

# The case for the exemption of aerodynamic devices in future type-approval legislation for heavy goods vehicles

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The work of our Brussels-based team is focused on the areas where European Union policy has the potential to achieve the greatest environmental benefits. Such policies include technical standards for vehicle fuel efficiency and pollutant emissions, environmental regulation of international transport including aviation and shipping, European rules on infrastructure pricing and environmental regulation of energy used in transport.

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Established in 1990, we represent around 50 organisations across Europe, mostly environmental groups and sustainable transport campaigners.

We are politically independent, science-based and strictly not-for-profit.

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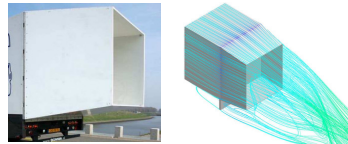
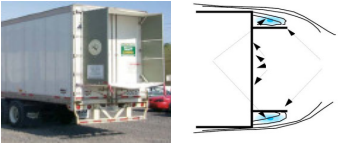
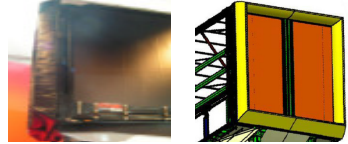

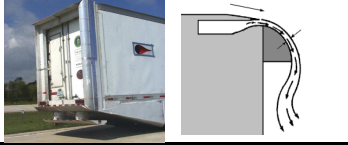
# 1 Executive summary

Decarbonising the transport sector has been established as a key priority of European Union transport policy. Within this context, the objective of this paper is to assess how the type approval legislation for heavy goods vehicles (HGVs) can be changed to allow for more aerodynamic design without harming road safety. The report also assesses the potential CO<sub>2</sub> emissions savings of such a change.

There is currently a window of opportunity to make changes to the HGV type approval legislation; the recently adopted General Safety Regulation requires a recast of the 97/27 type approval directive. It is the intention of the European Commission to replace the current 97/27 directive with a regulation that sets out the measurement of HGV masses and dimensions by no later than 2012.

Aerodynamic drag is responsible for 40% of HGV fuel consumption at motorway speeds. Drag at the rear side of the truck is a major contributor to this drag. T&E's key recommendation is that Article 2.4.1 in Annex I of the directive should be changed to exempt rear-end devices that reduce aerodynamic drag from HGV length definition.

Several technical solutions are on the market that have a strong potential to reduce CO<sub>2</sub> emissions and fuel consumption of lorries, particular in motorway driving:

Device	approx. additional dimension required	best suiting trailer type	approximate CO <sub>2</sub> reduction long haul	Image / working principle
Open cavity tails	1.0 - 1.5 m	box, curtain, reфриgerated box (reefer)	6%	
Inset open cavity tails	0.6 m - 0.8m	box, curtain, reфриgerated box (reefer)	5-8%	
Inflatable open cavity tails	0.4 - 0.6 m	box, curtain, reфриgerated box (reefer)	3-4%	
Inflatable closed cavity tails	1.0 - 1.5 m	box, curtain, reфриgerated box (reefer), chassis	5%	
Active Flow Control / Difusors	0.3 m	box, curtain, reфриgerated box (reefer)	7%	

T&E has researched the effects and pros and cons of these various solutions.

The main conclusions of this paper are:

- Including aerodynamic devices in the list of items to be excluded from lorry length measurement in the HGV type approval directive will likely lead to widespread application of such devices leading, in turn, to significant CO<sub>2</sub> emissions reduction, and cost savings to industry;
- On a per-vehicle basis, fuel and CO<sub>2</sub> savings of 5-8% can be expected compared with a no-change scenario, which represents a fuel cost saving for long-haul operators of around €2,000 per year;
- At EU27 level, some 5 to 7 MT of CO<sub>2</sub> savings can be achieved by 2020 which is 3-4% of total HGV emissions. This estimate is quite conservative: it includes likely market penetration and rebound effects from lower fuel costs on transport volume, but excludes emissions from fuel extraction and refining. It is equivalent to taking 2-3 million cars off the road, and avoiding up to €1bn a year in oil imports;
- The estimate can be achieved if transparency of CO<sub>2</sub> emissions of HGVs is improved e.g. through labelling;

The main policy recommendations are:

- Change the HGV type approval legislation to the effect that aerodynamic devices fitted to the back of trucks are, up to a maximum of 600mm, exempt from length measurement. Lengths over 600mm are not likely to yield significant environmental benefits, whereas they will likely pose additional vehicle stability and safety issues.
- Introduce additional safeguards to ensure that devices fitted do not cause vehicle stability problems or danger to other road users. They should only withstand very limited force (applied to the rear end); under no circumstances should they detach from the trailer; they should not have sharp edges; they should have a shock-absorbing structure; they should satisfy manoeuvrability, specifically turning circle, requirements.
- Introduce as soon as possible similar exemptions for aerodynamic devices in rear underrun protection legislation in order to clear remaining obstacles for aerodynamic devices.
- Change relevant national legislation simultaneously to allow for retrofitting the existing fleet and hence accelerating take-up;
- Provide transparency of fuel efficiency and CO<sub>2</sub> performance of lorries and components, e.g. through CO<sub>2</sub> measurement, labelling, and standards, in order to accelerate take-up of existing low-CO<sub>2</sub> technology and to boost the market for new technology.

Changing HGV type approval legislation to allow for more aerodynamic lorries is a modest step towards decarbonising the transport sector. But it will also promote engineering innovation and provide a boost to green jobs. As such, it is very much a no-regret opportunity, and one that should not be missed.

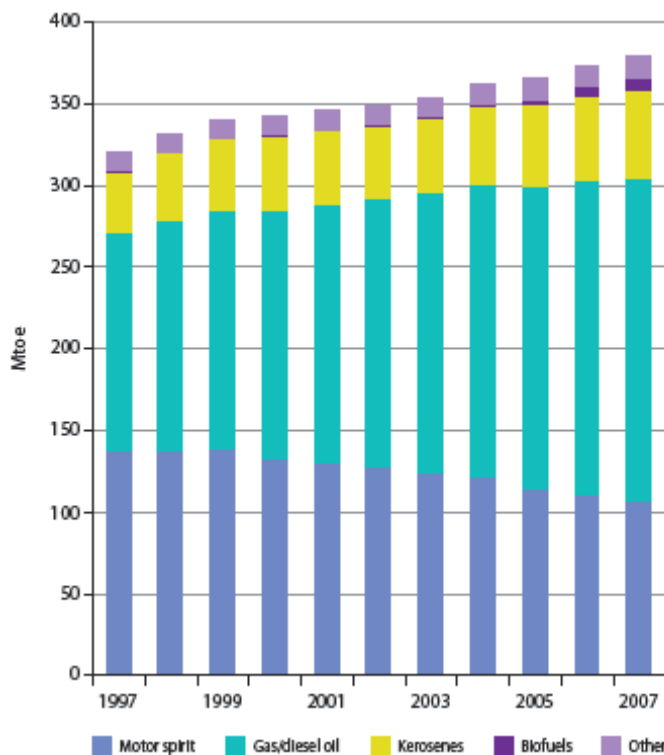
## 2 Introduction

The European Commission has set decarbonisation of transport as one of its priorities for the next five-years. The urgency of reducing CO<sub>2</sub> emissions from transport is clear. The European Union has set itself emissions reduction targets of 20% to be achieved by 2020 across all sectors<sup>1</sup> and Member States have agreed on virtually complete decarbonisation of the EU economy by 2050.

The transport sector remains almost entirely dependent on fossil fuels and is failing to tackle emissions effectively.

Indeed transport sector emissions growth continues to cancel out substantial progress made in other sectors and undermine progress towards targets for emissions reduction and energy security.

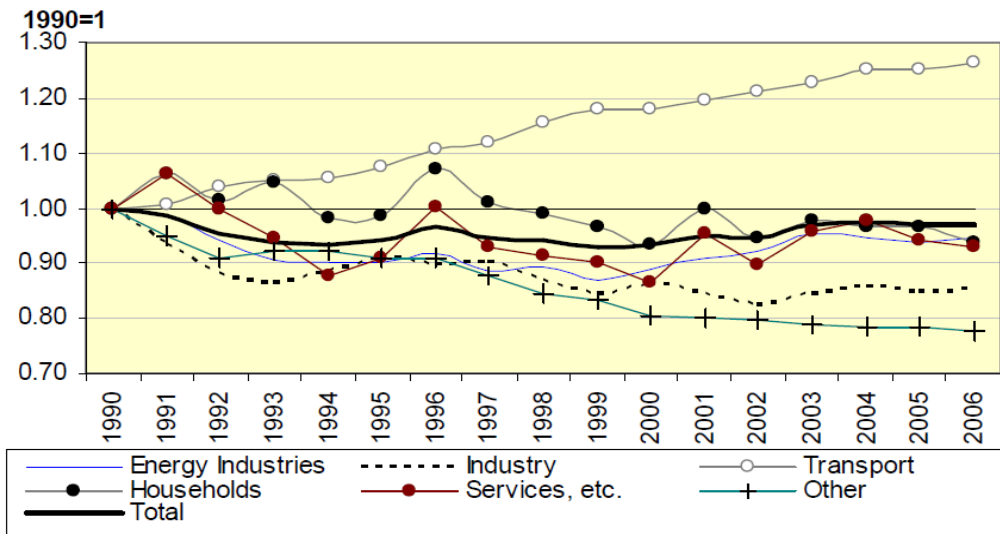
**Figure 2.1. EU-27 final energy consumption in transport, by fuel**



Source: Eurostat, 2009, Pocketbook Energy, transport and environmental indicators

<sup>1</sup> Decision number 406/2009/EC

**Figure 2.2. CO<sub>2</sub> emissions by sector in EU-27 – 1990 – 2006**



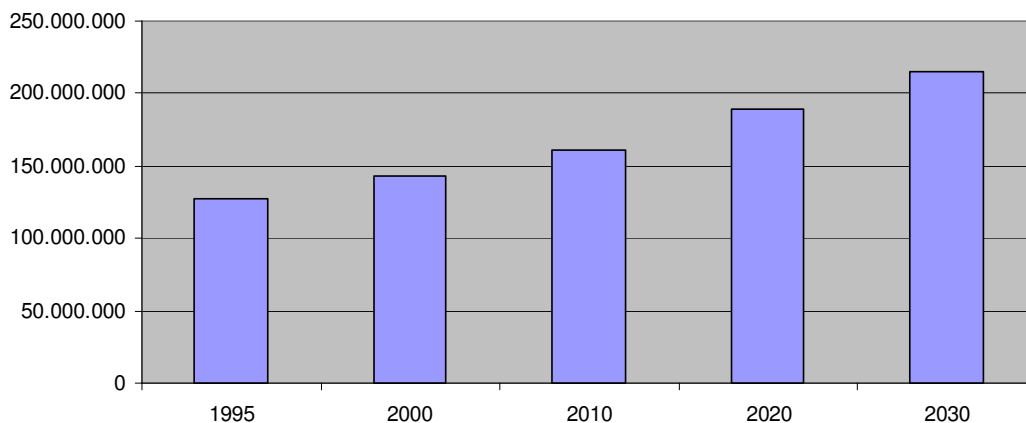
Note: transport excludes emissions from aviation and shipping. Including these two transport sectors CO<sub>2</sub> emissions have risen by 36% instead of 28%

Source: DG TREN, 2009, Statistical pocketbook 2009

Between 1990 and 2007 green house gas emissions from road transport have risen by 200 mega-tonnes (Mt) CO<sub>2</sub>-equivalent<sup>2</sup>.

Within road transport, road freight transport, has the fastest rate of emissions growth and is expected to continue to grow in the future. Trucks emit almost a quarter of CO<sub>2</sub> emissions from European road transport, and 5-6% of total EU CO<sub>2</sub> emissions<sup>3</sup>. CO<sub>2</sub> emissions from HGVs above 16t are on track to increase by 70% between 1995 and 2030. HGVs' share of EU CO<sub>2</sub> emissions is expected to be 7-8% by 2020<sup>4</sup>.

**Figure 2.3. Exhaust CO<sub>2</sub> emissions from HGV > 16t (in tonnes)**



Source: TREMOVE 2.7 b

<sup>2</sup> EEA, 2009, GHG trends and projections 2009

<sup>3</sup> CE Delft, 2009, Are trucks taking their toll? The environmental, safety and congestion impacts of lorries in the EU

<sup>4</sup> TREMOVE 2.7 b, www.tremove.org



To date there are surprisingly few policies focusing on fuel efficiency or CO<sub>2</sub> emissions reduction from heavy goods vehicles. Arguably speed limiters and fuel taxation, both introduced for reasons other than CO<sub>2</sub> savings, are the only EU-wide binding measures that reduce CO<sub>2</sub>.

However, measures to reduce truck emissions have been announced as a policy priority of the incoming Commission.

## 2.1 Objective of this paper

Within the context of decarbonising the transport sector, the objective of this paper is to assess how the HGV type approval directive can be changed to allow for more aerodynamic design of lorries without harming road safety, and to assess the potential CO<sub>2</sub> emissions reduction of such a change.

A window of opportunity is available. The EU General Safety Regulation (No. 661/2009) repeals a number of current directives including the type-approval directive, which the Commission intends to replace by a directly applicable regulation no later than 2012. This allows for the introduction of technical changes to the legislation, where such changes can contribute to achieving overriding policy objectives of CO<sub>2</sub> emissions reduction and improved energy security.

Articles 2.4.1. to 2.4.3. of Annex I to 97/27/EC acknowledge a number of devices such as mirrors, antennae or lift equipment, that do not need to be taken into account when measuring HGV dimensions.

Inclusion of aerodynamic devices in that list represents a “no regrets” policy option within the revision if it proves to reduce emissions, without compromising overarching policy objectives such as safety.

Allowing for such aerodynamic improvements to HGVs can set the frame for market players to develop, sell, and apply devices to HGVs that lower their carbon intensity. If this will reduce overall HGV CO<sub>2</sub> emissions it will be an invaluable step towards more sustainable freight transport.

This paper will establish policy recommendations regarding the type approval regulation, plus an additional recommendation regarding market uptake via labelling.

## 2.2 Scope of the analysis

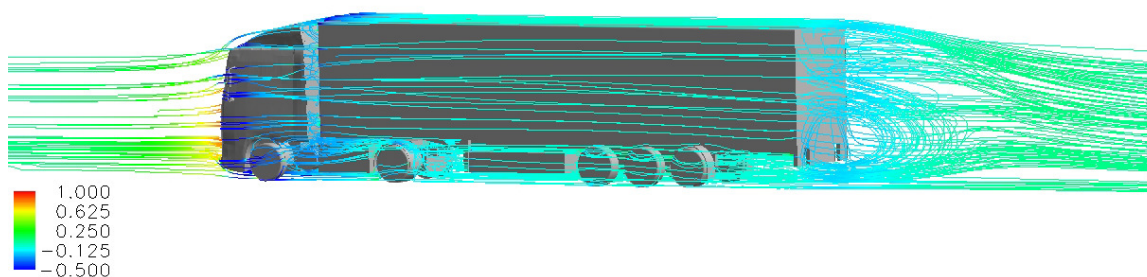
The type approval regulatory framework governs the dimensions (length, height and width) of all heavy goods vehicle types, being tractors, rigid trucks, HGV trailers and HGV semitrailers.

This paper however will only focus on whole vehicle length. As far as the vehicle is concerned, it focuses on trailers (respectively semitrailers), used in HGV combinations. This segment consists of articulated vehicles (combinations of a tractor and a semitrailer) and road trains (combinations of a lorry and a drawbar trailer).

The reason for not looking in detail at width and height of heavy goods vehicles is that infrastructure conditions and safety concerns represent obvious limitations. Bridge heights across most Member States are designed to allow for the maximum vehicle heights set out by the current legislation of four metres. National lane width requirements – especially with regard to highway road works – correspond to current maximum vehicle width of 2.55 m (2.60 m for refrigerated trailers). Tunnel dimensions and tunnel safety requirements represent infrastructural limitations to both increased height and width.

The focus on the (semi-)trailer is primarily because this is where the greatest, and most cost effective, savings can be achieved. Aerodynamic improvements of HGVs in the recent past have predominantly been achieved from the tractor unit whilst trailers remain relatively poor aerodynamic performers. Although recently HGV trailer aerodynamics have started to play a role, trailer rear sides have not yet been substantially redesigned. All in all, the drag behind the truck is one of the biggest contributors to the total drag and therefore fuel consumption.

**Figure 2.4. Airflow around a typical European articulated truck**



Source: van Tooren, 2009, Truck Aerodynamics – An overview of solutions for reducing aerodynamic drag

Another reason to focus on the trailer is that it appears far less straightforward to change 97/27 to allow for changes to the length of the cabin. There are numerous regulatory requirements which apply to the cabin which may entail complete cab redesign by OEMs.

There are two reasons to focus on articulated vehicles. First, this is the segment to which the current regulation prevents any further extension to length. Secondly, articulated vehicles travel more than twice as far as any other commercial vehicle segment<sup>5</sup>. Accordingly faster return on investment can be expected.

<sup>5</sup> Sturm, Hausberger, 2005, Energy and Fuel Consumption from Heavy Duty Vehicles COST 346 – Final Report

## 3 Methodology

### 3.1 Research methodology and acknowledgements

In the course of the research work, vital input about the determining factors was acquired through desktop research supported by meetings with European stakeholders from relevant sectors and expert interviews. Scientific institutes, engineers and suppliers in the field of trailer aerodynamics, as well as the main manufacturers and customers of HGV trailers and HGV consultants provided essential information for this paper. We are grateful for their contributions to this work.

### 3.2 Methodology of the examination

As stated, the key objective of this paper is to assess the potential for CO<sub>2</sub> emissions savings if aerodynamic devices at the rear of trailers were (partly) exempted from the measurement of HGVs dimensions.

The **static examination** must assess which per vehicle emissions savings can be achieved fitting a given trailer with the aerodynamic device that best suits it. It must evaluate how much CO<sub>2</sub> the relevant vehicle fleet emits on the relevant duty cycles and estimate the share of trailers that would actually be equipped.

The static savings potential can thus be described as follows:

(savings of device) \* (emissions from relevant transport operations) \* (market penetration)

A **dynamic element** also needs to be taken into account. A reduced fuel bill facilitated by better fuel efficiency is likely to lower the price that operators will demand for their services. This results, through the price elasticity of demand for freight transport, in more demand for these services.

The dynamic correction term can be described as:

( $\Delta$  price road freight transport) \* (price elasticity of road freight transport)

In order to quantify the different parts of the static elements and the correction term above, the next sections will highlight the main determining factors.

## 4 Per vehicle emissions savings potential of aerodynamic devices

A general overview of relevant devices and their savings potential will be provided. This exercise needs to identify which trailer types can be aerodynamically improved and which duty cycles have the highest emissions reduction potential using aerodynamic devices.

### 4.1 Aerodynamics in general

The examination will start by with a general breakdown of aerodynamic drag. First of all, at constant wind pressure ( $\frac{1}{2} \rho V^2$ ), the drag of a body depends on its frontal area, and the drag coefficient of the body. The drag coefficient is determined by the shape and the texture of the surface.

The drag  $D$  can be represented by the following formula:

**Figure 4.1. Breakdown aerodynamic drag**

$$D = C_D * \frac{1}{2} \rho V^2 * S$$

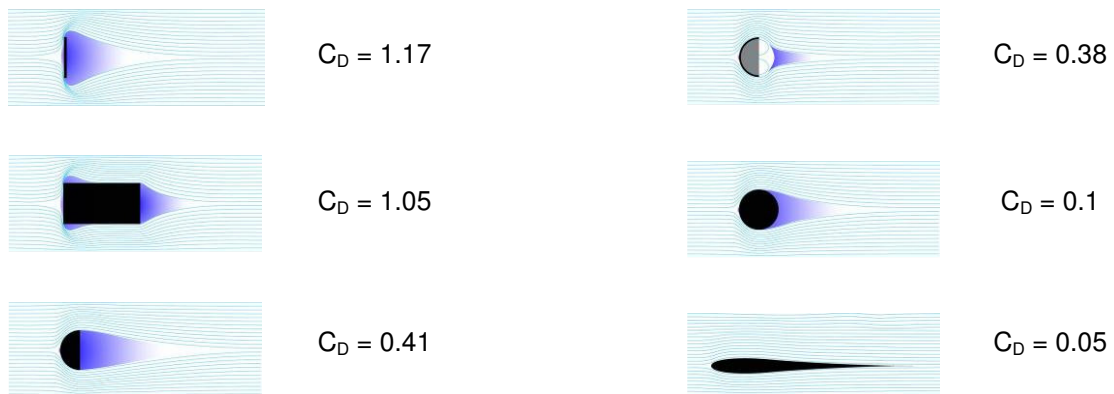
Diagram illustrating the breakdown of aerodynamic drag (D) into its components:

- $D$ : aerodynamic drag
- $C_D$ : drag coefficient
- $\frac{1}{2} \rho$ : air density
- $V^2$ : velocity
- $S$ : frontal surface

Source: NASA Glenn Research Center

The following examples show how different sizes and shapes factor in to the drag of an object of a given texture at constant wind pressure.

**Figure 4.2. Different shapes and the drag**



Source: Don Bur

Cubed blunt-faced shapes perform poorly, whilst rounded shapes show much better performance. Aerodynamically, the drop shape delivers optimal drag results.

The blue and white areas around the bodies indicate regions of air pressure variation as compared to the atmospheric pressure. They are responsible for pressure drag, which is by far the main component of an HGV's drag coefficient (as opposed to friction drag, which is determined by the surface texture of the object)<sup>6</sup>.

## 4.2 Aerodynamic streamlining for HGVs

The general analysis shows that the box shape significantly contributes to the comparatively poor aerodynamic performance of HGV trailers. To a certain extent this shape can be explained by the fact that cubed trailer load compartments maximise load volume. But as outlined above, trailer shapes are also determined by the fact that European legislation discourages more aerodynamic design.

If the legal framework would allow, the drag for HGV trailers could be reduced by applications that provide an advanced aerodynamic shape. Referring to the formula above, this would improve the **drag coefficient** via pressure drag optimisation.

However, the fuel savings potential of streamlining depends on the total aerodynamic drag. As shown by the above formula, the wind pressure  $\frac{1}{2} \rho V^2$  and the frontal surface of the vehicle also factor in to the drag.

Whereas the frontal surface will neither be affected by aerodynamic improvements at the rear of the trailer nor by operating conditions, the wind pressure increases at an exponential rate with the speed of the vehicle.

This demonstrates the importance of the examination of different duty cycles. Urban duty cycles and short extra urban trips are characterised by relatively low speed respectively by short intervals at high speed and frequent accelerations and decelerations. Long high speed periods are typical to long haul operations.

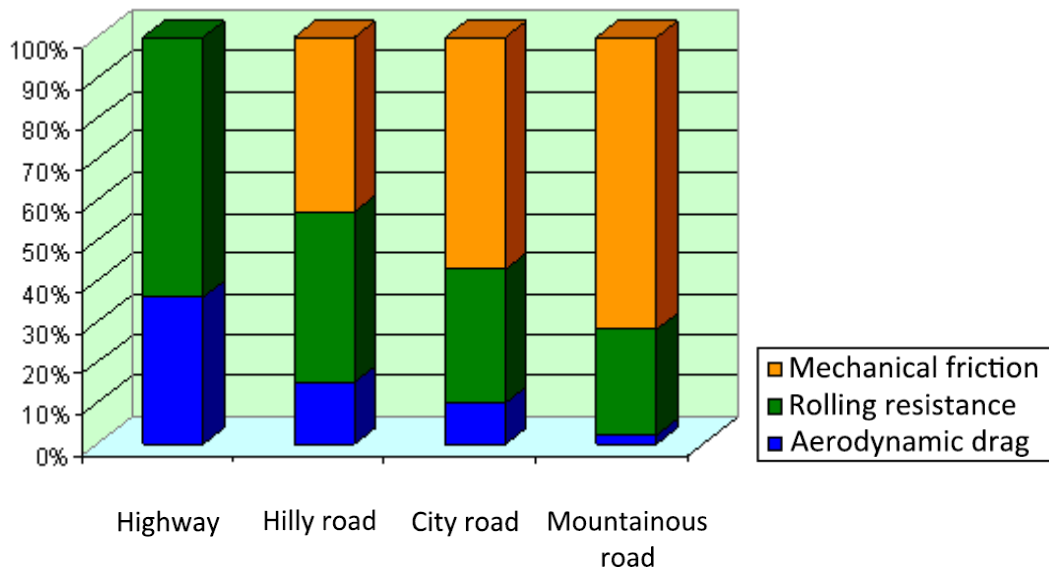
As outlined, an aerodynamic optimisation works via the improvement of the drag coefficient. Due to the high relevance of wind pressure within high speed long haul duty cycles, the potential of an optimised drag coefficient to reduce overall drag for heavy trucks is the highest for these operations.

The following figure estimates the contributing factors to fuel use for different duty cycles.

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<sup>6</sup> Van Tooren, 2009, Truck Aerodynamics – An overview of solutions for reducing aerodynamic drag

**Figure 4.3. Break down of fuel consumption contributors by duty cycle**



Source: Wood, R.M., en Bauer, S.X.S., 2003, Simple and low-cost aerodynamic drag reduction devices

The drag reduction potential translates into fuel reduction potential according to the share that drag contributes to fuel use.

Various sources show, that overcoming aerodynamic drag at typical European highway speed accounts for fuel use of 40%<sup>7</sup>.

At this point, it needs to be stressed, that any extra device mounted to an HGV also adds weight to it which results in a trade-off. The additional weight raises the rolling resistance of that vehicle and causes additional fuel use especially during accelerations<sup>8</sup>. This effect is very small. However, the weight of devices may even cause slightly more fuel use when the truck's duty cycle characteristics entail only a few constant high speed passages.

The examination shows that aerodynamics improvements on HGVs will bring the most substantial benefits to long haul cycles. An application by market players operating other duty cycles can not be expected.

Any further exploration of aerodynamic devices will therefore refer exclusively to long-haul duty cycles with corresponding trip characteristics.

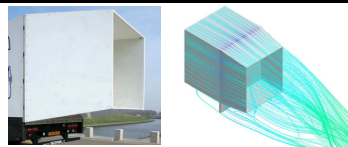

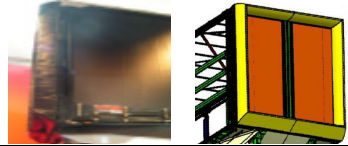

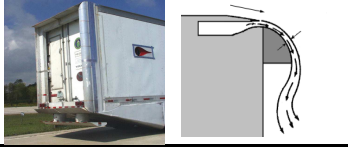
### 4.3 Emissions reduction potential in long haul operations

A number of aerodynamic devices for the rear of long haul HGVs trailers are market ready; more are under development. Besides standard and trapped rigid boat tails, inflatable devices and solutions that blow air into the low pressure region behind the trailer have also been developed.

<sup>7</sup> VDA, 2009, Das Nutzfahrzeug – umweltfreundlich und effizient

<sup>8</sup> IFEU, 2005, Energy savings by light weighting for European articulated trucks

**Figure 4.4. Overview of solutions (non-exhaustive)**

Device	approx. additional dimension required	best suiting trailer type	approximate CO2 reduction long haul	Image / working principle
Open cavity tails	1.0 - 1.5 m	box, curtain, reefer, refrigerated box (reefer)	6%	
Inset open cavity tails	0.6 m - 0.8 m	box, curtain, reefer, refrigerated box (reefer)	5-8%	
Inflatable open cavity tails	0.4 - 0.6 m	box, curtain, reefer, refrigerated box (reefer)	3-4%	
Inflatable closed cavity tails	1.0 - 1.5 m	box, curtain, reefer, refrigerated box (reefer), chassis	5%	
Active Flow Control / Difusors	0.3 m	box, curtain, reefer, refrigerated box (reefer)	7%	

- Standard open cavity tails of up to 5ft (1.5m) of length have proven their potential on regular operation in North American countries and European road tests<sup>9</sup>.
- Inset open cavity tails have shown significant drag reduction potential in extensive scientific road tests<sup>10</sup>.
- Inflatable open cavity tails have been part of a long haul truck concept shown in 2008<sup>11</sup>.
- Inflatable closed cavity tails are commercialised in the North American market<sup>12</sup>.
- The working principle of active flow control implies the use of pressure air. It causes a redirection of the airflow around the end corner of the trailer. The net potential has been scientifically examined and reported<sup>13</sup>. Road tests are planned.

All of the above solutions can be designed so as to guarantee access from the rear.

Interestingly, the long haul CO<sub>2</sub> reduction potential lies within a relatively small bandwidth. Only inflatable solutions can theoretically be fitted to chassis trailers, the other solutions are attached to the frame of the trailer body.

For further analysis, an average savings potential estimate of six percent will be assumed for fitted solutions.

<sup>9</sup> <http://www.part20.eu/en/applications/container/#boattail>

<sup>10</sup> Coon and Visser, 2004, Drag reduction of a Tractor-Trailer Using Planar Boat Tail Plates

<sup>11</sup> [www.iea.org/work/2007/vehicle//Durelli/pdf](http://www.iea.org/work/2007/vehicle//Durelli/pdf)

<sup>12</sup> [www.aerorevolution.com](http://www.aerorevolution.com)

<sup>13</sup> Seifert et al., 2008, Large Trucks Drag Reduction Using Active Flow Control

## 5 Aggregated long haul HGV CO<sub>2</sub> emissions

TREMOVE data indicates an aggregated mileage of European HGVs over 16 tonnes gross weight in the order of 202 billion kilometres in 2010 and 245 billion kilometres by 2020. Associated exhaust CO<sub>2</sub> emissions add up to 161 Mt and 189 Mt respectively<sup>14</sup>.

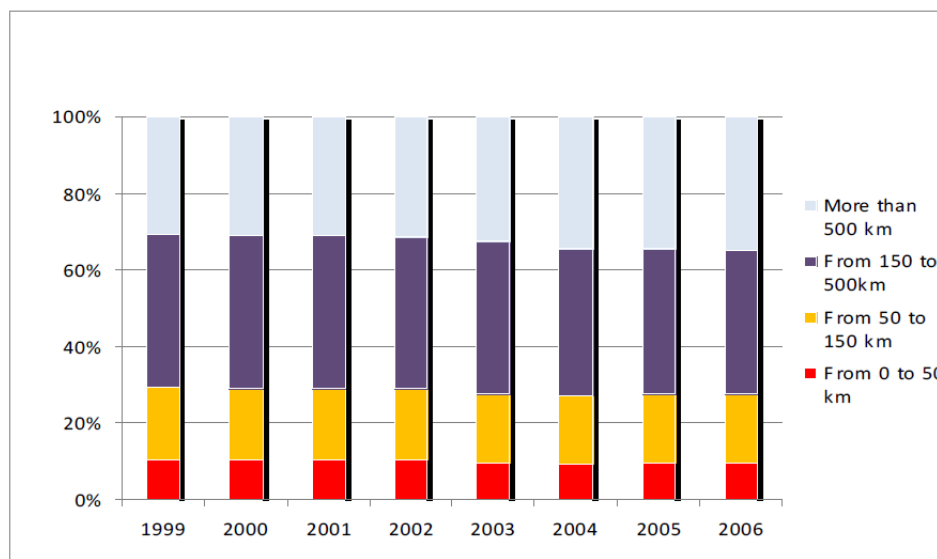
In order to estimate the share of long haul trips within these operations, the analysis will first follow a top down approach and crosscheck the finding using a bottom up approach.

The distance classes of interest for the analysis are trips of more than 150 km.

### 5.1 Top down approach

The share of European road freight transport performed in long haul trips represents about 75%. The trend is increasing.

**Figure 5.1. Total road freight transport by distance classes, on the basis of vehicle-kilometres travelled in the EU 27**



Data source: Eurostat

The figure includes all goods vehicles, including light and medium commercial vehicles. The analysis of LCV driving patterns to feed into the FLEETS report shows that they are mostly used in urban conditions travelling shorter trips<sup>15</sup>. Medium commercial vehicles of 3.5 to 16 tonnes gross weight also travel shorter trips as they are predominately used for distribution purposes.

Consequently it can be assumed that the share of long haul operations within HGVs is significantly higher than 75%. In accordance with other studies<sup>16</sup>, the top down approach delivers an estimate of ninety percent in terms of vehicle kilometres driven in long haul operations.

This adds up to 182bn vehicle kilometres in 2010 and 221bn vehicle kilometres by 2020.

<sup>14</sup> TREMOVE 2.7b, 2009

<sup>15</sup> <http://lat.eng.auth.gr/copert/>

<sup>16</sup> IFEU, 2005, Energy savings by light weighting for European articulated trucks



## 5.2 Bottom up approach

To confirm the share of HGV long haul operations via a bottom up approach, the analysis will be carried out in several steps:

- First, the average annual mileage of relevant long haul HGVs in Europe will be assessed.
- Then, the above assessed long haul HGV aggregated mileage of 182bn vehicle kilometres will be divided by the findings on average vehicle mileage. The result delivers the vehicle population that would be needed to carry out this distance.
- Thirdly, registration and population data of HGV tractors and rigid trucks of a gross weight of more than sixteen tonnes will be analysed and the population of long haul vehicles in that segment will be estimated.
- Finally, this population will be assessed against the theoretical value that the first two steps of the analysis delivered.

### 5.2.1 Average mileage of motorised long haul HGVs in Europe

NEA Transport Research and Training found annual HGV mileages in international transport of about 140,000 km across the EU 15 and a bandwidth between 90,000 km and 140,000 km in the newer member states in 2004<sup>17</sup>.

For the UK, data on average annual vehicle kilometres by vehicle is available from the Transport Statistics Bulletin published by the Department of Transport<sup>18</sup>. In the UK, across all duty cycles, the average mileage of HGV combinations of more than 35 tonnes gross weight added up to about 100,000 km in 2007.

Research results in German fleets from 2004 indicate average annual distances of 169,000 km for heavy long haul trucks<sup>19</sup>.

The different findings suggest average distances travelled by motorized long haul HGV vehicles of about 140,000 to 150,000 km per year.

### 5.2.2 Required vehicle population

The division as outlined above delivers a required long haul HGV population of 1.2 to 1.3m vehicles.

### 5.2.3 Motorised long haul vehicles of more than 16 t

The “European Motor Vehicle Parc Report 2007” indicates a population of propelled HGV exceeding 16 t gross weight of approximately 2.3 m vehicles across the EU27 in the year 2007<sup>20</sup>.

ACEA statistics for this segment declare an average of 300,000 newly registered vehicles per year between 2003 and 2008<sup>21</sup>. Being cyclical goods, new registrations of tractors have dropped severely in 2009. However, latest national HGV order figures indicate slight recovery<sup>22</sup>.

Whilst in this segment HGV tractors only made up about one third of the registrations in the late nineties, available data suggests, that they have been responsible for a share

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<sup>17</sup> NEA, 2006, Selected recent statistics on road freight transport in Europe

<sup>18</sup> [www.dft.gov.uk/adobepdf/162469/221412/221522/222944/28584011/01\\_Road\\_Freight\\_Stats\\_2007.pdf](http://www.dft.gov.uk/adobepdf/162469/221412/221522/222944/28584011/01_Road_Freight_Stats_2007.pdf)

<sup>19</sup> Léonardi, Baumgartner, Krusch, 2004, CO<sub>2</sub>-Reduktion und Energieeffizienz im Straßengüterverkehr

<sup>20</sup> ANFAC, 2009, The European Motor Vehicle Parc Report 2007

<sup>21</sup> <http://www.acea.be/index.php/collection/statistics>

<sup>22</sup> <http://www.vda.de/de/meldungen/news/20100114.html>

exceeding 60% of total new HGV registrations by 2008<sup>23</sup> <sup>24</sup>. The remaining vehicles are rigid lorries that operate with and without drawbar trailers.

In terms of vehicle population of motorised HGVs of more than 16 tonnes, this suggests a market penetration of tractors of approximately fifty five percent. The remaining vehicles are rigid lorries.

Tractor units mainly operate in long haul applications but tractors which are used to pull tippers or in short distance intermodal operations do not belong to the long haul market. On the other hand, rigid lorries usually operate in duty cycles that have short to medium trip lengths, such as distribution routes. But road trains that consist of a rigid lorry and a drawbar trailer are typical long haul vehicles.

Both effects, to a certain extent, neutralise each other.

In conclusion, it can be estimated that within the propelled HGV fleet of over sixteen tonnes gross weight, roughly 55% are long haul vehicles.

### 5.3 Plausibility check and conclusion

The estimated 55% share of motorized long haul HGVs within the relevant fleet of about 2.3m HGVs, equates to 1.265m vehicles.

This lies within the set out bandwidth. The top down approach is plausible as it is backed up by the bottom up approach.

In conclusion, it can be assumed that long-haul HGVs are responsible for 90% of the distances travelled by HGVs exceeding 16t gross weight.

For the purpose of further analysis, this equates to an estimate share of 85% in terms of CO<sub>2</sub> emissions as HGV fuel efficiency in long haul operations is significantly better than in other duty cycles.

The estimated share of emissions of 85% of all HGV emissions from vehicles over 16 t gross weight equals 137 MT in 2010 and 161 Mt by 2020.

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<sup>23</sup> <http://www.schmidt-paderborn.de/cms/de/news/>

<sup>24</sup> [http://lessiak.mercedes-benz.at/de/pressezentrum/mercedes/news/nw\\_news.asp?Page=Detail&Start=53&Kategorie=0&Zeitraum=0&Suchbegriff=](http://lessiak.mercedes-benz.at/de/pressezentrum/mercedes/news/nw_news.asp?Page=Detail&Start=53&Kategorie=0&Zeitraum=0&Suchbegriff=)

## 6 Potential market penetration

The type approval legislation governs newly registered vehicles.

The rate at which the aerodynamic devices would get applied to the relevant group of newly registered trailers is the potential market *share*.

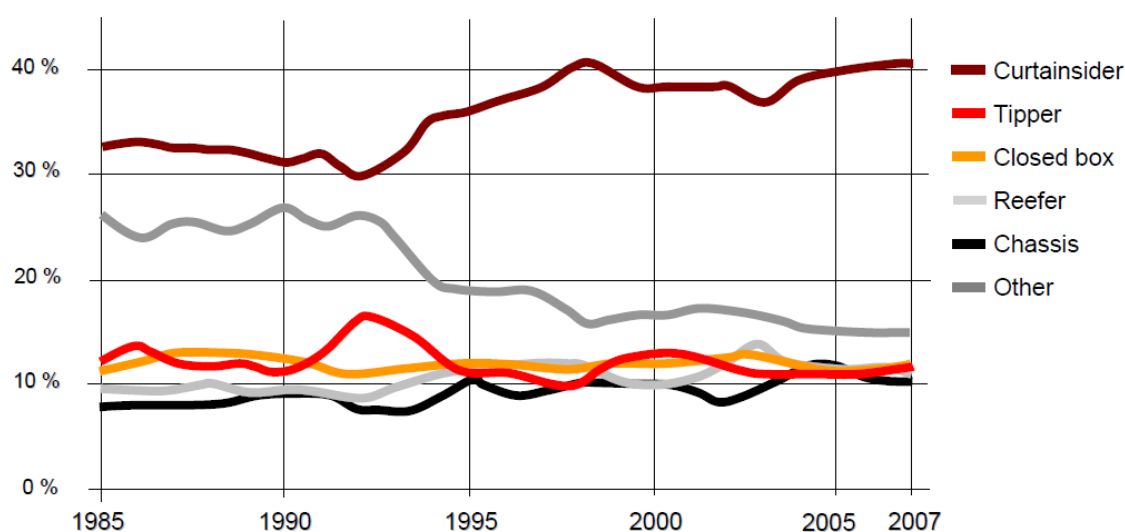
The market *penetration* of aerodynamic devices within the long haul trailer population will converge towards the market share according to the rate of fleet renewal.

### 6.1 HGV trailers and semitrailers

In 2008, EU wide new registrations added up to approximately 220,000, of which 200,000 are semi-trailers and 20,000 are drawbar trailers<sup>25 26</sup>. Sharp cuts have occurred in 2009. Nevertheless, according to expert forecasts, the market is expected to be back to 2008 levels by 2012 or 2013.

Available statistics on trailer registrations do not classify the trailers according to whether or not they are being used for long distance operations. However, given the fact that trailer body types and payload classes will generally be operated in those duty cycles that best suit them, it is possible to estimate the share of relevant trailers through their body type.

**Figure 5.2. Break down HGV semitrailers by body type**



Source CLEAR

The graph shows that standardised curtain-sided trailers become increasingly popular, replacing specialised bodies. This trend can be explained by their flexibility and affordability<sup>27</sup>.

These findings suggest that within the total HGV trailer market, long haul trailers being curtain-siders, closed box trailers, refrigerated box trailers and some chassis trailers, have a market share in the order of 70% or 150,000 trailers in terms of new registrations.

<sup>25</sup> Truck & Bus Builder Reports Ltd, 2009, The European truck trailer report 2009

<sup>26</sup> <http://www.stiftung-industrieforschung.de/images/stories/dokumente/petersberg/2007/jung.pdf>

<sup>27</sup> Truck & Bus Builder Reports Ltd, 2009, The European truck trailer report 2009

## 6.2 Drivers

The rate at which aerodynamic devices would be applied is driven by the rationale of the purchase decider.

Therefore, the return on investment of the solutions will be analysed and compared to the periods required by stakeholders. The basic analysis needs to assess the savings potential from a reduced fuel bill against the additional cost that the devices entail.

Some stakeholders may however expect additional costs due to trade-offs with regard to utility limitations or insufficient robustness of the devices. They may also not believe in the savings potential figures due to a lack of robust information. Chapter 9 assesses the need for access to accurate and independent information on fuel / CO<sub>2</sub> benefits in detail.

Also, if the purchase decider does not operate the vehicle, this can hamper market penetration e.g. when the owner expects that higher initial investments can not be passed on to the end user.

### 6.2.1 Return on investment (ROI)

In the course of the preparation work of this paper, the potential suppliers of aerodynamic devices have indicated purchase prices that implied payback periods of 9 to 18 months for annual trailer mileages of 100,000 km at current fuel prices.

With regard to experience from the North American market<sup>28</sup> it can be assumed, that these ROI bandwidths are adequate to allow for an application of trailers exceeding these distances.

The average mileage for HGV trailers was assessed from HGV trailer manufacturer information directly and suggests that leasing and owner-operated trailers circulate in the range of 120,000 to 200,000 km per year, short term rental trailers operate in the order of 75,000 to 100,000 km per year. Annual mileages of rental trailers vary heavily with the overall economic situation.

From the angle of pay back periods, the fitting of aerodynamic devices to trailers circulating more than 100,000 km would be economically rational. This applies to almost all HGV trailers with the exemption of some rental trailers.

Provided competition, it can be expected that the fuel price development on one side and learning processes by the aerodynamic suppliers on the other side will bring return on investment periods down to and allow for more and more rental trailers to become equipped over time.

### 6.2.2 Utility impacts

Hauliers have expressed concerns that some solutions might reduce vehicle utility. To them, easy loading, compatibility with hubs, longevity and robustness for piggy backing by train and ship are necessary requirements to be fulfilled. The number of stops on a daily route, the way by which the trailer is loaded and unloaded and the rate at which the trailer will be used in intermodal operations determine which device would be first choice

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<sup>28</sup> Cooper et al., 2009, REDUCING Heavy-Duty Long Haul Combination Truck Fuel Consumption and CO<sub>2</sub> Emissions

Suppliers of aerodynamic solutions are acutely aware of this. They are ready to apply tailored solutions to individual drive cycles. Collapsible solutions and / or various materials are available according to the individual need of the customer.

Again, this might cause some time delay before maximum application of aerodynamic devices is achieved.

### **6.2.3 Market structure and justification for investment**

Another concern broadly discussed with stakeholders arises for the fact, that in many cases the purchase decider and the user are not the same entities, being the fact in the case of short term rental trailers which make up an important share of the market<sup>29</sup>.

If the fuel savings potential is merely communicated by the suppliers of the solution, the information will be perceived as intransparent or even biased. According to experts, in many cases equipped trailers could then not be rented out at higher rates.

The same risk arises from company structures in which the purchase intention of fleet managers would fail to pass validation by controlling bodies because the better performance has not been independently approved.

## **6.3 Estimate for market penetration**

As stated above, the population of equipped vehicles will build up gradually.

If the scope was extended to the existing fleet, this would allow for retrofitting which could accelerate the effect. Then, the population would grow faster in the early years.

The discussion of the drivers suggests a phase-in period for newly registered trailers in which early adopters equip their fleets. Within this group the annual mileage can be expected to be above average. However, after the applications have proven to be cost effective, high market shares can be reached.

The above mentioned structures of ownership can potentially hamper market success in the longer term, if the savings communication is perceived as an unreliable source of information. A neutral third party appraisal could provide transparency about the real performance of aerodynamic solutions.

If market transparency is provided, this paper concludes a mid to long term market share in the range of two thirds to ninety percent to be within reach.

Market penetration will be reached on a growth path that is determined by the rate of trailer renewal.

However, without market transparency, the potential is significantly lower. If customers are not aware or convinced of fuel savings, they will not invest. For that to change, CO<sub>2</sub> emissions need to be measured and clearly communicated.

Further details and recommendations on transparency-related policy options will be discussed in section nine.

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<sup>29</sup> [http://www.sci.de/fileadmin/user\\_upload/logistikbarometer/pdf/DVZ-T\\_100\\_S01.PDF](http://www.sci.de/fileadmin/user_upload/logistikbarometer/pdf/DVZ-T_100_S01.PDF)

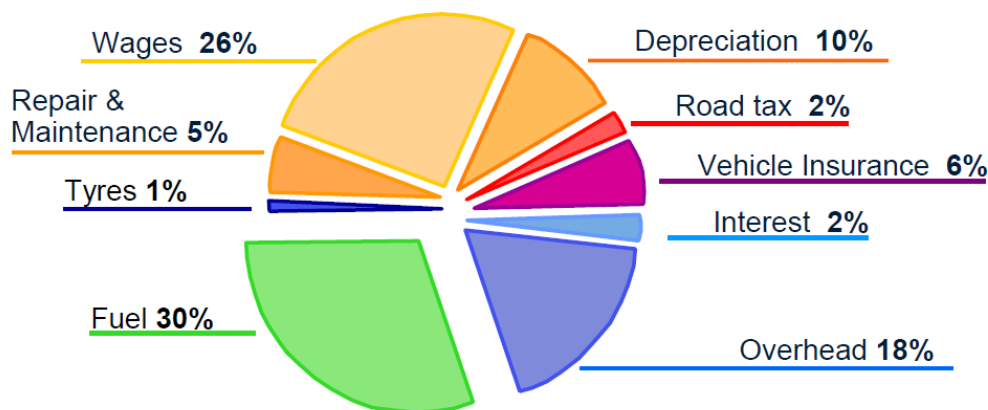
## 7 Dynamic correction term

### 7.1 Price effect

The expected haulage demand increase is determined by fuel price saving effects from aerodynamically improved long haul HGVs.

The share of fuel costs within the total operational cost structure of European road freight operators adds up to approximately 30%.

**Figure 7.1. Breakdown HGV operational costs**



Source: UK RHA 2007

With regard to the findings of the fourth section, a fuel efficiency improvement of six percent will be assumed.

At a 30% share of fuel cost within the total operational costs, this leads to a per-kilometre cost reduction of 1.8 percent. For the purpose of further analysis, the price of road haulage carried out with equipped vehicles will then decrease by about 1.5 percent.

### 7.2 Demand effect

Since the analysis needs to detect the increase in vehicle mileages, it will focus on the price elasticity of demand in terms of vehicle kilometres in European HGV long haul road freight transport.

T&E has recently commissioned a study, in which different findings on European road freight elasticities and recent traffic data were collected and interpreted<sup>30</sup>. The price elasticity road freight transport of demand in terms of vehicle kilometres was found to be in the order of -0,9.

This results in an estimated increase in HGV long haul vehicle kilometres *of the equipped fleet* of 1,35 percent.

At 90% market penetration, the *total long haul* HGV mileage would increase by 1.2 percent, 0,9% at a market penetration of two thirds, respectively.

<sup>30</sup> Significance, forthcoming

## 8 Total CO<sub>2</sub> savings potential

The total CO<sub>2</sub> emissions savings potential will be estimated through the findings of sections four to seven.

Due to the design of the market penetration assessment, the findings will describe the long term annual CO<sub>2</sub> savings following a complete fleet renewal / retrofitting.

The calculation will be based on 2020 TREMOVE data for the two above scenarios.

**Table 8.2. CO<sub>2</sub> savings potential**

BASELINE		SCENARIO 1 (MARKET PENETRATION 90%)		SCENARIO 2 (MARKET PENETRATION 66,6%)	
Data TYPE	2020	Data TYPE	2020	Data TYPE	2020
<b>LONG HAUL</b>		<b>LONG HAUL - STATIC</b>		<b>LONG HAUL - STATIC</b>	
vkm	220.663	vkm	220.663	vkm	220.663
Emissions	161.021.483	Emissions	152.326.323	Emissions	154.580.624
		<b>LONG HAUL - DYNAMIC + 1,215%</b>		<b>LONG HAUL - DYNAMIC + 0,9%</b>	
vkm		vkm	223.345	vkm	222.649
Emissions		Emissions	154.177.088	Emissions	155.971.849
<b>OTHER DUTY CYCLES</b>		<b>OTHER DUTY CYCLES</b>		<b>OTHER DUTY CYCLES</b>	
vkm	24.518	vkm	24.518	vkm	24.518
Emissions	28.415.556	Emissions	28.415.556	Emissions	28.415.556
<b>TOTAL</b>		<b>TOTAL</b>		<b>TOTAL</b>	
vkm	245.182	vkm	247.863	vkm	247.168
Emissions	189.437.039	Emissions	182.592.644	Emissions	184.387.405
<b>Δ BASELINE TOTAL</b>		<b>Δ BASELINE TOTAL</b>		<b>Δ BASELINE TOTAL</b>	
vkm	0	vkm	2.681	vkm	1.986
Emissions	0	Emissions	-6.844.395	Emissions	-5.049.634
<b>Δ BASELINE %</b>		<b>Δ BASELINE %</b>		<b>Δ BASELINE %</b>	
vkm	0	vkm	1,1%	vkm	0,8%
Emissions	0	Emissions	-3,6%	Emissions	-2,7%

The calculation delivers a CO<sub>2</sub> emissions decrease of 2.7 to 3.6 percent if transparency would support aerodynamic improvements.

Assuming complete fleet renewal / retrofitting by 2020, this would translate into annual net CO<sub>2</sub> emissions savings of as much as 5.0 to 6.8 Mt.

## 9 Increasing transparency of CO<sub>2</sub> performance

The analysis in this paper clearly shows that more transparency in CO<sub>2</sub> performance of lorries, trailers and components is urgently necessary to improve the market penetration of fuel saving technology and the consequent CO<sub>2</sub> reductions. If customers are not aware or convinced of fuel savings, they will not invest. For that to change, CO<sub>2</sub> emissions need to be measured and clearly communicated.

CO<sub>2</sub> labelling of lorries and components is a tried and tested way to improve market transparency.

Labelling should not be limited to trailers and rear-end devices, but rather extend to advanced side skirts, optimised aerodynamic underbody design, outer box shapes and surfaces, advanced light weight technology or innovations that yield reduced emissions from auxiliary loads.

Cars must already be labelled according to g CO<sub>2</sub>/km performance. An A-G fuel efficiency label will be introduced for tyres, including truck tyres, in 2012. National and public procurement standards and incentives, including fiscal incentives, may then be based on the scheme, under the condition that such incentives are in line with Community State Aid rules.

Other existing transparency-increasing examples that could serve as an inspiration are:

- Endorsement or "excellence" label, based on, for example, the EU Eco-label, or German Blue Angel schemes, to indicate best-available-technology. However, such schemes do not yet incorporate an assessment of energy savings or performance grading<sup>31</sup>.
- Accreditation scheme, such as the US EPA SmartWay programme, which identifies a list of accredited products, including aerodynamic devices, low rolling resistance tyres and fuel efficient engines, which are eligible for purchase grants<sup>32</sup>.
- Performance labels, such as the EU energy label, which is already applied to other "energy-related products" and indicates A-G classes for a range of performance. The Action Plan on Sustainable Consumption and Production and Sustainable Industrial Policy (COM(2008)397/3) recommends extending the scheme to further product categories<sup>33</sup>.

As an EU-wide policy measure, the latter performance labelling scheme is preferable as it indicates relative performance and can incorporate an indication of fuel and CO<sub>2</sub> savings compared to a baseline level. EU energy-efficiency labels are widely recognised throughout Europe, and have already proven their effectiveness in accelerating market uptake of energy-efficient products and stimulating rapid innovation.

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<sup>31</sup> <http://www.eco-label.com/>

<sup>32</sup> <http://www.epa.gov/smartway/transport/>

<sup>33</sup> <http://www.energy.eu/#energy-focus>



## 10 Safety issues

As stated, the key objective of this paper is to assess the potential fuel and CO<sub>2</sub> savings impacts of allowing aerodynamic devices to be fitted to the rear end of articulated vehicles. It is perfectly obvious that any such aerodynamic improvements should not go at the expense of traffic safety. We have identified three areas of attention.

### 10.1 Crosswind stability

Large aerodynamic extensions at the back of a trailer could lead to stability issues for unloaded vehicles under transient crosswinds.

Crosswind sensitivity of a truck is mainly determined by the length, height, centre of gravity, track width and stiffness of the suspension<sup>34</sup>.

When length extensions are limited this effect is probably not very important. First, in the UK, a windy country, higher trailer bodies of up to 16'' are allowed. This likely has a big impact of stability; however, no major problems are reported. Second, we did not find any references to stability problems in the US and Canada, where long aerodynamic devices are already allowed.

Another reason for reduced stability may be caused by vortices that get caught up inside the aerodynamic device at slow speeds. This could take place in long devices with designs susceptible to vortex formation, such as open cavity boat tails of more than one metre length.

Setting a maximum length of around 600mm (above which no or only very limited CO<sub>2</sub> benefits have been demonstrated) hence seems an appropriate way to address stability concerns and still facilitate significant CO<sub>2</sub> savings.

### 10.2 Rear underrun protection

Currently, Council Directive 70/221/EC governs rear underrun protection requirements for European HGVs.

According to Article 19 of the General Safety Regulation 661/2009, Dir 70/221/EC will be repealed by the UN ECE Regulation No. 58 no later than 1. November 2014.

The requirements set out in both pieces of legislation<sup>35</sup> entail a maximum distance from the rear protection bar to the outermost rear part of the trailer of 400mm. Compliance has to be proven when the trailer is resting.

The purpose of governing requirements on rear underrun protection is to effectively protect car and van occupants in the event of rear collision with a truck<sup>36</sup>. It is well imaginable that fitting hard and sharp aerodynamic devices at the rear end could seriously compromise safety.

Nevertheless it seems perfectly feasible that a change in wording of the relevant legislation could pave the way for aerodynamics without compromising on safety. This could take the shape of standards for the physical characteristics of aerodynamic devices such as:

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<sup>34</sup> <http://www.ifh.uni-karlsruhe.de/science/aerodyn/pub18.htm>

<sup>35</sup> Article 5.4.5. of Annex I to the current version of 70/221 EC, Article 25.6 of part III to UN ECE 58 respectively

<sup>36</sup> Article 2 of UN ECE 58

- a material that poses no passive safety threat
- no sharp edges
- a shock-absorbing structure
- fitting requirements ensuring that the device, under no circumstances, detaches from the trailer

It is recommended that the issue be addressed to the EEVS working group 14 in order to find a solution that optimises both, safety and aerodynamic performance.

### 10.3 Manoeuvrability

Aerodynamic extensions at the back of a trailer lead to an increased rear overhang which can affect the 'swing-out' and the turning cycle of the vehicle.

This can raise safety concerns in the case of turning trucks with regard to vulnerable road users that are situated close to the rear of the vehicle.

To properly address this concern, any aerodynamic devices should comply with the manoeuvrability requirements set out in Article 7.6 of the current version of 97/27/EC. This means that, if the trailer itself already reaches the legal limits, aerodynamic devices cannot just be linear extensions of the trailer. In that case they will either have to have a tapered shape, or be 'inset' from the trailer body frame.

### 10.4 Conclusion

Taking safety aspects into consideration, a length limitation of 600mm for aerodynamic devices with the above mentioned requirements on their physical composition in order to exclude negative passive safety impacts seem appropriate.

To avoid negative safety trade-offs it is highly recommended to change rear underrun legislation as soon as possible and not to wait for the 2014 deadline.

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