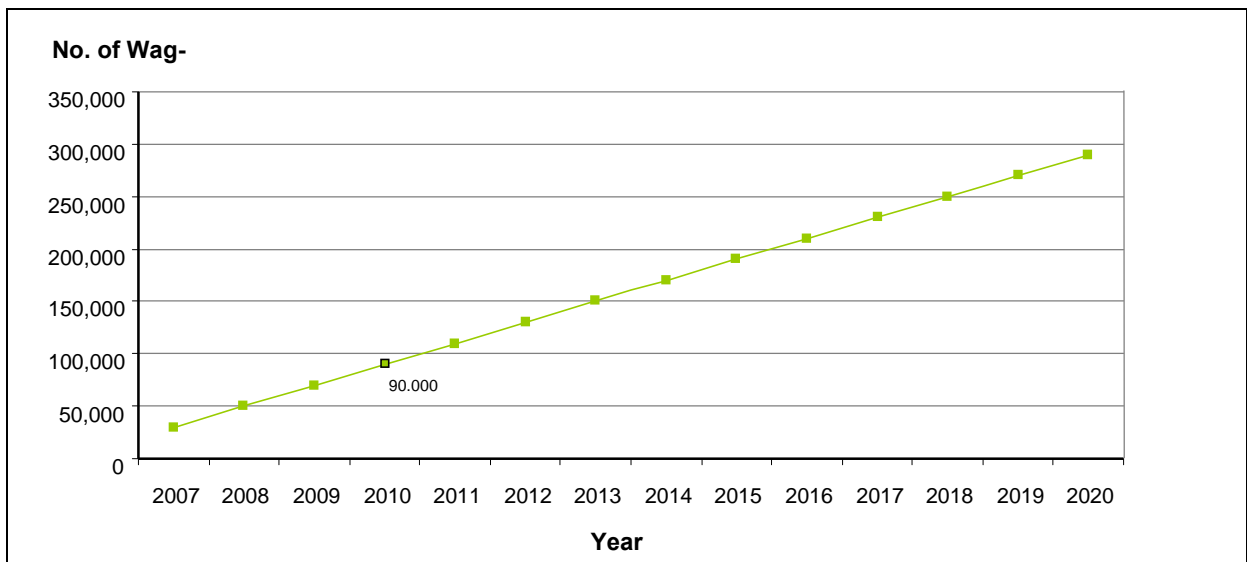
Source: KCW/ SDG/ TUB

This results in an average yearly mileage of 60,000km. This value is used for further calculations.

Treatment of New Wagons and Silent Wagons

Although new wagons procured in 2007 or later and already ‘silent’ wagons – retrofitted or having silent brake systems already – do not need to be modernised again for noise purposes, it seems adequate to compensate owners of such wagons in order not to discriminate industry stakeholders and include such wagons in the incentive system in the same manner as future retrofitted ones. A new wagon, replacing an old one, is an equivalent contribution to noise reduction as the retrofitting of an old one with silent brake blocks. With the assumption of 20,000 new wagons per year and 10,000 silent units at the beginning in 2007, the following graph is generated.

Figure 21: New and Silent Wagons Evolution Europe



Source: KCW/ SDG/ TUB

7.3.2 Retrofitting Evolution Scenarios

The retrofitting rate will highly be dependent on strategic behaviour of involved stakeholders. Major determinants for decision makers to decide whether a wagon should be retrofitted or not are:

- the anticipated cost and revenue stream,
- The likely share of routes where the bonus will be applied in combination with the likely routes on which the RU operates,
- The availability of retrofitting capacity,
- The age of the wagons with respect to the inspection cycle,
- The age structure of the fleet, and
- The willingness to contribute to the solution of environmental problems such as noise-emissions.

The conversion rate has been estimated by the previous study⁴⁴ to be 90,000 wagons per year considering that each wagon visits an inspection workshop every six years and that there is a total amount of 560,000 wagons in EU25. This is an approximation of the theoretical capacity for retrofitting. However companies would try to encompass retrofitting with the scheduled wagon maintenance. Even though LL-blocks are very easy to install, companies probably would try to exhaust CI blocks first and keep replacements on scheduled basis to reduce extra costs. On that basis, this study makes a more pessimistic assumption and looks at three different retrofitting rates for a central, low and high case scenario:

- A **central case scenario** considers that 370,000 wagons would have to be retrofitted, and that they need to be inspected every six years. This means that the yearly average is about 60,000 wagons.
- A **low case scenario** follows the same assumptions as the central case but assumes that stakeholders act more risks hesitant and retrofit only 30,000 wagons per year, while
- A **high case scenario** follows the same underlying assumptions as the above mentioned previous study, namely a retrofitting rate of 90,000 wagons per year.

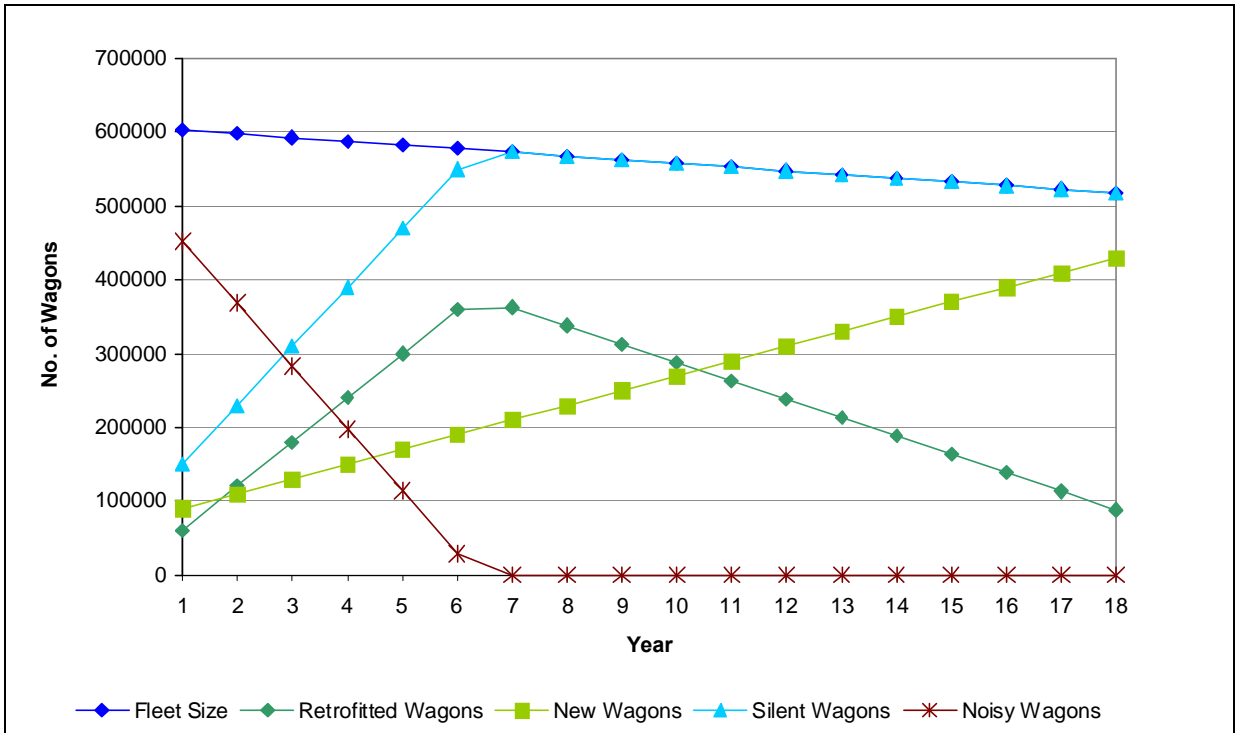
It is important to note that the retrofitting rate is treated as a model-input. The model does not calculate it. Stakeholder consultations undertaken as part of this study concluded that it is impossible to predict the strategic behaviour of the involved parties which determine the retrofitting rate.

The number of retrofitted wagons that will be eligible to receive the bonus will grow cumulatively and is expected to reach with 370,000 wagons the peak in the sixth year (central scenario, figure 21) after the programme is implemented. If the bonus period continues beyond that point, 370,000 retrofitted wagons can benefit from the bonus every year, which should cover their LCC costs further. However it should be pointed out that a number of retrofitted wagons will also be put out of service because they will have reached the end of their life cycle. It is estimated that, from the seventh year forward, 25,000 retrofitted wagons will be taken out of service every year. For that reason the sooner a wagon undergoes retrofitting, the better its chances to recover its whole LCCs. Companies will be able to decide what is more convenient for them: undertaking retrofitting promptly or waiting for the scheduled maintenance of their wagons.

Retrofitting Evolution Forecast

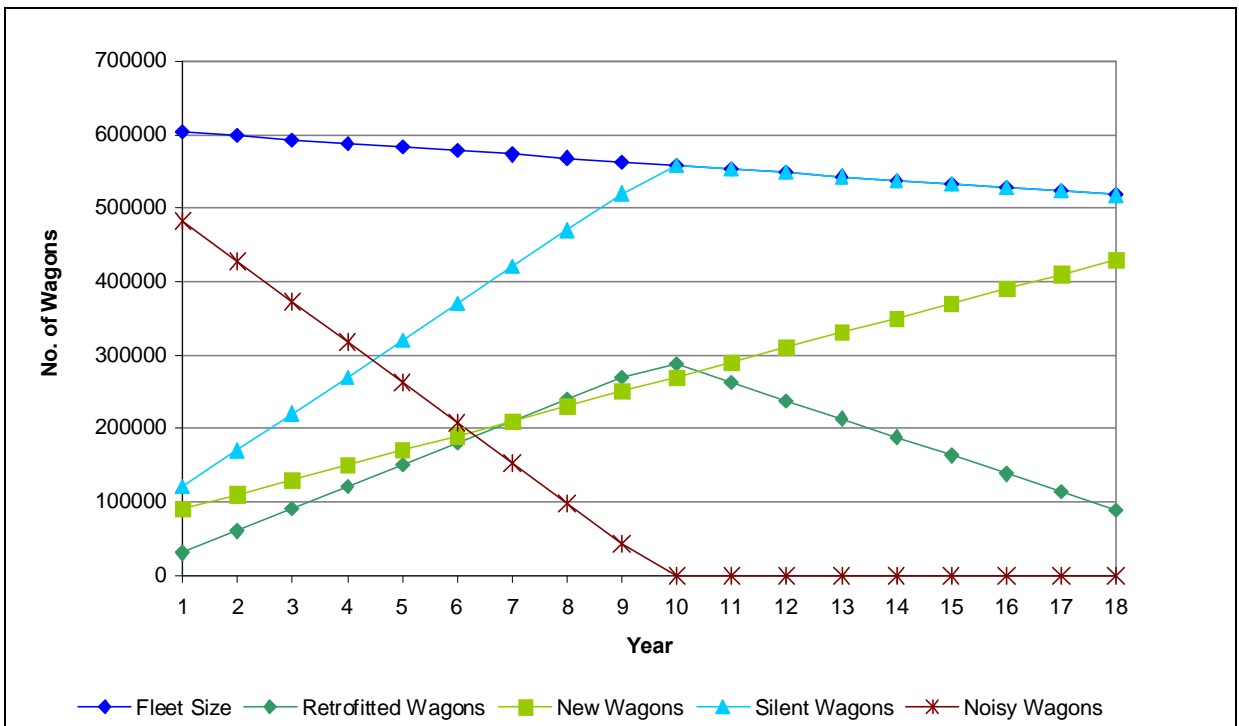
The following figures present a forecast of the wagon fleet considering the above mentioned three scenarios. Year dates are not given to reflect the uncertainty of when a NDTAC might start.

Figure 22: Fleet Evolution for Central Case Scenario (Retrofitting Rate at 60,000/year)



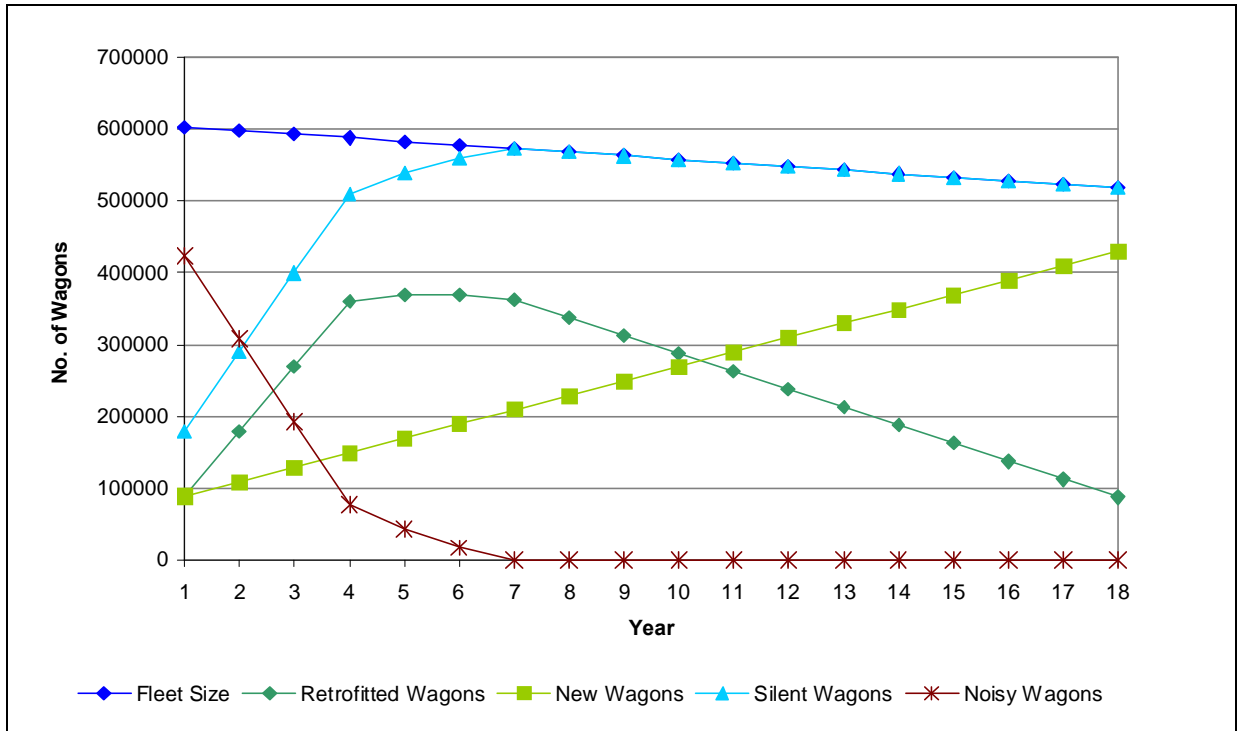
Source: KCW/ SDG/ TUB

Figure 23: Fleet Evolution for Low Case Scenario (Retrofitting Rate at 30,000/year)



Source: KCW/ SDG/ TUB

Figure 24: Fleet Evolution for High Case Scenario (Retrofitting Rate at 90,000/year)



Source: KCW/ SDG/ TUB

An all-silent fleet would be reached in both, the high case and the central case scenario in the seventh year. This is because once all relevant wagons (estimated at 370,000 wagons) have been retrofitted there will still be a residual of older ‘noisy’ wagons which will never be retrofitted due to their marginal mileage on NDTAC networks or operation only on networks without any NDTAC. From the seventh year onwards, retrofitted wagons will start to be taken out of service.

In the low case scenario an all-silent fleet would be reached in the 10th year of a NDTAC in operation.

7.3.3 Economic Costs of the System

Retrofitting costs have been set out in the previous section. The following six figures show an estimate of cumulative retrofitting costs (and cumulative bonus payments for retrofitted wagons respectively) for both, the six-year and the twelve-year funding period scenarios. Please note that the numbers given exclude administrative costs of the IM.

In the first two figures (Figure 25 and Figure 26) it is assumed that the rate of retrofitting is 30,000 (low case) wagons per year whereas in the next two figures (Figure 27 and Figure 28) a retrofitting rate of 60,000 (central case) wagons per year is assumed. The last two figures (Figure 29 and Figure 30) assume a retrofitting rate of 90,000 (high case). In all figures the average annual mileage of 60,000km is assumed.

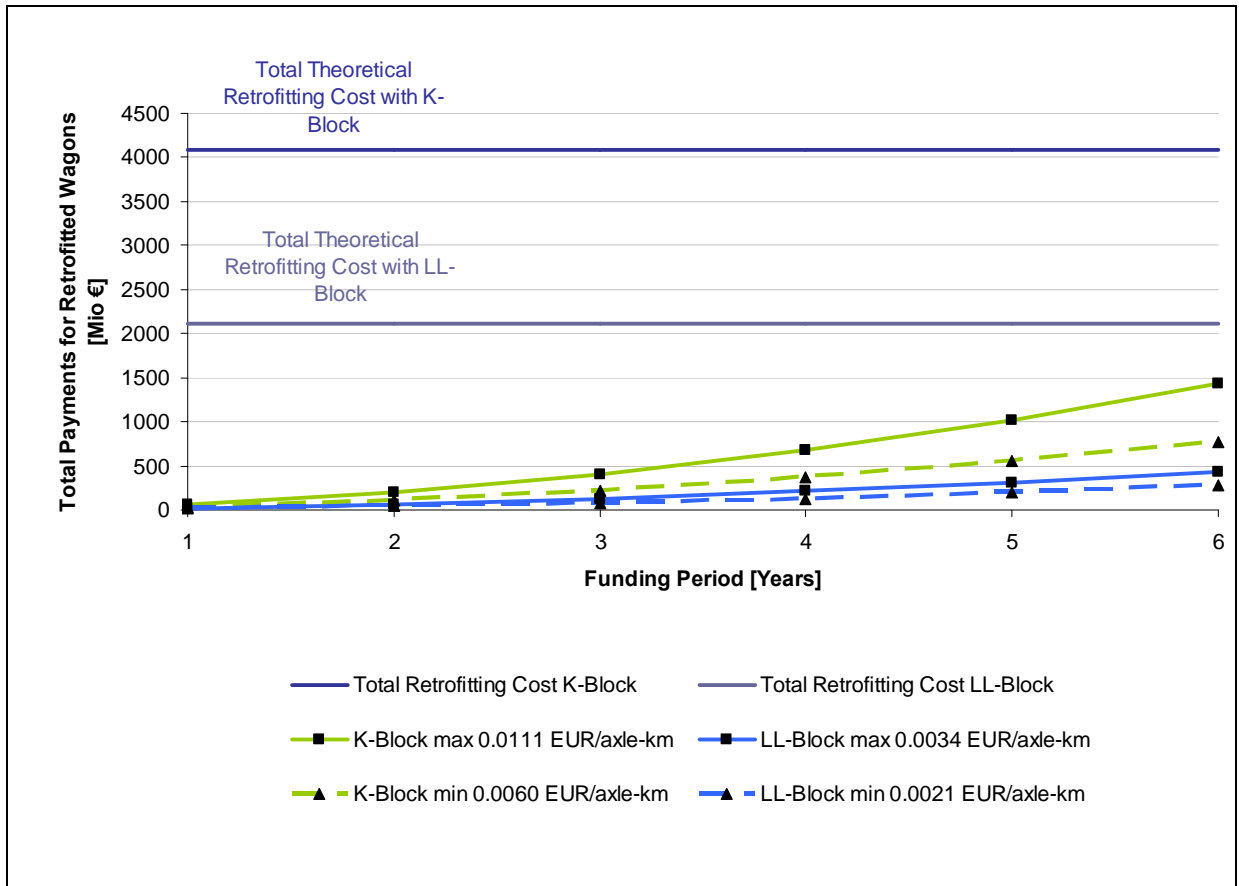
The horizontal lines represent the total accumulated retrofitting costs for both, K- and LL-block technologies of retrofitting all of the 370,000 wagons in the fleet. Including bonuses paid to new wagons, this leads to:

- I Total theoretical Retrofitting Cost with LL-blocks: € 2.11 billion (including all LCC until wagons are taken out of service); and
- I Total theoretical Retrofitting Cost with K-blocks: € 4.1 billion (including all LCC until wagons are taken out of service).

A range of bonus levels is shown; they correspond to the findings of chapter 7.2, reflecting the minimum and maximum bonus level derived and shown in Table 17.

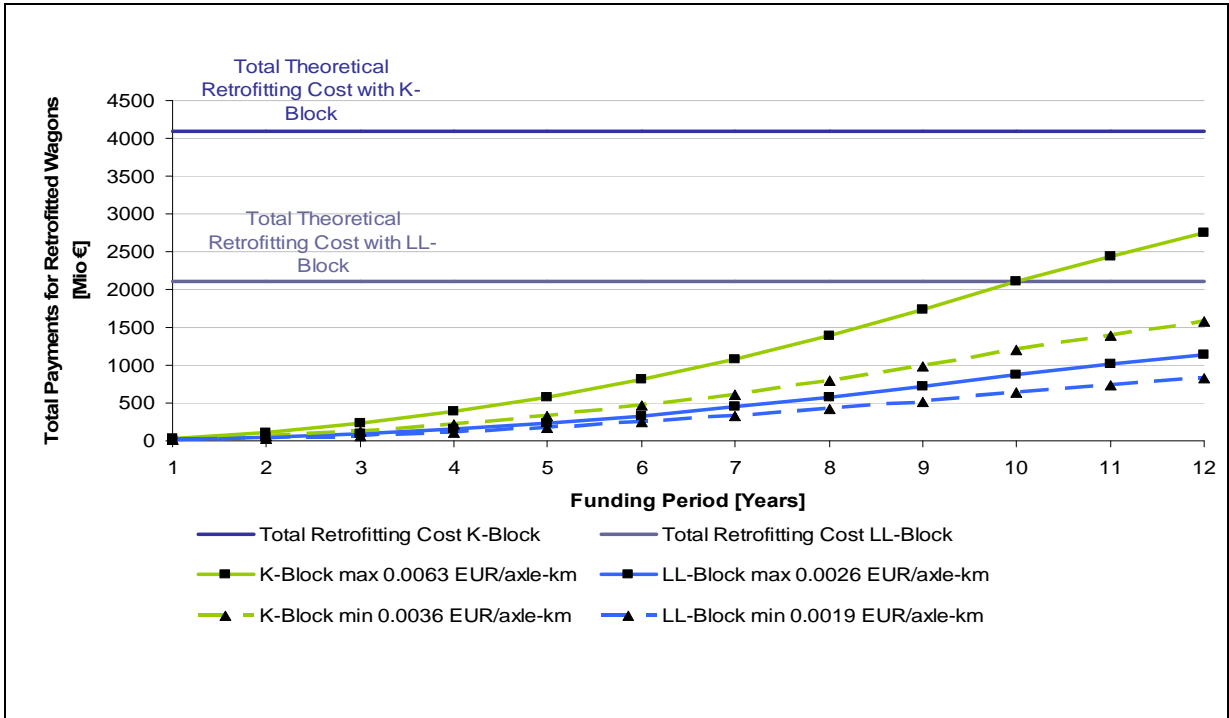
Because the rate of retrofitting varies between the scenarios, the amount of time required before the fleet is entirely modified varies as well, though the total amount necessary for covering the costs for retrofitting, modification and extra operational costs remain identical. The relation that exists between the bonus amount, the funding period and the rate of retrofitting depends on companies' choices about retrofitting. This choice is usually influenced by a combination elements, for instance risk evaluations, economic analyses, and company strategies.

Figure 25: Bonus Payments (accumulated): 6 Year Funding Period / Retrofitting Rate of 30,000 Wagons per year



Source: KCW/ SDG/ TUB: Figures are in € per axle-km representing the minimum and maximum values recommended in Table 17 for the respective funding period. Green lines show accumulated bonus payments for K- block brakes, blue lines accumulated bonus payments for LL-block brakes.

Figure 26: Bonus Payments (accumulated): 12 Year Funding Period / Retrofitting Rate of 30,000 Wagons per year



For both figures: Source: KCW/ SDG/ TUB: Figures are in € per axle-km representing the minimum and maximum values recommended in Table 17 for the respective funding period. Green lines show accumulated bonus payments for K- block brakes, blue lines accumulated bonus payments for LL-block brakes.

Figure 27: Bonus Payments (accumulated): 6 Year Funding Period / Retrofitting Rate of 60,000 Wagons per year

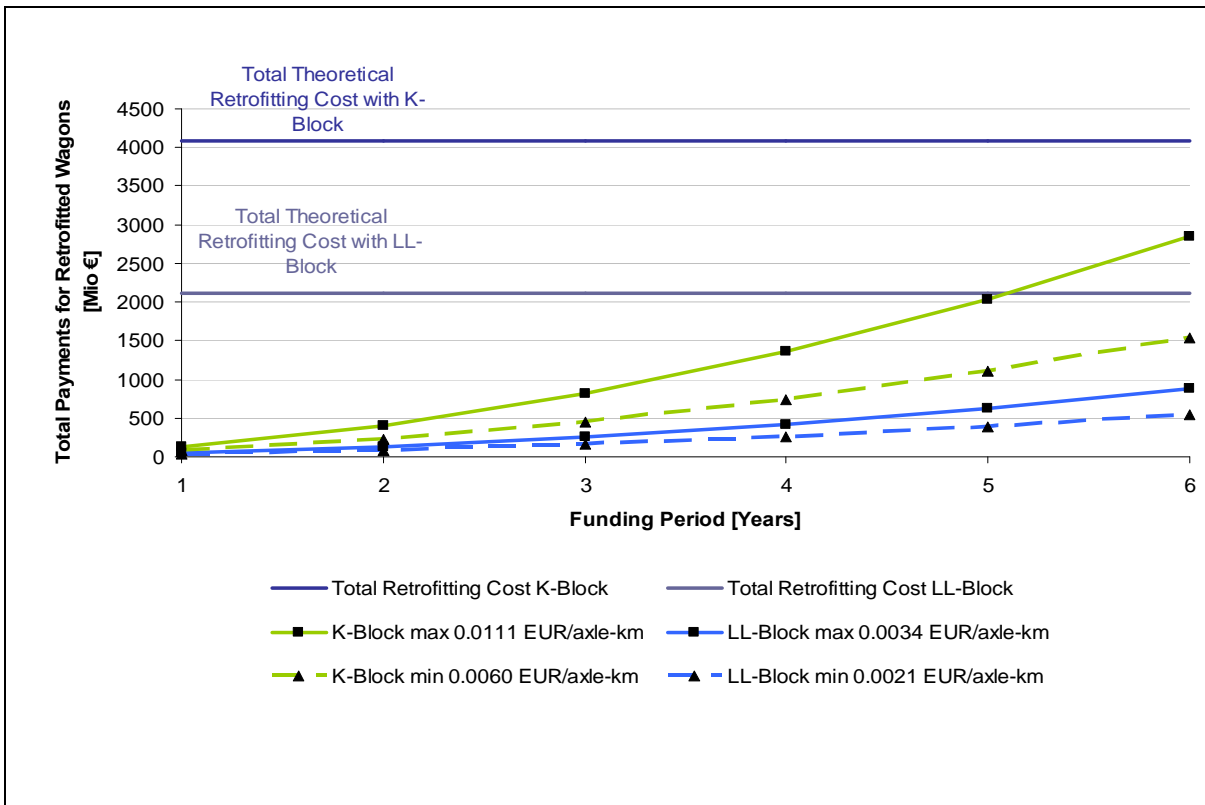
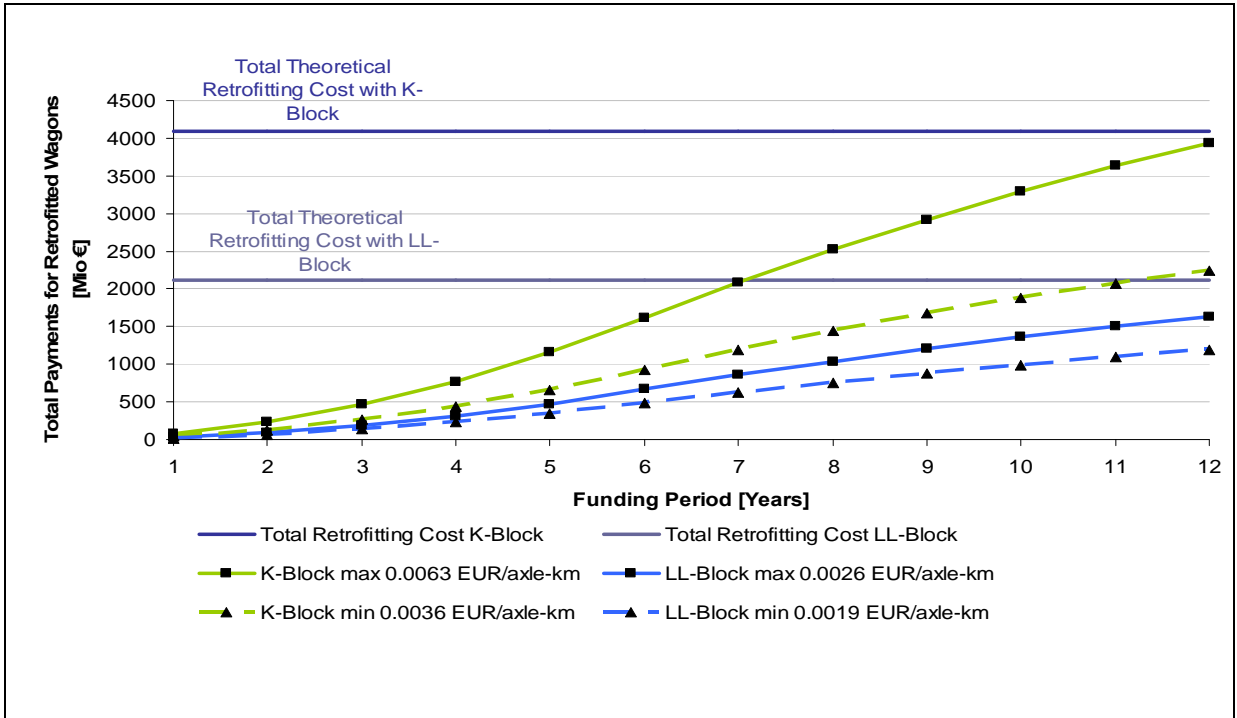


Figure 28: Bonus Payments (accumulated): 12 Year Funding Period / Retrofitting Rate of 60,000 Wagons per year



For both figures: Source: KCW/ SDG/ TUB: Incentive levels figures are in € per axle-km representing the minimum and maximum values recommended in Table 17 for the respective funding period. Green lines show accumulated bonus payments for K- block brakes, blue lines accumulated bonus payments for LL-block brakes.

Figure 29: Bonus Payments (accumulated): 6 Year Funding Period / Retrofitting Rate of 90,000 Wagons per year

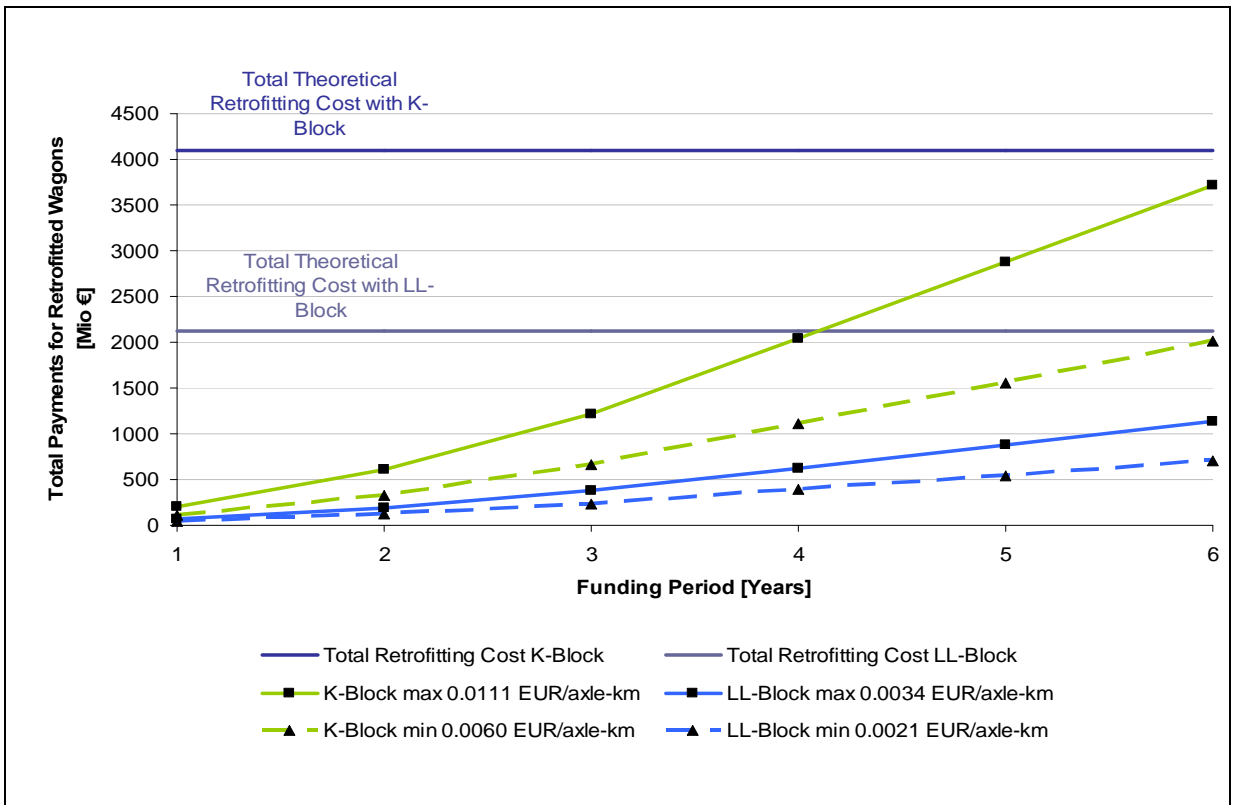
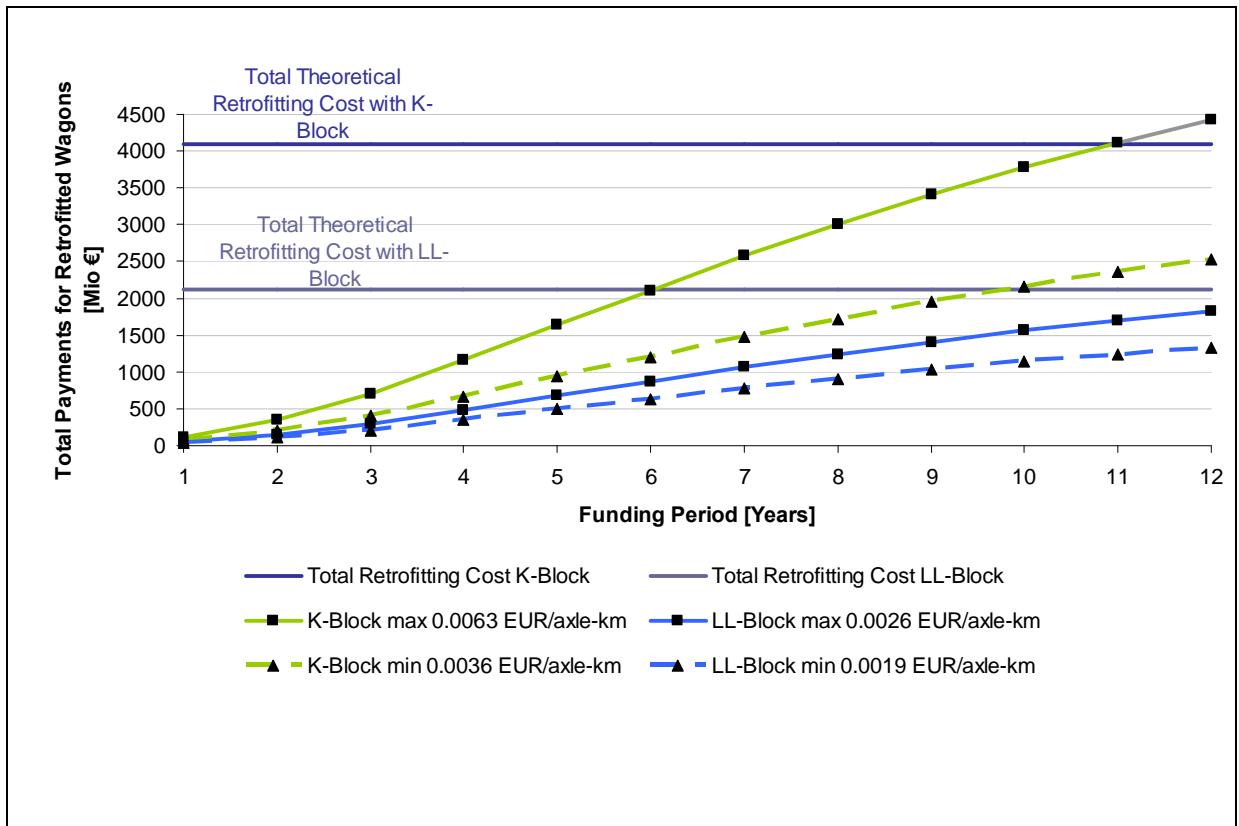


Figure 30: Bonus Payments (accumulated): 12 Year Funding Period / Retrofitting Rate of 90,000 Wagons per year



Source: KCW/ SDG/ TUB: Incentive levels figures are in € per axle-km representing the minimum and maximum values recommended in Table 17 for the respective funding period. Green lines show accumulated bonus payments for K- block brakes, blue lines accumulated bonus payments for LL-block brakes.

7.4 Funding of NDTAC

Generally, the incentive effect for RUs and Wks is determined by the difference between charges for either using ‘silent’ or non-‘silent’ wagons. The incentive level of this differential between either acting in the way intended by the NDTAC or refusing using ‘silent’ wagons must be sufficiently high to cover the additional cost of using this ‘silent’ rolling stock (the “bonus level” calculated in chapter 7.2 and 7.3). Different approaches refer to different sources of funding.

In general, three options seem to be feasible:

- I funding bonuses through the railway sector (either through corresponding malus payments or through an overall increase of TAC);
- I funding bonuses through the Member States; or
- I Through a combination of the above described options.

7.4.1 Funding through the railway sector

This approach incorporates only the railway sector to cover the costs for the NDTAC. Basically there are two general possibilities:

Bonus-Malus-System:

A malus would be raised if a wagon is not retrofitted on silent brake blocks or has a TSI Noise homologation respectively. The total revenues of collected maluses have to be in accordance with the total costs for bonuses paid for 'silent' wagons. If the total costs for bonuses are not covered by the total malus, the IM would make a deficit if no other financing option exists. In case of higher revenues by maluses than costs for bonuses, the IM would have an (unjustified) additional revenue. Thus the basis for the malus which has to be earned from the not 'silent' wagons should correspond to the yearly total cost for the bonuses for beneficiary wagons.

With the increasing amount of 'silent' wagons both, bonus and malus will have to be adjusted. To ensure RU and WK a sufficient calculability of their advantage for being 'silent' the differential between bonus and malus applied should be constant. As a consequence, the bonus will decline in the course of time towards zero and parallel to this effect the railway sector in absolute terms carries more and more additional costs to finance this NDTAC.

The main disadvantage of this approach and (unless TAF TSI provides an easy solution with low administrative costs) a possible knock-out criterion is the requirement to record all wagon movements: not only 'silent' wagons of volunteers have to be recorded, but - to allocate the respective malus - the kilometric performance of *all wagons* operated by all RU. This would create enormous administrative costs and couldn't be covered with the method of self declaration.

Increasing the TAC level:

The second possibility to burden the costs of NDTAC to the sector is to raise the general level of TAC for freight trains. From this additional revenue the IM could gain the necessary budget for paying bonuses for 'silent' wagons. The increase of the general TAC has to cover the costs of bonuses. These additional TAC have to be paid by all rail freight trains – regardless of being silent or noisy. Not to use retrofitted wagons would mean under such a regime de facto to pay a malus indirectly via the generally increased TAC.

The IM might need to be allowed to increase the TAC in advance according to estimated bonus payments in order to avoid a burden for the IM.

While bonuses need to be paid on the basis of 'silent' wagons or rather axles the compensatory increase of the general TAC in most existing charging systems would apply on a train basis.

While bonuses need to be paid on the basis of 'silent' wagons or rather axles the compensatory increase of the general TAC in most existing charging systems would apply on a train basis. The big advantage compared to a bonus-malus-system would be that no specific recording of 'noisy' wagons is necessary. The administrative cost would be low in this respect and even a voluntarily participation in a NDTAC scheme would be possible as well as self declaration.

To ensure calculability for the RU and WK a sufficient level of bonus must be implemented. With an increasing amount of 'silent' wagons the amount of bonuses to be paid increases significantly. This leads to increasing TAC level.

The disadvantage for the sector would be that despite a relatively well calculable incentive the general intermodal competitiveness of rail declines unless other modes of transport would have to internalise such costs, too. In the environment of a worsening intermodal competitiveness the willingness to invest in noise reduction might decline despite the bonus incentive.

In both cases – a bonus-malus-system or the increase of the TAC – the regulatory body has to monitor the payment levels permanently and adjust in case of over- or undercompensation on the part of the IM.

Basically both possibilities would lead to an increase of costs for the railway sector. This weakens the position of the sector unless other modes of transports are treated in the same manner.

7.4.2 Funding through the Member States

In this case the costs of the bonuses will be financed by state authorities, this means the Member States. Thus the sector – neither RU nor IM – won't have to carry the financial burdens of the NDTAC. Either the IM will be compensated for the costs of bonuses paid when claimed by the RU or afterwards. Or there will be an estimated payment to the IM in advance by the state to cover the expected costs. This payment would have to be balanced after clarification of the real payments.

Theoretically, there is also an option that the bonus is directly paid by the authorities. This is not practical in two respects: First, there is a cash flow already between RU and IM, which can be used for this accounting. Second, the IM has the better data to check the claims for bonuses.

A disadvantage of the pure public funding of bonuses can be seen in the disregard to the polluter-pays-principle. However, it has to be noted that so far this principle is applied only in few cases in the transport sector and would therefore not automatically be a privilege of rail. Otherwise changes towards a higher internalisation of external costs are part of current EU legislation and initiatives.

7.4.3 Mixed approach

As a result of the advantages and disadvantages of the above drafted approaches a mixed approach seems to be worthwhile. Due to the disadvantage of the sector when covering all costs on the one hand and an unbalanced approach when the sector has not to cover any of the costs on the other hand, a mixed financing could be appropriate. This means the costs will be shared by the sector and the Member States. Several variations are possible following a mixed approach:

For example the IM is allowed to increase the TAC on the basis of a minimum retrofitting scenario with the obligation to spend the additional revenues for bonus payments. This is the amount which has to be paid by the sector. Additional costs occurring by a higher willingness to retrofit would be covered by the Member States. Alternatively it is also feasible, that the state provides a fixed annual amount of money and the bonus payments which are not covered by this budget lead to an eligible increase of the TAC level.

Another possibility is a shift of the funding source by time, e.g. the Member States exclusively finance the first years of the funding period until TAF-TSI is implemented and allows an integration of a contribution by the sector based on a bonus-malus system.

Of course, any funding system needs to fulfil the requirements of the EU funding guidelines.

Regardless of the funding regime, it should be considered to reimburse the IM's administrative costs for the NDTAC. However, the amount of these costs should be verified carefully. It is likely that most of Europe's IMs nevertheless need to enhance their charging schemes towards more possibilities of incentives and price differentiation, e.g. depending on the quality of the rolling stock or other environmental requirements.

Therefore not all of the costs and efforts of the advancement of the charging scheme can be attributed by NDTAC. Besides the IMs must have a strong self-interest e.g. in the ability to set differentiated incentives, in respect to track friendly vehicles or better network utilisation. If a reimbursement of such costs to the IM in respect to NDTAC is justified, it can be as well done either directly by Member States or as a contribution of the sector by an eligible increase of TAC.

8. RECOMMENDATIONS

The present study analysed the preconditions for the implementation of a NDTAC in the EU. This chapter concludes the results of the study and summarises recommendations for the implementation of a NDTAC.

The main characteristics of the preferred NDTAC are:

General Characteristics

- The NDTAC should be a pure bonus system. If maluses are applied the system would become more complex und administrative costs raise inadequately. Additionally, this could endanger the competitiveness of the railway sector.
- In general, the bonus should be granted to all ‘silent’ wagons with silent brake blocks respectively if a wagon has a TSI Noise homologation.
- The study recommends a focus on LL-block with respect to the costs of their usage and the bonus level applied. In any case, the Commission should pursue a solution which prefers one specific brake block technology – either LL-block or K-blocks – and design the bonus scheme for an optimised effectiveness according to this technology.
- The focus on K-blocks might be feasible if LL-block homologation is further delayed. But a delay within a certain timeframe is not fatal due to the necessary announcement of a NDTAC at an early stage.
- The bonus level should be calculated on the basis of costs of retrofitting plus additional operational and administrative costs which occur on the side of the RU and the WK. Emerging costs at the IM-side should not be part of the bonus level applied.
- The basis of the bonus should be the number of brake blocks per axles. This number depends on the authorised maximum speed level.

Table 19: Derivation of Incentive Level: Bonus per wagon-km and axle-km

Type of wagon	Type of cost [unit]	K- block			LL- block		
		min	recommended	max	min	recommended	max
4 axle-wagon	6 yr funding [€/km]	0.024	0.032	0.040	0.009	0.012	0.015
	12 yr funding [€/km]	0.015	0.019	0.023	0.007	0.009	0.011
2 axle-wagon	6 yr funding [€/km]	0.012	0.016	0.023	0.004	0.005	0.007
	12 yr funding [€/km]	0.007	0.009	0.013	0.004	0.004	0.005
Average per axle	6 yr funding [€/axle km]	0.0060	0.0079	0.0111	0.0021	0.0027	0.0034
	12 yr funding [€/axlekm]	0.0036	0.0046	0.0063	0.0019	0.0021	0.0026

Source: KCW/ SDG/ TUB

- Not all emerging costs of RUs and Wks can be compensated by the bonus. After the end of the funding period the higher operational costs of retrofitted wagons will have to be covered by the RU/WK .
- The bonus should be predefined and fixed during the funding period. Moreover, the level should be the same throughout Europe. This is caused by the fact that additional costs of using ‘silent’ wagons

do not differ within Europe and wagons are increasingly operating cross-border. Anyhow, if essential changes of costs or prices occur, the bonus should be reviewed at a certain time.

- Some countries and IMs – especially those which are not affected by rail noise problems – might consider not to participate in the NDTAC. However, for the effectiveness of the NDTAC it should be implemented EU-wide. In case important rail freight corridors are not covered by the NDTAC regime, it would be more difficult for RU/WK to calculate bonuses reliably and it would weaken the incentive for retrofitting.
- Otherwise the implementation of NDTAC on all networks is not reasonable. For smaller networks the administrative costs might be higher than the effect of noise reduction. The problem of rail noise is mainly a problem of the high runners on the main corridors/networks.
- The funding of the system can be allocated either to the sector or to Member States. If the sector funds the system a general increase of the level of TAC is conceivable. If funding is done by the Member States the IM's bonus payments have to be reimbursed by state authorities. A third way could be a combination of both approaches: The financing is then shared by Member States and the sector.

Charging process

- The NDTAC charges wagon-specific respectively axle-specific whilst 'ordinary' TAC mostly charge whole trains. Anyhow, the existing charging processes can be used in respect to data flow and financial accounting between RU and IM. At the end of the chain the bonus should be transferred to that party which pays the retrofitting: If the RU is not the WK within one entity, the transfer could be done in two ways: As a mileage related transfer from RU to WK or factored into the renting price.

The clearing body should be the IM and the claiming body should be the RU.

Interim:

- As an interim solution self declaration is recommended. This keeps administrative costs low due to the voluntary character of this solution.
- The IM invoices the RU as part of the 'ordinary' TAC. This invoice is the basis for the reimbursement based on listings of silent wagons per train and day as well as the registration number.
- The regulatory body has full access to relevant data from IM, RU and – if needed – WK.
- Random checks by the authorities can minimise leakage effects and at the same time keep the administrative costs relatively low. Penalties should apply for not justified bonus claims to avoid abuse.

Long term:

- A central database in the environment of TAF TSI should be used to collect the relevant data for the NDTAC. This includes information on routing, mileage, train composition and technical characteristics of the wagon.
- The use of TAF TSI and existing charging processes lowers administrative costs and keeps the system efficient.

Length of funding period

- The funding period should be predefined in order to secure planning reliability. The limitation also avoids overcompensation.
- Recommended are 6 years or 12 years as a multiple of the timeframe of wagon revision.

Time and route dependent variation

- A differentiation of the bonus (by route or time) is hypothetically possible but rather as an additional element appropriate to enhance incentives in sensitive areas.

- If at any specific time or on any specific network section the problem of rail noise is extraordinary high, the respective Member State should try to find an individual solution together with the IM.

Additional aspects

- To ensure that noisy brake blocks will not be used after the funding period, that aims to make rail freight less noisy, the use of CI brake blocks should be prohibited after a certain transition period. In any case re-retrofitting CI blocks onto a previously 'silent' wagon must be forbidden.
- Trains (almost) only entirely consisting of 'silent' wagons might get an additional bonus. This could be an incentive for the dispatching decisions of the RU towards an allocation of 'silent' wagons within train compositions. This would reflect the physical effect of noise reduction in a logarithmical way according to the shrinking share of 'noisy' wagons.
- Currently, TSI Noise is not absolutely clear. Thus the TSI should be modified to clarify that retrofitting a wagon with composite brake blocks as well as sintered brake blocks results in a self-acting homologation according to TSI Noise.
- The NDTAC environment can be used for other differentiated TAC in the future. This can be e. g. track friendly rolling stock or other emissions than noise.

9. ABBREVIATIONS

AB	aktiebolag (stock company)
AG	Aktiengesellschaft (joint stock company)
APL	Axles per Length
ARTIS	Austrian Rail Information System
BLS	Bern-Lötschberg-Simplonbahn AG
CCG	Common Components Group
CI	Cast Iron
CHF	Swiss Frank
CZK	Czech Koruna
DB	Deutsche Bahn
ERVID	European Rail Vehicle Information Database
ETA	Estimated Time of Arrival
ETCS	European Train Control System
ETH	Eidgenössische Technische Hochschule
ETI	Estimated Time of Interchange
EU	European Union
FTAC	Fixed Track Access Charge
IM	Infrastructure Manager
GCU	General Contract for the Use of wagons
GPS	Global Positioning System
LCC	Life Cycle Costs
LN	Low-Noise
NDTAC	Noise-Differentiated Track Access Charge
ORR	Office of Rail Regulation
RFF	Réseau Ferré de France
RFID	Radio-frequency Identification
RM	Regionalverkehr Mittelland
RU	Railway Undertaking
SBB	Schweizerische Bundesbahn AG
SEDP	Strategic European Deployment Plan
TAC	Track Access Charge
TAF	Telematic Applications for Freight
TSI	Technical Specifications for Interoperability
VTAC	Variable Track Access Charges
WIMO	Wagon & Intermodal Unit Operational Database
WK	Wagon Keeper
WO	Wagon Owner

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