THE IMPACT
OF MEGATRUCKS

STUDY

PROVISIONAL VERSION
Abstract
This study provides an analysis of the current evidence on Longer and Heavier Vehicles (LHV) and the potential impact of allowing the use of these 'Megatrucks' throughout the EU - as is the case in Finland and Sweden which already permit LHVs in normal traffic. It rests on a literature review of prominent research in this field, as well as case studies looking into the experiences of LHVs in the five Member States in which they are either allowed or tested. In addition to this, it analyses available statistical data and considers the impact of 'Megatrucks' in relation to EU objectives on road safety and greenhouse gas emissions.
CONTENTS

LIST OF ABBREVIATIONS 7
LIST OF TABLES 9
LIST OF FIGURES 9
EXECUTIVE SUMMARY 10

1. LITERATURE REVIEW 11
   1.1. Terminology 11
   1.2. Introduction 11
   1.3. Review of Studies 12
      1.3.1. TML - Effects of adapting the rules on weights and dimensions of heavy commercial vehicles as established within Directive 96/53/EC 12
      1.3.2. TRL - Longer and/or Longer and Heavier Goods Vehicles - a Study of the Likely Effects if Permitted in the UK (2008) 14
      1.3.3. ISI - Long-Term Climate Impact of the Introduction of Mega-Trucks 15
      1.3.4. VTI - The Effects of Long and Heavy Trucks on the Transport System (2008) 16
      1.3.5. JRC - Introducing Megatrucks: A Review For Policy Makers (2009) 18
      1.3.7. ITF – Moving Freight With Better Trucks (2010) 21
   1.4. Conclusions 24

2. ASSESSMENT OF ISSUES 25
   2.1. Current LHV traffic within the EU 25
      2.1.1. Freight transport in the European Union 25
      2.1.2. Road freight in the European Union 26
      2.1.3. LHV traffic in the European Union 28
      2.1.4. LHV cross-border traffic in the European Union 30
      2.1.5. Potential of LHV traffic in the European Union 31
      2.1.6. Summary: Current Traffic 33
   2.2. Intermodal Competition and Modal Shift 34
      2.2.1. Current Modal Splits 34
      2.2.2. Elasticities 35
      2.2.3. Introduction of LHV's and modal shift 37
      2.2.4. Summary: Intermodal Competition and Modal Shift 38
   2.3. Impact on Road Infrastructure 39
      2.3.1. Road Wear 40
      2.3.2. Volume 41
2.3.3. Structures
2.3.4. The costs of adapting road infrastructure
2.3.5. Empirical evidence of the impact of LHV on infrastructure
2.3.6. Summary: Impact on Infrastructure

2.4. Road Traffic Flow
2.4.1. Junctions and Intersections
2.4.2. Overtaking manoeuvres
2.4.3. Impact of reduced vehicle movements and modal shift on road traffic flow
2.4.4. Summary: Road Traffic Flow

2.5. Impact on road safety
2.5.1. Vehicle kilometres
2.5.2. Likelihood of accidents
2.5.3. Severity of accidents
2.5.4. Summary: Impact on Road Safety

2.6. Impact on Greenhouse Gas (GHG) Emissions
2.6.1. Relative fuel efficiency of LGVs and LHV
2.6.2. Predicted impact of LHV on GHG emissions
2.6.3. Evidence of GHG emissions effects of LHV
2.6.4. Summary: Greenhouse Gas Emissions

3. MEGATRUCKS AND EU OBJECTIVES ON GREENHOUSE GASES AND ROAD SAFETY
3.1. EU Objectives
3.2. LHV and EU Objectives on Greenhouse Gases
3.3. LHV and EU Objectives on Road Safety
3.4. Policy Proposals
3.4.1. Do Nothing
3.4.2. Payload neutral increase in length to 25.25m
3.4.3. Performance based standards for LHV
3.4.4. Permit LHV throughout Europe

4. CONCLUSIONS

REFERENCES

ANNEX 1 – CASE STUDY SWEDEN
ANNEX 2 – CASE STUDY FINLAND
ANNEX 3 – CASE STUDY NETHERLANDS
ANNEX 4 – CASE STUDY DENMARK
ANNEX 5 – CASE STUDY GERMANY
ANNEX 6 – LIST OF STUDIES CONSIDERED FOR LITERATURE REVIEW
LIST OF ABBREVIATIONS

**ABS**  Anti-Lock Braking System

**CO2**  Carbon Dioxide

**DG**  Directorate General

**DKK**  Danish Krone

**EC**  European Commission

**EEA**  European Environment Agency

**ETF**  European Transport Workers Federation

**EU**  European Union

**EU12**  The Member States which joined the EU in 2004 and in 2007

**EU15**  EU Member States before the 2004 enlargement

**EU27**  The current Member States

**FIM**  Finnish Mark

**GCW**  Gross Combined Weight

**GHG**  Greenhouse Gas

**GPS**  Global Positioning System

**IRU**  International Road Transport Union

**Kg**  Kilogram

**Km**  Kilometre

**LGV**  Large Goods Vehicle

**LHV**  Longer and Heavier Vehicle

**LST**  Longer Semi-Trailer

**MS**  Member State

**Mt**  Million tonnes

**NOx**  Nitrogen Oxide
**NPV**  Net Present Value

**PM**  Particulate Matter

**SDG**  Steer Davies Gleave

**SEK**  Swedish Krona

**SRT**  Static Rollover Threshold

**SWOT**  Strengths, Weaknesses, Opportunities, Threats
LIST OF TABLES

Table 1:  
Studies selected for literature review  
Table 2:  
LHV and likelihood of accidents: a review  
Table 3:  
Impact of the introduction of LHVs – summary of studies

LIST OF FIGURES

Figure 1:  
Tonne-km generated in inland freight transport in the EU in 2010  
Figure 2:  
Share of inland modes in the total EU freight transport market in 2010  
Figure 3:  
Evolution of the road freight market in the EU, measured in tonne-km  
Figure 4:  
Yearly growth of road freight volumes in the EU  
Figure 5:  
The size of the national transport markets in the EU – share in the total of national markets based on tonne-km  
Figure 6:  
EU road freight market in volume and the share of those national markets where LHVs are permitted  
Figure 7:  
EU road freight market in volume and the share of LHVs  
Figure 8:  
Evolution of the share of different trip length ranges in the total tonne-km transported in the EU  
Figure 9:  
Industry sectors participating in the Dutch LHV trial  
Figure 10:  
EU27 Freight Modal Split in volume (% 2001 – 2010)  
Figure 11:  
Percentage Market Share of Rail in Freight Market, in volume (2008)  
Figure 12:  
Road wear factors by gross weight and number of axles  
Figure 13:  
GHG Emissions from transport ('000s tonnes CO₂ equivalent)  
Figure 14:  
GHG Emissions by transport mode ('000s tonnes CO₂ equivalent)  
Figure 15:  
Deaths in road accidents per annum, EU27
1. LITERATURE REVIEW

1.1. Terminology

There are several names given to Longer and Heavier Vehicles, and usage varies between studies. Moreover, different names are in common usage in different countries. For the purposes of this study, we use two primary definitions:

- **Large Goods Vehicle (LGV):** Any truck with a gross combined weight (GCW) in excess of 3.5 tonnes. These are also referred to as Heavy Goods Vehicles (HGVs).
- **Longer and Heavier Vehicle (LHV):** Any LGV longer than 18.75m or heavier than 44 tonnes (i.e. over the limits set by Directive 96/53/EC). These are also often referred to as Megatrucks, Euro-Combis, European Modular System (EMS) Trucks, or Road Trains.

LHVs are by definition a type of LGV. When referring specifically to an LGV that is not an LHV, we use the term ‘conventional LGV.’

1.2. Introduction

This Part consists of a literature review of the most relevant studies in the field. The findings of the review were used to inform subsequent stages of the study.

We have selected eight studies for review. These were selected from a long list of 29 studies identified through an internet search, and by identifying others referenced by those that we had found. The final list was selected according to the following criteria:

- The range of issues covered (safety, modal shift, infrastructure wear, etc);
- Geographical coverage (studies which covered the European Union were preferred, although some studies focusing on individual Member States were useful for the depth of their analysis); and,
- Ensuring a balanced selection, including some studies that were supportive of the use of LHVs and others that were against.

The above mentioned 29 identified studies are comprehensively listed in Annex 6. The studies selected are shown in Table 1 below:

<table>
<thead>
<tr>
<th>Study</th>
<th>Author</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effects of adapting the rules on weights and dimensions of heavy commercial vehicles as established within Directive 96/53/EC (Final report)</td>
<td>TML</td>
<td>2008</td>
</tr>
<tr>
<td>Longer and/or Longer and Heavier Goods Vehicles - a Study of the Likely Effects if Permitted in the UK</td>
<td>TRL</td>
<td>2008</td>
</tr>
<tr>
<td>Long-Term Climate Impacts of the Introduction of Mega-Trucks</td>
<td>ISI</td>
<td>2008</td>
</tr>
</tbody>
</table>
### 1.3. Review of Studies

#### 1.3.1. TML - Effects of adapting the rules on weights and dimensions of heavy commercial vehicles as established within Directive 96/53/EC (2008)

This study was commissioned by the Directorate General for Energy and Transport of the European Commission. It identified four possible scenarios for the introduction of LHV, and performed a cost benefit analysis, taking account of operating costs, safety, infrastructure costs and greenhouse gas emissions. The scenarios were:

- (1) Baseline scenario: defined as ‘business as usual’, with no change to existing regulations;
- (2) LHV permitted throughout the EU: the largest vehicles currently permitted on some European roads (25.25m, 60 tonne LHV) are able to operate throughout the EU;
- (3) LHV (25.25m, 60 tonne) are permitted in only six Member States (Sweden, Finland, Denmark, the Netherlands, Germany and Belgium); and
- (4) Smaller LHV (20.75m, 44 tonne) are permitted throughout the EU.

The effects in each scenario were assessed for the year 2020.

The study found that, dependent on the scenario chosen, the introduction of LHV would be likely to reduce transport costs by 15%-20% compared to conventional LGV. This reduction in operating costs could be expected to lead to modal shift. In the scenario in which 25.25m, 60 tonne LHV were allowed throughout Europe, the study’s central case showed the volume of freight moved by road increased by 0.99%, whilst the volume moved by rail and waterways fell by 3.8% and 2.9% respectively. The increase in volumes transported by road was nonetheless accompanied by a fall in vehicle-km of 13%, primarily in the transport of heavy cargo, which implies that any reduction in vehicle movements will depend on cargo type. Hence, different Member States could be expected to experience varying levels of reduction in vehicle movements. The scenario in which LHV were permitted in a limited number of countries resulted in similar outcomes, although the fall in
The proportion of traffic carried by waterways was larger, since the six countries examined are relatively more dependent on waterways for the carriage of freight than the EU as a whole. The intermediate scenario in which 20.75m, 44 tonne vehicles are permitted resulted in a smaller increase in road freight volumes of 0.4%.

Notably, the study found that “despite the risk of more intense competition between road, rail and waterborne, the growing transport demand (expected to grow by 1.5 to 2% per year in the future) will allow rail and waterways to continue growing. There is no downward spiral projected.”

The study also concluded that, in all three scenarios, there was no “inherent increase of safety risks in general.” It made the important point that “LHVs are expected to be newly designed and well equipped vehicles, with the latest safety technologies.” Whilst the study accepted that the increased weight and length of LHVs may lead to more severe accidents and casualties, the reduction in vehicle-km as a result of the introduction of LHVs would bring about an overall improvement in safety.

The study investigated the infrastructure wear caused by a number of different possible combinations of vehicles. It found that vehicles within a 20.75m, 44 tonne limit (which would have at least six axles) would only have a moderate negative impact on infrastructure. 25.25m vehicles with a gross weight of up to 50 or 52 tonnes would not cause significantly more wear than current vehicles as the increased weight would be spread over more axles. However, if the weight limit for these vehicles were 60 tonnes, “some bridge lifetimes would be affected and higher investments in bridge maintenance and replacement would be needed.” The study noted that investment in LGV parking facilities would also be needed, but stated that further research in this area was required.

The study anticipated a fall in greenhouse gas emissions if 25.25m, 60 tonne LHVs were introduced, since these vehicles were found to be 12% more efficient in terms of fuel consumption per tonne-km. Importantly, the study noted that “this effect is bigger than the predicted increase in tonne-km by road.” In total, CO₂ emissions from transport as a whole were expected to fall by 3.6%, NOₓ by 3.8% and PM by 5%. In the scenario in which only six countries introduced LHVs, the reductions were nearly four times smaller. However, in the scenario in which 20.75m, 44 tonne vehicles were allowed throughout Europe, CO₂ emissions were found to increase by 0.3% compared to the baseline. This reflected the use of a heavier vehicle with only one additional axle, which would have the effect of increasing fuel consumption per tonne-km by 0.3%.

The cost benefits analysis of the scenarios showed that all three of the non-baseline scenarios produced overall positive effects on society. The scenario involving 25.25m, 60 tonne LHVs performed best, mainly because of a far smaller societal cost per tonne-km of transported goods. The study noted that this result was dependent on assumed elasticities.

The study concluded that there is “no evidence of strong negative impacts of LHVs on road safety and infrastructure, if the relevant investments are done.” It recommended that 25.25m vehicles could be introduced with overall benefits to society, but that it may be beneficial to start with weight limits of 50 or 52 tonnes as opposed to 60 tonnes. This is due to the reduced infrastructure impact of the 50 or 52 tonne variants, coupled with the study’s finding that most operators are more concerned about increasing available volume than weight.
1.3.2. **TRL - Longer and/or Longer and Heavier Goods Vehicles - a Study of the Likely Effects if Permitted in the UK (2008)**

This study was commissioned by the UK Department for Transport. It centred on the potential effects of introducing longer and/or heavier goods vehicles in the UK. It considered eight potential scenarios in which the regulations on the length and weight of LGVs were relaxed from the current UK standards (a maximum of 44 tonnes and 16.5m for articulated heavy goods vehicles, and 44 tonnes and 18.75m for drawbar combinations), with 34m vehicles with a maximum weight of 82 tonnes being permitted in the most extreme scenario. The study used desk research to attempt to monetise the various impact of the different scenarios, including impact on safety, infrastructure and the environment. This research included analysis of freight data, modelling of road flows, and a computer simulation of vehicle performance characteristics. Where possible, costs and benefits were monetised in order to appraise the relative performance of the different scenarios.

The study made a number of findings. In particular, it concluded that the historic increase in permitted weights from the previous limit of 41 tonnes to the current limit of 44 tonnes (in 2001) had, other things being equal, reduced vehicle-km, transport costs and carbon dioxide emissions. It also concluded that increasing the limits on weight and length would be likely to increase casualty rates per vehicle-km for most of the scenarios tested, although casualty rates per tonne-km would be likely to fall slightly. Similarly, fuel consumption for longer and/or heavier vehicles increased per vehicle-km, but decreased per tonne-km, thereby increasing costs and greenhouse gas emissions per vehicle-km, but reducing them per tonne-km.

The study found that permitting longer and/or heavier vehicles would be likely to lead to mode shift from rail to road, but not from waterborne transport to road. In particular, allowing vehicles of 25.25m or longer would be likely to present a “substantial threat to rail operations in the deep sea container market,” with a maximum of 8%-18% (depending on the scenario) of all rail tonne-km migrating to LHVs.

When comparing the results of the different scenarios, the study found that an increase in the permitted length of articulated vehicles from 16.5m to 18.75m would represent a “low risk-low reward” option, with negligible impact on safety, and a reduction in vehicle movements reducing costs and greenhouse gas emissions. This was presented as being likely to have a high benefit to cost ratio. A movement to 25.25m vehicles with a payload neutral weight increase to 50 tonnes was considered to be likely to increase the scope of cost savings available due to reduced vehicle mileage, again reducing greenhouse gas emissions. However, it was also found that the associated mode shift from rail to road would significantly increase emissions, more than offsetting the potential benefits.

In addition to problems of mode shift, the report highlighted the likelihood of currently unquantifiable capital costs that would be required to improve parking facilities, bridge supports and other parts of the road infrastructure to accommodate the longer vehicles. Hence, “it is uncertain […] as to whether the benefit to cost ratio would exceed one.” Larger increases in permitted weights (to 60, 63 or 82 tonne vehicles) would be likely to lead to similar risks to those arising in the case of 25.25m, 50 tonne vehicles, but with increased costs for upgrading infrastructure including, potentially, a strengthening of trunk road bridges. There would also be “a much greater risk of environmental effects” due to additional mode shift from rail to road.

Whilst these findings are based on an analysis of the UK market, they readily illustrate some of the main points regarding changes to the regulation of freight in the Member
The Impact of Megatrucks

States. While all EU countries are currently bound by Directive 96/53/EC, many have infrastructure that could be adapted relatively easily for LHV.

One of the principle findings, common to other studies, was that longer and heavier vehicles increase costs (including operating costs, environmental costs, safety, etc) per vehicle-km, but reduce them per tonne-km. If the road freight market were to remain the same size, then the reduction in per tonne-km costs would lead to improvements in safety, greenhouse gas emissions and infrastructure wear. However, a reduction in operating costs could be expected to lead to an increase in the size of the road freight market. This increase could lead to a rise in total environmental, safety, and infrastructure costs associated with road freight, even if costs per tonne-km were lower. The “assessment of likely mode shift was confined to a predominantly econometric analysis based on simple price elasticities [and] there is a risk that the mode shift predicted could be an under or over estimate.” Hence, the impact on important factors such as greenhouse gas emissions, safety, and infrastructure costs cannot be accurately predicted, especially for the larger vehicle sizes considered, and the study is therefore not able to definitively show that the impact would be positive or negative.

1.3.3. ISI - Long-Term Climate Impact of the Introduction of Mega-Trucks (2008)

This study considered the likely effects of the introduction of LHVs in Europe, with a focus on the impact on the environment. It was commissioned by the Community of European Railway and Infrastructure Companies (CER), the industry association for the incumbent rail operators. The study took the form of a literature review and market review, both of which informed a system dynamics model of the reaction patterns of the various stakeholders in the industry. It also included a number of case studies and modelling of the impact of LHVs on logistics. The analysis focused on 25.25m, 60 tonne LHVs for its central case; 25.25m, 50 tonne LHVs were also considered.

The findings of the literature review and market review suggested that “the cost saving potential in unimodal road transport due to the introduction of [LHVs] is much higher than in combined transport with access and final haul performed by [LHVs].” The study also noted that experience in Sweden and in German and Dutch trials suggested "lower or even negligible modal shift effects than model- or corridor-based desktop studies" was a result of “manifold restrictions of [LHVs] in practice as required by Directive 1996/53/EC to national territories, particular road classes and specific exceptional permissions” and of “rather relaxed conditions implicitly assumed by the analytical model.” It therefore concluded that “the real market potential of [LHVs] thus will range somewhat below the values found by the theoretical studies.”

The study included two analyses of freight corridors, the first between Dutch seaports and Poland, and the second used by north/south trans-Alpine traffic. In the case of the first corridor, the study found that anticipated improvements in the Polish rail industry, coupled with the poor condition of Polish roads, would lead to “low modal shift potential” if LHVs were introduced. In the case of the trans-Alpine corridor, the study found that the

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1 ‘Unimodal’ transport is transport undertaken by only one mode (road, rail, waterborne). ‘Combined Transport’ is transport undertaken by more than one mode, with each mode generally being used for the section of the journey for which is it most advantageous.
introduction of LHVs “could have an impact on the road sector, where a reduction in the number of vehicles is expected.” The particular regulatory environment in Switzerland, where rail is favoured and receives “benefits of political will and big investments in new infrastructure”, means that the market potential for LHVs is likely to be limited to competition with the existing road freight sector.

The scope of analysis also included using computer modelling software to derive the potential market share of LHVs for comparison with results obtained in other studies. The results indicated that LHVs could be expected to take a significant share of the road freight market, the share increasing significantly with distance, and that LHV traffic would be concentrated along major European corridors. In particular, allowing LHVs to be used for international traffic would increase the overall proportion of LHV journeys since LHVs have a comparative advantage in longer-distance flows. A review of other studies suggested a reduction of 20% to 30% in rail demand in continental container traffic and of 10% to 20% in maritime container services above 800km. These reductions were much lower than those predicted by the computer modelling, which indicated “a reduction of up to 85% of container traffic” for rail, which could be reduced to 50% if direct freight rail connections were installed across Europe.

A further modelling exercise involved simulating “the impact of the introduction of [LHVs] on market shares and then on CO₂ emissions over time at the strategic level.” The analysis found that introducing LHVs would lead initially to a decline in CO₂ emissions, “as the road haulage sector can react more quickly on this concept.” However, “the modal split effect in the medium to long run remains stronger than the road side efficiency gains.” The study concluded that “the final output of the central scenarios should give enough warning not to consider the introduction of [LHVs] as an element of climate protection policy.” The results indicated that, due to their “lower energy and CO₂ efficiency and a high share of size sensitive goods in the railway market,” the introduction of 50 tonne LHVs would be “even worse than for [60 tonne LHVs]” in terms of climate impact.

In conclusion, “the study finds strong evidence that most likely the introduction of [LHVs] will end in a negative climate gas balance in the medium term.”

1.3.4. VTI - The Effects of Long and Heavy Trucks on the Transport System (2008)

This study was commissioned by the Finnish Government. It analysed the road freight market in Sweden, where LHVs are already permitted, and investigated the potential impact of removing LHVs on freight in Sweden. Four scenarios were tested in order to isolate individual elements of the changes in the road freight market that would be anticipated if such a change were to happen. The scenarios were:

- (1) Do nothing (baseline);
- (2) Restricting LGVs to 18.75m, 40 tonnes (the European standard) with no option to change mode;
- (3) Restricting LGVs to 18.75m, 40 tonnes with an enhanced railway network and mode shift allowed; and
- (4) Enhanced capacity on the Swedish rail network, with LHVs still permitted (this final scenario was used to separate different effects in the other scenarios).

The range of scenarios was required to derive a realistic picture of the effect across modes of a change in regulations – this was because the Swedish rail network has very limited
capacity to absorb any more freight at present, a constraint that needed to be captured in the modelling.

The study used computer modelling software to estimate the impact of the scenarios on tonne-km and vehicle-km for freight in Sweden. The primary driver of change between the scenarios was the change in operational transport costs per tonne-km. The model minimised generalised transport costs (i.e. taking account of all aspects of transport cost, including time) for the transport system, enabling an analysis of the pattern of demand in each case. The model was also able to analyse the impact on infrastructure wear, road safety, and external costs.

The study detailed the cost assumptions used in the modelling process. These costs were assessed for 12 different commodity groups, covering a large majority of freight transport in Sweden. The number of additional vehicles required for the scenarios in which LHVs were removed from Sweden was calculated by considering whether, for each commodity, payloads were generally weight limited, volume limited, or both. For commodities where the payload was weight limited, it was assumed that removing LHVs would require 67% more trucks. If payload was volume limited, 50% more trucks would be required, and if payload was both weight and volume limited, 58.5% more trucks would be required. Furthermore, the study made the conservative assumption that capacity utilisation was 85-90% for Swedish LHVs, but 100% for vehicles adhering to the European standard. As a result, the model predicted that the removal of LHVs would require 37% more vehicles to transport the same amount of freight.

The model results indicated that vehicle-km would increase by 24% if no mode switching was allowed. This outcome was considered realistic in the short term, due to the lack of available freight paths on the Swedish rail network. If, however, the network received sufficient investment to be able to compete for additional freight, removing LHVs would lead to a 14% increase in vehicle-km for road freight, and a 30% increase in train kilometres. In order to further understand the relationship between road and rail freight, the study examined historic data from 1985 to 2005. It found that “one of the two modes of transport is heavily dominant in most of the commodity groups [...]. This suggests that trucks and freight trains are good at different things and that there is a great difference between them in terms of competitiveness.” The study concluded from this that “modest changes in competitiveness [between modes] are not expected to outweigh the existing comparative differences.”

The study also found that the scenario in which LHVs were removed from Sweden and there was no mode shift in response would cost Swedish business SEK 7.5bn (€900m) per annum in 2001 prices. In the scenario in which the Swedish rail network was upgraded to be able to absorb some of the additional freight journeys, the cost to business fell to SEK 3.1bn (€350m) per annum in 2001 prices. The increase in costs was most acute for commodities which currently make most use of LHVs – for example, the cost of transporting round timber increased by 22% with no mode shift, and 12% with mode shift allowed.

At the same time, the study results suggested that removing LHVs from Sweden would reduce the cost of infrastructure wear. This reflected the assumption that removing LHVs from Swedish roads would lead to a higher proportion of trucks with 6 or 7 axles than is currently the case. Since trucks with more axles carry a lower weight per axle, and since weight per axle drives infrastructure maintenance costs, this implied lower infrastructure maintenance costs. While the underlying assumption was considered reasonable, it was not explained.
The study used historical data on accidents, as well as economic valuations of the cost of various aspects of a road accident, in order to estimate the impact that removal of LHVs from Swedish roads would have on safety. Having accounted for the various factors that affect the likelihood and cost of accidents, the study found that “there is nothing [...] to suggest that the accident cost per kilometre differs significantly between the various categories [of vehicle] concerned.” As a result, the increase in vehicle-km anticipated if LHVs were removed would lead to an increase in the cost of accidents. The study found that the scenario in which mode switching was not possible (with an increase in vehicle-km of 24%) led to an additional economic cost associated with safety of nearly SEK 500m (€60m) per annum. In the scenario in which mode switching was possible, this was reduced to SEK 300m (€35m) per annum.

The study used ARTEMIS, a European computer programme for calculating exhaust emissions, to derive the environmental impact of removing LHVs from Sweden. Applying this to the scenarios defined showed that removing LHVs would lead to a total cost of SEK 600m (€70m) per annum if mode switching were not allowed, but would lead to benefits of SEK 250m (€30m) per annum if mode switching to rail were possible. This implies that mode shift can make a significant difference to the impact of introducing or removing LHVs.

After taking account of all the economic impact of the scenarios, including the business impact, safety, infrastructure and emissions, the study concluded that the scenario in which LHVs were removed and no mode switching occurred (which is likely to represent the short term response if such a change happened) would lead to economic costs of SEK 9bn (€1bn) per annum. If there were investment in the rail network to allow for mode switching in such an instance, the cost would be lower, at SEK 4bn (€50m) p.a.

1.3.5. JRC - Introducing Megatrucks: A Review For Policy Makers (2009)

This study built upon three previous studies, as well as additional research and analysis, in order to provide the European Commission with further evidence on the likely impact of introducing LHVs in Europe. The three studies that were considered were (the above-mentioned) TML (2008), ISI (2008), and TRL (2008).

After comparing the results of this earlier research, the study outlined the main factors surrounding the potential introduction of LHVs. The starting point for the analysis was the assertion that the loading capacity of LHVs is typically 40-50% greater than that of conventional trucks. Based on this assumption, the study set out a broad range of variables and parameters that affect the outcome of any introduction of LHVs. It was noted that the road freight sector would benefit from “a substantial cost reduction per tonne-km.” The resulting increase in demand for road freight was then dependent on the associated price elasticity of demand, although this effect would be counter-balanced by the reduction in the number of vehicles required to transport the same quantity of freight. The corresponding decline in demand for rail freight was dependent on the cross-elasticity of demand between road and rail. The study noted that “the impacts can vary considerably depending on the commodity type, the distance travelled, the geographical area, time, whether tonne-volume or tonne-km are considered, etc.”

The study stated that, “due to the much higher loading capacity (60 tonnes) offered by [LHVs], cost reductions would probably range between 20% and 30% compared to conventional 40 tonnes [LGVs].” In support of this, it noted the results of another study
The Impact of Megatrucks

which found that, in the UK, weight limit increases from 38 to 41 tonnes (in 1999) and from 41 to 44 tonnes (in 2001) reduced road haulage costs by 7% and 11% respectively.

The study reviewed the evidence available on the price elasticity of demand of road freight, and found that while “there are many elasticity estimates available in literature leading to very different orders of magnitude” it “is likely to fall between -0.5 and -1.5, meaning that the elasticity is negative and rather elastic.” In reviewing the cross elasticities in the literature for road freight against rail freight, the study found that there was once again significant variation, with values ranging “from 0.3 to 2 depending on the trip length and commodity type.”

The study considered the loading capacity of LHVs, and the impact that the loading rate of LHVs would have on their use relative to conventional trucks. Due to difficulties in obtaining data on the proportion of empty running that trucks undertake (since this varies by distance travelled, the availability of back loads, and the type of commodity), the study did not identify a universal value for this. However, it noted that “due to the economical disadvantages of running an empty [LHV] over long distances, one can expect that hauliers would optimise their routes in order to get maximum profit,” thereby limiting the proportion of empty running undertaken by LHVs.

Using the outputs of other research as inputs, the study applied Monte Carlo\(^2\) analysis to assess the potential effects of introducing LHVs. This analysis allowed for different assumptions on elasticities and loading rates to be tested and indicated that “the net welfare impact of a large scale introduction [of LHVs] in the EU would be positive in all possible combinations of values for the input variables.” Sensitivity analysis was undertaken in order to determine which parameters and variables were most likely to affect the results. Three main conclusions were drawn from this analysis: first, “the net welfare gain has a high correlation with the level of uptake of [LHVs]”; second, “the average increase in payload is also an important factor”, although the economic imperative of using LHVs efficiently means that they are unlikely to be used much in the short-distance sector (in which payloads tend to be smaller). Finally, the assumptions surrounding external costs have a large impact on the analysis of the effects of LHVs.

The mean values found in the Monte Carlo analysis informed the selection of input values and parameters for use with the computer modelling software. This, in turn, was used to forecast which transport corridors throughout Europe would be subject to increased use of LHVs. The trade flows served are “spread across Europe. There is a higher concentration in Germany, Belgium, the Netherlands and the UK.” Whilst the areas in which LHV traffic was predicted to increase would “benefit from the decreased traffic and congestion levels” they would also bear “the costs of improving the design characteristics of infrastructure where necessary.”

The study found that “there seems to be a consensus concerning the benefits that [LHVs] can bring for operators and for the economy as a whole.” However, it accepted that some other studies “identify potential problems raised by the introduction of [LHVs] that in most cases concern their external costs.” The analysis undertaken by the study suggested that these concerns could be managed. In the first instance, it found that the main market for [LHVs] would be in replacing conventional trucks, and that this would lead to reduced

\(^2\) A computer-based simulation technique that models risk by providing a range of possible outcomes and probabilities for different scenarios.
external costs, suggesting that any such costs related to modal shift would not be as great as external benefits. Furthermore, the impact of modal shift could be limited by regulatory requirements for a minimum load factor for LHVs, and by applying a charge on operators per journey undertaken by LHV.

The study concluded that “the introduction of [LHVs] would be beneficial for the EU economy and – under certain conditions – environment and society as a whole.”


This study focused on the results of 15 years’ experience in the Netherlands of trialling LHVs. These results are of particular interest due to the location of the Netherlands (sharing many land borders with other Member States) and the nature of its economy, which is highly developed and has a strong rail and waterborne freight industry. The report was strongly in favour of LHVs, claiming that “the experience in the Netherlands, and in other countries like Sweden and Finland, clearly indicate that the benefits are great and the risks non-existent or manageable.”

The study explained at length the nature of the trials undertaken in the Netherlands, giving technical details of the LHV configurations allowed in the test, the numbers of road haulage operators taking part in the trials, the approach to the phasing of the trials (which at the time of publication of the report had involved three distinct phases, each with a larger number of participants than the last), and the performance of the vehicles in terms of safety and infrastructure wear.

The study detailed the Dutch government’s approach to the way LHVs interact with infrastructure, noting that “the basic principle that guides the Dutch policy relating to LHVs is that they should fit the existing road infrastructure and not the other way round.” As a result of studies undertaken into the strength of bridges and other infrastructure, the Dutch government cleared LHVs for use on the Dutch motorway network. In addition to this a number of ‘LHV core areas’ were established, such as ports and industrial facilities, where LHV trips would be expected to start or to end. Besides, roads that connect motorways to LHV core areas were cleared for LHV use by regional road authorities. The principle that LHVs should fit the existing infrastructure has an exception, in that the Dutch government accepted there would be a need to invest in motorway rest areas, due to the increased size of LHVs.

In assessing the impact of the LHV trials on infrastructure, the study noted that “LHVs are unlikely to create any additional damage to the primary structure of concrete traffic infrastructures” but that there may be additional damage to steel structures. Furthermore, the study pointed to research undertaken into the Dutch LHV trials which showed that “a regular 50-tonnes tractor/semi-trailer combination appears to exert more pressure on a structure than a 60-tonne LHV.” The study found that there were “very few traffic situations in the Netherlands that clearly require some kind of adjustment to the road layout and infrastructure to allow LHVs.”

The study considered the impact of LHVs on safety in two ways – objective safety, and subjective safety. Objective safety is the empirically realised effect on safety of LHVs, whilst subjective safety is to do with how safe LHV and other road users feel. In terms of objective safety, the study found that “from 2007 to mid 2009, eleven accidents occurred
involving an LHV. In all of these eleven cases there was only material damage [...] In seven out of the eleven accidents, one of the LHV-specific characteristics may have played a part (i.e. the extra length, or swerving). However, these seven accidents all are typical truck accidents.” The study concluded that there was “no deterioration of traffic safety when LHVs are admitted.” In terms of subjective safety, the study reported surveys that showed that “there is little resistance to LHVs and that motorists do not usually feel unsafe when they encounter LHVs in traffic.”

The study was able to draw on the evidence of the trials in order to assess the extent of modal shift from rail and waterborne to road. Based on an analysis of the second Dutch trial of LHVs (2004-2006), the study found that “in theory a maximum of 505,000 extra tonnes of freight could be transported by LHVs that were originally moved by inland shipping (357,000 tonnes) and rail (148,000 tonnes).” This implied an increase of 0.1% in road transport, with a fall of 0.3% in inland shipping and of 2.7% in rail. The study considered this to be a limited impact.

The study included a number of interviews with stakeholders involved in multi-modal freight, and concluded that “LHVs do not pose a threat to the use of inland waterway shipping and rail.” This was the case because “the various modes (road, rail and inland shipping) each operate within their own sub-markets [...] An LHV will therefore mostly take cargo away from regular road transportation, but the effects on the modal split will be marginal.”

1.3.7. ITF – Moving Freight With Better Trucks (2010)

This study considered improvements in efficiency and productivity in road freight that could be achieved through regulation, as well as improvements in safety and emissions. The study was not specifically focussed on Europe, and therefore included analysis of trucks in Australia, Canada, the USA and other countries.

The study analysed regulatory regimes in different countries and compared the impact of different approaches to regulation. One of the conclusions was that “performance based standards can enable innovation in truck design to more fully respond to industrial and societal demands.” Performance based standards, as opposed to prescriptive vehicle design regulations, have been adopted in Australia for a number of regulations. This approach has allowed for a greater degree of innovation in vehicle design, whilst still meeting the policy objectives of the regulation. In Canada, performance standards have been used to test potential vehicle types and configurations, with the results then informing the development of prescriptive standards.

The study supported the conclusions of other research that “considerable productivity improvements and emissions reductions can be achieved” through the introduction of longer and heavier vehicles. It cited other studies undertaken in Sweden, Canada and Australia in which estimates were made of how many additional ‘conventional’ trucks would have been required had these countries not adopted longer and heavier vehicles. In all three cases, the studies found that a significant additional number of trucks would have been required. In the Swedish and Canadian studies, the percentage of additional trucks was estimated at 35-50% and 80% respectively, with the total additional cost to hauliers estimated at 24% and 40% respectively.

With regard to modal shift, the study stated that “reducing the unit cost of road freight will tend to stimulate demand for road haulage,” leading to modal shift. However, it did not
predict what proportion of rail and waterborne freight would transfer to road if longer and heavier trucks were introduced, since “the impact of road freight productivity improvements on other modes of freight transport varies greatly between freight market sectors and between regions.” It also noted that “the economic literature on the price sensitivity of road freight demand is thin and records a wide range of responses.” At the same time, the study did point out that by facilitating an increase in the use of intermodal load units, LHVs could improve multi-modal operations, and that introducing LHVs “can therefore have positive impact on rail markets as well as negative impacts.” This was dependent on whether road and rail were complements or substitutes.

In terms of safety, the study conclusions were in line with the consensus that by reducing the number of vehicle-km, the introduction of LHVs should lead to “proportionate safety benefits.” It went further than many others by using computer simulations to provide a “comparative analysis of the dynamic stability, geometric performance, payload efficiency and infrastructure impact” of 39 different types of LGV, including LHVs. This analysis found that LHVs performed as well as LGVs in terms of stability in lane change manoeuvres, and in terms of yaw damping (the rate at which a vehicle ceases oscillating after a manoeuvre) as long as roll-couples were fitted throughout. LHVs performed significantly better than conventional trucks in terms of their static rollover threshold (the amount of force that needs to be applied laterally before a truck will roll over). The only measure on which conventional trucks outperformed LHVs was the low speed swept path – the amount of road required to negotiate a specific turn at low speed.


This study investigated possibilities for increasing the permitted length of semi-trailers in the UK from 16.5m to 18.55m. It was commissioned by the UK Department for Transport after an initial study (TRL, 2008) into LHVs in the UK ruled out allowing LHVs on UK roads, even on a trial basis. The TRL study showed the potential benefits of increasing the allowable dimensions of LGVs in the UK to provide more volume – volume rather than weight is typically the limiting factor in truck loadings. Since the other impact of introducing LHVs were considered to preclude that option, a more focussed study, looking at options for increasing the permissible length of semi-trailers, was commissioned.

The study reviewed evidence from other research, particularly from Europe, in order to draw together evidence on the potential impact of longer semi-trailers (LST). It noted that many of the studies it reviewed were focussed on LHVs, but such studies often focused on LSTs or comparable vehicles, at least in part. It only found two trials specifically focussed on LSTs, one in Germany using ‘300 Big-MAXX’ semi-trailers, and one in Italy (‘progetto diciotto’/’project eighteen’), which trialled LSTs with a total vehicle length of 18m. Results were only available for the German study, and these suggested that “the Big-MAXX will not have any impact on the road safety of other road users.” The study noted that “one of the key points of debate regarding the conflicting results from the different forecasting studies of LHVs/LSTs relates to the embedded demand elasticities within the models that were used.” In comparing the different evidence bases across Europe, the study asserted that “the relevance to Great Britain of Dutch experience is probably greater than that in Scandinavia owing to similarities in geography and population density.”

The evidence available on the impact of increased semi-trailer length on vehicle performance was also considered. This evidence was gathered from several sources, including desk research, engagement with industry, computer modelling, and analysis of
accident data. In considering several possible vehicle combinations that would increase the length of a vehicle to 18.55m or less, the study found that “it would be very difficult for a longer vehicle to provide an improved performance over an existing vehicle in every metric considered.” In effect, improvements in vehicle performance in one area were often accompanied by comparative deteriorations in performance in other areas. For example, if the increased semi-trailer length were to be achieved through an increase in the wheelbase, the vehicle would become more susceptible to cross-winds, but would have better dynamic performance when changing lanes. However, if the increased length were achieved with a shorter wheelbase, it would perform better in cross-winds, but worse when changing lanes.

The study found that “overall there can be net performance improvements relative to existing vehicles” and that “where individual reductions in performance are predicted, these can be mitigated or improved by the imposition of design restrictions or new performance standards.” Three broad regulatory approaches were considered: do nothing (baseline); increase semi-trailer length whilst requiring compliance with existing regulations; or increase semi-trailer length and require longer vehicles to exceed or match the performance of existing vehicles.

In terms of safety, the study found that allowing longer semi-trailers without insisting on improved vehicle performance may lead to a very small increase in casualty risk per vehicle-km, but that this is a very small risk and can be mitigated by restricting the height of the vehicles to 4.6m. If better vehicle performance were required, a very small reduction in the casualty risk per vehicle-km would be expected.

A cost benefit analysis of 14 different ‘vehicle options’ was undertaken in order to derive a ‘best estimate’ of the costs of the vehicle operation. For each vehicle option, the study also stated which regulatory system would be required to encourage its take-up. This analysis used computer modelling of take-up rates for the various different vehicles, taking account of the characteristics of freight markets such as average length of haul, and whether the payload was weight or volume constrained. External factors, such as greenhouse gas emissions, congestion and noise were estimated by using adjustments agreed with the UK Department for Transport. No impact on infrastructure was modelled, on the basis that the previous study into LHVs in the UK had found that longer semi-trailers would not have a negative impact in terms of infrastructure wear.

By considering all of these factors together, the study quantified the likely benefit to the road freight industry of the introduction of each of the 14 possible vehicle combinations considered. It found that in all cases there were benefits to the road freight industry, with the exception of one combination; even in this case, benefits were expected in the central case scenario, but dis-benefits were expected in a ‘low’ benefits sensitivity test. When taking into account external costs (greenhouse gases, safety, etc), including the impact of anticipated modal shift from rail to road, all 14 combinations still produced benefits with the exception of one combination in a ‘low’ benefits sensitivity test.

The analysis found that, in net present value (NPV) terms, over the period 2011-2025 the introduction of longer semi-trailers (if accompanied by the use of longer intermodal units by the rail freight industry) would be likely to lead to £5bn benefits for the road freight industry, with an additional £1.5bn of environmental and other societal benefits. The study anticipated that the introduction of LSTs would lead to a “major diversion of the growth in domestic intermodal traffic from rail to road, though nevertheless the rail traffic market would grow strongly over time.”
The study found that the vehicle options with the greatest benefit to the road freight industry and to wider society could be introduced without the requirement that the vehicles should have improved vehicle performance.

1.4. Conclusions

The studies reviewed reflect a range of opinions and research on the subject of LHVs. There are a number of commonalities between these studies which can be considered to represent broadly accepted conclusions, such as:

- LHVs will make road freight transport more cost-efficient, by reducing costs per tonne-km;
- Costs will be higher per vehicle-km, however, due to the increased size and weight of the vehicles;
- A degree of modal shift from rail to road is anticipated if LHVs are introduced;
- Casuality rates would be unlikely to deteriorate on a per tonne-km basis and could probably improve, although they may worsen on a per vehicle-km basis; and,
- There are significant gaps in the evidence base.

The remainder of this study focuses on those areas where there is little or no consensus, such as:

- The extent of any modal shift effects;
- The appropriate parameters, especially elasticities, to use in deriving anticipated modal shift effects;
- Whether LHVs will improve the performance of freight with regards to GHG emissions;
- The extent to which LHVs will increase the deterioration of various aspects of road infrastructure, and how much investment would therefore be required in the road network; and
- The degree to which experiences in Member States which either already permit or have trialled LHVs can be extrapolated to an EU level.
2. ASSESSMENT OF ISSUES

2.1. Current LHV traffic within the EU

This chapter gives an overview of the recent evolution of megatrucks traffic in the European Union and discusses the main factors influencing the size of the potential market for such vehicles.

2.1.1. Freight transport in the European Union

Figure 1 shows the evolution of the total inland freight market (including road, rail, inland waterways and pipelines) in the European Union. After remaining broadly constant between 2006 and 2008, total volumes within the EU experienced a fall due to the recession in 2009. In 2010, the market for freight transport recovered slightly, but remained smaller than the 2007 peak.

Figure 1: Tonne-km generated in inland freight transport in the EU

In 2010, the dominant mode in freight transport was the road sector, accounting for a market share of 73%. This was followed by rail with 16% and inland waterways with approximately 6%. Pipelines accounted for the remaining 5%.
2.1.2. Road freight in the European Union

Figure 3 shows the evolution of the total road freight market within the EU. In 2011, 67.2% of a total of 1,730 billion transported tonne-km was national transport within one of the 27 Member States. International transport, including cross-border\(^3\), cross-trade\(^4\) and cabotage\(^5\) transports, accounted for 32.8% of transported tonne-km.

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\(^3\) Cross-border transport is international road transport between two different countries performed by a road motor vehicle registered in one of these two countries.

\(^4\) Cross-trade transport is international road transport between two different countries performed by a road motor vehicle registered in a third country.

\(^5\) Cabotage transport means the national carriage of goods for hire or reward carried out by non-resident hauliers on a temporary basis in a host Member State.
Due to the economic downturn, the road freight market experienced a sharp decline in 2009, decreasing by 10.1%. Although the market recovered slightly in 2010, its transported volumes in 2011 still remain about 10% below its peak in 2007. International transport volumes have proven to be more volatile than national volumes over the last five years, as can be seen in Figure 4.

Together, the six largest national markets (Germany, France, Spain, the UK, Italy and Poland) account for approximately 80% of the total of national road freight markets in the EU, as presented in Figure 5. At the moment, LHVs are only permitted in one of these countries (Germany), and even there this is only on a trial basis.
2.1.3. **LHV traffic in the European Union**

Weights and dimensions of heavy goods vehicles are currently regulated by Directive 96/53/EC which sets a maximum length of 18.75m and a maximum weight of 40 tonnes (44 tonnes for combined transport) for a truck with trailer in the European Union. However, several possibilities are open to the Member States (under conditions) to permit longer/heavier vehicles for transport within their own borders.

**The normal use of LHVs with a maximum weight over 40 tonnes is currently only permitted in Finland and Sweden.**

- In Finland in 2010, the share of road freight (in tonne-km) for LHVs with a maximum permissible weight equal to or more than 60 tonnes was 73%. Given that the total size of the Finnish road freight market was 25bn tonne-km in 2010, the market share of LHVs with a maximum permissible weight equal to or more than 60 tonnes was approximately 18bn tonne-km.

It should be noted that statistics in Finland do not provide a clear distinction between vehicles with maximum permissible weight of up to 40 tonnes and LHVs with maximum permissible weights of over 40 tonnes. The market share of LHVs with permissible weights over 40 tonnes may therefore be higher than the above mentioned 73%, which only accounts for vehicles with a maximum permissible weight of 60 tonnes or more.

- In Sweden, LHVs with a gross combined weight of more than 40 tonnes had a market share of 90% in the road freight market in 2010. This share translates to a total of 33bn tonne-km transported by LHVs.
In addition to these two exemptions from the Directive, trials are currently taking place in Denmark, Germany and the Netherlands.

- The trial in Denmark started at the end of 2008, and by 2010 the share of LHVs in the national road freight market was 3.6%. The number of LHVs on Danish roads was around 450 at the end of 2010 and was estimated to be 600 at the beginning of 2013.

- In Germany the trials only started at the beginning of 2012. As of April 2013, the number of registered LHVs is negligibly small, at 38. Accordingly, freight volumes transported by LHVs are also negligible.

- In December 2001, the Dutch government started a limited trial with just four participating companies and LHVs. This was followed by a more extensive second trial, and the current on-going third trial, which started in 2007. In January 2010, the trial involved 196 participating companies and more than 400 LHVs.

Figure 6 shows the national markets in Europe where the use of LHVs is currently permitted and their respective size, in volume, compared to the whole EU market (LHVs are permitted in Member States that together account for approximately 32% of the European market in volume). Nonetheless, as set out in Figure 7, LHVs are only used for transporting just over 4% of the European market in volume (given that no information on the size of the markets (in tonne-km) was available for Germany and the Netherlands, the figures for these two Member States were estimated based on the number of vehicles participating in the trials).

**Figure 6:** EU road freight market in volume and the share of those national markets where LHVs are permitted

When comparing market shares of LHVs in different countries, differences in maximum permissible length and weights, and the respective dates of the opening of the market need to be taken into account. While in Finland and Sweden vehicles with a maximum permissible weight of 60 tonnes are permitted, Germany normally permits only vehicles with a maximum permissible weight of 40 tonnes, or 44 tonnes in the case of combined transport, and LHVs are an exception. Weight restrictions clearly impact the size of the market as they exclude particularly heavy goods with low capacity utilisation. The recent opening of the market to LHVs, by way of a trial, at the end of 2008 may explain the low, but gradually increasing, market share in Denmark compared to its two Scandinavian counterparts. In the recent trials in Germany, the size of the market for LHVs is restricted by the limited road network where they are allowed.

### 2.1.4. LHV cross-border traffic in the European Union

There has been controversy relating to the issue of cross-border traffic and in particular whether LHVs are allowed to operate internationally under Directive 96/53/EC. In 2010, the European Commission indicated that cross-border traffic would not be permitted, an interpretation which was then largely shared.

In spite of this, since 1st December 2009 LHVs have been used between Denmark and Nützen-Kampen in Schleswig Holstein in Germany, crossing the border at Ellund. However, very few vehicles appear to operate between the two countries as Germany has strict rules at the regional level and registration of LHVs is required prior to entry.

In addition to traffic between Denmark and Germany, significant cross-border LHV traffic also occurs between Denmark and Sweden: on the Øresund Bridge, LHVs form a substantial share of total road based goods traffic (about 5.3% of total traffic in 2010, equivalent to 50 vehicles per day in each direction. In 2011, the number of LHVs across the Øresund link increased by 24%).
LHV traffic also occurs between Sweden and Finland - both countries in which megatrucks are operated on a regular basis. According to Lastbilstrafik (2011), in Sweden only 42m tonne-km of international traffic was carried by conventional LGVs, with just under 3,500m tonne-km (99%) carried by LHVs with a gross combination weight above 40 tonnes.

This has prompted several protests and the matter has been referred to the European Commission which, in March 2012, altered its stance, indicating that cross-border traffic would be permitted. The rationale for this was that EU rules were intended to prevent Member States from keeping foreign vehicles that met the standards set out in Directive 96/53/EC from their markets, not to prevent Member States accepting vehicles larger than the maximum set out in the directive.

The Commissioner for Transport confirmed this interpretation in a letter sent to the Chairman of the TRAN Committee on 13 June 2012, noting that “the definitive interpretation of EU law remains with the Court of Justice of the European Union”.

Moreover, in April 2013 the European Commission proposed to amend Directive 96/53/EC to, notably, clarify the position of LHVs regarding international traffic. The proposal states that “the cross-border use of longer vehicles is lawful for journeys that only cross one border, if the two Member States concerned already allow it, and if the conditions for derogations under Article 4(3), (4) or (5) of Directive 96/53/EC are met.”

2.1.5. Potential of LHV traffic in the European Union

The suitability of LHVs for the transport of goods depends on a number of influencing factors. The following sections give an overview of some of the most important ones and explain how they relate to the definition of the potential market for LHVs.

A substantial influencing factor is the existence and network coverage of alternative modes of transport. In many cases the use of a block train results in lower costs than the use of road-based vehicles. However this requires a railway connection on a frequently served link.

In addition, the quality and coverage of the road network allocated to use for LHVs plays an important role. In Germany, LHVs taking part in the trial may only use the motorway network and selected sections of the national road network. A door-to-door service is therefore not normally possible, and in order to reach the ultimate client, goods need to be loaded on smaller goods vehicles which substantially increase transport costs and weaken the competitive position for LHVs.

A recent study prepared by K+P (2011) suggests that LHVs have a particular advantage compared to conventional LGVs in long-distance transport. Figure 8 shows the evolution of the distribution of different trip length ranges in the total transport market of the EU. The figure shows that in 2011 almost 62% of all transported tonne-km had a trip length of over 150km. In addition, the share of long-distance trips of over 300km has gradually increased over the last five years. This was at the expense of short-distance trips of less than 150km.

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In Sweden, LHVs carry almost 10 times as many goods as conventional LGVs in tonne-km terms, but only about 2.5 times the tonnage. This implies a significantly longer average journey length for LHVs (131km) than for conventional LGVs (34km). This finding is in line with the above mentioned anecdotal evidence that LHVs are better suited for long distance transport.

**Figure 8: Evolution of the share of different trip length ranges in the total tonne-km transported in the EU**

![Graph showing the share of different trip length ranges in the total tonne-km transported in the EU over the years 2006 to 2011.]

**Source:** SDG analysis of Eurostat (2012).

The maximum permissible weight and length play an important role in identifying the commodities most suited for LHVs.

For instance, if maximum permissible length were to be increased to 25.25m, but the weight limit remained at 40 tonnes, the maximum payload weight would decrease compared to conventional LGVs due to the longer and therefore heavier vehicle. While the available loading volumes would increase by approximately 54%, the maximum payload weight would decrease by 20%. As a result, LHVs would only be able to take full advantage of their increased length when carrying relatively low density products.

However, if the maximum permissible length were set to 25.25m and the maximum permissible weight increased to 60 tonnes, the potential market for LHVs would be extended to heavier goods that are volume and/or weight constricted when using conventional LGVs.

Evidence from Finland suggests that LHVs are employed predominantly in the transport of agriculture, food, and textiles products, as well as coke and refined petroleum products. In these market segments, LHVs have a market share of at least 75%. On the other hand, their market share is comparably lower in the transport of machinery, transport equipment and basic metals. However, in these markets the market share of LHVs is still around 50%.

**Figure 9** gives an overview of the types of companies participating in the LHV trial in the Netherlands. A total of 150 companies, predominantly from the retail, container transport and floriculture sectors, participate in the trial. The maximum permitted length is 25.25m with a maximum permitted weight of 60 tonnes. The sectors with the largest take-up of

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7 Statistics Finland (2012).
LHVs (retail and floriculture) are largely characterised by low density products, making them ideally suited to transport by LHV. The increased permissible weight of 60 tonnes also encouraged the participation of companies from sectors with typically high loading weights like container transport and bulk cargo.

**Figure 9: Industry sectors participating in the Dutch LHV trial**

![Bar chart showing the number of companies participating in the Dutch LHV trial, with percentages for different sectors.]

**Source:** Dutch Ministry of Transport (2010).

### 2.1.6. Summary: Current Traffic

Following the economic downturn in 2009 and the accompanying decrease in road freight traffic in the EU, 2011 traffic levels are still about 10% below their peak in 2007. Between 2006 and 2011, however, the share of journeys with a length of more than 300km increased gradually, at the expense of journeys with less than 150km.

Road transport is still by far the dominant mode in freight transport in the EU (with 73% in 2010). However, in the EU15 Member States the share of road slightly decreased from 2006 (69.7%) to 2010 (69.3%), whereas in the EU12 Member States its share is gradually increasing (from 62.4% in 2006 to 68.1% in 2010), largely at the expense of rail.

Currently, LHV traffic is only permitted in five Member States, but in three of these only within the framework of a trial. Finland and Sweden are the only two Member States permitting normal use of LHVs on their road network. While the share of LHVs in the total transported tonne-km in Finland and Sweden exceeds 70% and 90% respectively, the respective shares in the other three MSs are substantially smaller (below 10%), mainly due to the nature of the trials and their recent introduction.

An analysis of evidence from Member States where LHVs are permitted and a review of recent research work in this area have shown that there are a number of factors strongly influencing the potential market for LHVs. The main issues discussed in this chapter are the strength of competing modes, network coverage for LHVs, trip length and the type of transported commodity.

In particular, evidence suggests that a high network coverage of roads suitable for LHVs, the absence of competing modes, long trip lengths and low density products generally favour the use of LHVs against alternative modes and conventional LGVs.
LHVs cross-border traffic is also an issue given that it is currently not clear whether it is permitted according to European legislation. Nonetheless, at the moment there are a number of LHVs carrying out transport services between different European countries.

### 2.2. Intermodal Competition and Modal Shift

#### 2.2.1. Current Modal Splits

Freight transport in Europe is dominated by three modes – road, rail and waterborne. Small amounts of freight are transported by air. Additionally, pipelines account for a similar proportion of freight transport to waterborne. However, since pipelines can only transport fluids and are generally not in competition with other modes, we have excluded this form of transport from our analysis. Given the dominance of road, rail and waterborne in the freight sector, these modes will be the focus of this section.

The modal split between road, rail and waterborne across the EU27 countries has remained broadly constant over the last decade, with road freight accounting for approximately 76%, rail approximately 18%, and waterborne approximately 6%.

**Figure 10: EU27 Freight Modal Split in volume (% 2001 – 2010)**

There is a large variation in modal split between Member States. Two of them do not have a rail network (Cyprus and Malta). Rail’s market share in the remaining Member States is shown in Figure 11 below:
Member States have been coloured according to the UN Statistical Division's\(^8\) definition of northern Europe (shown in blue), eastern Europe (red), western Europe (Green) and southern Europe (orange).

The three Member States with the largest market share for rail are Latvia, Estonia and Lithuania, a reflection of the importance of transit rail traffic from Russia. In general, eastern European Member States have larger market shares for rail, whilst in southern European Member States rail typically has a lower market share. The eastern European Member State with the lowest market share for rail (Romania, at 19\%) has a larger rail share than the southern European Member State with the largest rail share (Slovenia, at 18\%).

Northern and western European Member States show no clear pattern; even though five of the six Member States with the largest share for rail are northern European, other northern European countries (the UK, Denmark and Ireland) have low market shares for rail.

### 2.2.2. Elasticities

Amongst the studies reviewed, and elsewhere, the variation in predicted effects of the introduction of LHVs on modal split tends to stem from varying assumptions on elasticities. An elasticity represents the extent to which demand for a good or service changes when its price, or the price of competing goods or services, changes. There are two types of elasticity that are relevant when considering the impact LHVs may have on modal split: ‘own elasticity’ and ‘cross elasticity.’

An ‘\textit{own elasticity}’ represents how demand for a good or service changes when its own price changes. This is also known as the ‘price elasticity of demand’ for a product. The own

\(^8\) [http://unstats.un.org/unsd/methods/m49/m49regin.htm#europe](http://unstats.un.org/unsd/methods/m49/m49regin.htm#europe)
elasticity can be used to calculate the change in demand for a product or service anticipated for a given change in its price, according to the following relationship:

\[
\text{Change in Demand} = e_{RF} \times \text{Change in Price}
\]

where the change in demand and change in price are expressed in percentages, and \( e_{RF} \) is the own elasticity of road freight. So, for a 10% fall in price, an own elasticity of -0.6 would imply a 6% increase in demand, whereas an own elasticity of -1.5 would imply a 15% increase in demand. Own elasticities are normally negative (since demand usually increases when prices fall). A product with an own elasticity between 0 and -1 is said to have inelastic demand, reflecting the fact that a change in price leads to a relatively small change in demand. A product with an own elasticity larger than -1 is said to have elastic demand, reflecting the fact that a change in price leads to a relatively large change in demand.

There is a reasonable degree of consensus regarding the anticipated change in operating costs faced by hauliers if LHV are introduced. From this, it is possible to model the likely change in price for road freight. However, there are significant variations in the own elasticity that different studies consider road freight to have. As a result, in spite of some consensus of the impact of LHV on road freight costs, there is far less consensus on the impact of LHV on the demand for road freight.

A ‘cross elasticity’ represents how demand for a good or service changes when the price of other goods or services changes. The cross elasticity can be used to calculate the change in demand for a product or service anticipated for a given change in price of another product or service, according to the following relationship:

\[
\text{Change in Demand for Product A} = e_{A,B} \times \text{Change in Price of Product B}
\]

where the change in demand and change in price are expressed in percentages, and \( e_{A,B} \) is the cross elasticity of product A with respect to product B. So, for a 10% fall in the price of product B, a cross elasticity of 0.5 would imply a 5% fall in demand for product A. A cross elasticity of -1.2 would imply 12% increase in demand for product A. A positive cross elasticity implies that two products are in competition – product B becoming cheaper makes it more attractive and abstracts demand away from product A. A negative cross elasticity implies that two products are complimentary, such as cars and fuel. Since they are used together, increasing the price of fuel makes owning a car less attractive, and so reduces the demand for car ownership.

Once again, the reasonable consensus on the likely impact of LHV on the price of road freight does not translate to a consensus on the likely impact of LHV on rail freight demand, since there is little consensus on the cross elasticity of rail freight with respect to road freight.

The anticipated reduction in operating costs associated with the introduction of LHV varies between studies, but is usually between 20-30%. However, the variation in elasticities used, and the potential mode shift effects, is much wider. TML (2008) investigated the variation in elasticities used in other studies at length. Within the modelling suites reviewed, there was a range of own elasticities from -0.08 (suggesting inelastic demand which does not react much to changes in price) to -1.55 (suggesting elastic demand which reacts fairly strongly to changes in price). TML also reviewed cross elasticities of rail freight with respect to the price of road freight, and found a range of values from 0.4 to 2.08.
2.2.3. Introduction of LHVs and modal shift

The introduction of LHVs across Europe is generally anticipated to reduce the operating costs per tonne-km of transported goods for road freight, even if the costs of operating each vehicle are higher. This reduction in costs would then lead to road freight transport becoming more competitive at the expense of rail and waterborne, and consequently to modal shift.

Whilst there is broad consensus within the literature on LHVs that some modal shift effects would occur should LHVs be introduced, there are large variations in the predicted size of this impact. Several factors affect the variance in predicted outcomes:

- The choice of elasticities used in modelling freight flows by mode;
- The anticipated reduction in road freight operating costs per tonne-km;
- The assumed level of substitutability between road freight and other modes; and
- The available capacity of other modes.

Of the studies considered in our literature review, the ISI (2008) study predicts severe modal shift impact across the EU as a whole, anticipating declines in rail volumes (in tonne-km) of 20-30% in the continental container traffic market, 10-20% in the maritime container traffic market, 10-15% in the food market and 3-5% in the bulk goods market. TRL (2008), focussing on the UK market, found even higher anticipated reductions in tonne-km transported in the bulk goods market (5-10%) and deep sea containers market (22-54%). These two market segments, as defined by the study, make up 88% of total UK rail freight, and the total impact on UK rail freight of introducing LHVs was anticipated to be a fall in tonne-km of 8-18%. The TRL study did note that the trials in the Netherlands showed a much lower modal shift effect, and that these trials have the benefit of having “considerably more objective evidence available from which to quantify [the] effects.”

The report by the Netherlands Ministry of Transport found, anecdotally, that “the vast majority of participants [in the study] (90%) think that LHVs will not cause measurable mode shift.” The limited macro-analysis that the Ministry was able to carry out using data from its second trial estimated the modal shift impact of the introduction of LHVs in the Netherlands would be very small compared to those anticipated by ISI and TRL, with a 0.1% increase in tonne-km transported by road, a 0.3% decline in waterborne, and a 2.7% decline in rail. Based on observed evidence and stakeholder submission, the report found that LHVs “will mostly take cargo away from regular road transportation [and] the effects on the modal split will be marginal.”

JRC’s (2010) study also found modal shift impact to be small compared to those found by TRL and ISI, predicting a decline in rail tonne-km of 1.5% in the year 2020 if LHVs are introduced. TML on the other hand, using the TRANS-TOOLS modelling approach, found that rail tonne-km would decrease by 5-15% as a result of the introduction of LHVs. However, it set this decline against anticipated growth in the rail freight sector of 60.8% from 2005 to 2020. Hence, the study found that the modal shift effect would simply slow the rate of growth in rail freight, from 3-4% per year without LHVs to 2.5-3.5% with LHVs.

VTI (2008) studied the potential impact in Sweden (where LHVs are already permitted) of removing LHVs. The study made explicit reference to the fact that the Swedish rail network has no spare capacity for additional rail freight. Therefore, no mode shift would happen in Sweden even if LHVs were to be removed, implying higher operating costs for road freight which would normally lead to mode shift to rail. To address this, the study investigated the impact that removing LHVs would have assuming that the necessary investment in rail
capacity had occurred. The study found that the scenario in which LHVs were removed from Swedish roads, but where there was spare capacity in the rail industry, would lead to a modal split of 60% for road and 40% for rail. With LHVs permitted, the modal split would shift to 66% for road and 34% for rail.

A key implication of the study is that the degree to which competing modes are operating at or near capacity will affect the potential for changes to the modal split. In the Swedish case, the conclusion is that improving rail’s competitive position does not improve its modal share, since it has no more capacity. Similarly, if rail freight is already operating at or near capacity in other parts of the EU, the introduction of LHVs, whilst potentially making road freight more competitive, may have no effect on modal split if it only reduces the excess of demand for rail freight.

Due to the limited areas in which LHVs have been permitted in Europe hitherto, there is a lack of direct evidence to show the impact of the introduction of LHVs on modal split. Evidence gathered for the case studies of Denmark and Germany, where limited trials of LHVs have taken place, is not comprehensive enough to draw any conclusions. As noted above, the Ministry of Transport in the Netherlands has drawn upon the limited evidence available from its trials, and anticipates only low levels of modal shift as a result of the introduction of LHVs. As part of the ongoing trials in the Netherlands, more detailed investigation into modal shift as a result of the introduction of LHVs will be undertaken. A ‘baseline’ measurement of the modality use of incoming and outgoing goods at multi-modal terminals has already been taken, and a follow-up measurement at the end of the third trial will also be taken to compare the results and find evidence for any apparent modal shift.

The Swedish case study noted the large market share for rail in the Swedish freight market compared to other EU Member States, which is in spite of LHVs being historically permitted throughout Sweden. Whilst the geography of Sweden plays a part in the high modal share for rail (rail covers large distances, with the network having been strategically planned to cater for Sweden’s mines and logging industry and a few very large shippers generating most of the traffic), the Ministry of Enterprise, Energy and Communications note that the demand is there for rail’s modal share to be even higher.

The Finnish case study, similarly to the Swedish one, showed that in spite of being one of only two Member States to permit the use of LHVs throughout the country, Finland still has one of the largest modal shares for rail in Europe.

### 2.2.4. Summary: Intermodal Competition and Modal Shift

In assessing the likely effects of the introduction of LHVs across Europe, the impact that this would have on modal split is of critical importance. The impact of introducing LHVs on infrastructure, greenhouse gas emissions and road safety depends critically on the demand response of both road freight and competing modes, most specifically rail freight, to their introduction, as this directly influences the modal split. These effects will be examined in detail in the following sections.

There is significant disagreement about the impact of LHVs regarding the extent to which the benefits accruing from using less vehicles to transport the same amount of goods are offset, or even reversed, by changes in modal split. If reduced operating costs lead to substantial modal shift to road freight, there are likely to be overall disbenefits associated with freight moving from relatively clean modes, like rail, to road.
Whilst some of the studies estimate a relatively large impact on modal split as a result of the introduction of LHVs, it is notable that this has not been observed in the trials in the Netherlands, and is not reflected in the modal split in Sweden and Finland, which have some of the largest modal shares for rail in spite of historically allowing LHVs. Stakeholders in Sweden attribute this to each mode having its own competitive advantages in different sectors, and to continued investment in both the rail and road freight networks in Sweden.

The difference between modal split effects anticipated through modelling and those observed in the field could be explained by a number of factors. ISI (2008) consider the low modal shifts observed in the field to be a result of the limited geographies of the trials undertaken, which restrict LHVs to operating within national boundaries (the issue of cross-border traffic is dealt with in Paragraph 2.1.4). This has the effect of removing LHVs’ main competitive advantage, which is in long distance travel. Whilst this theory could certainly be supported in the Netherlands trials, it is less easy to extend it to the examples of Sweden and Finland, both of which are large countries where freight is often transported over very large distances. It may also be the case that the modelling assumptions do not adequately take account of the various competitive advantages of different modes in different sectors, and therefore underestimate the resilience of rail to reduced operating costs for road freight. However, the modelling frameworks used to undertake the analyses are intended to be comprehensive and to take account of the different impact by sector, which should control for this.

Finally, the modelled results may not adequately assess the potential capacity for rail freight. If the demand for rail freight is already constrained by infrastructure supply, as in Sweden, this may lead to reduced road freight costs reducing the level of excess demand without impacting significantly on the realised demand for rail freight. It is particularly difficult to assess the capacity for rail freight in different Member States, since the availability of freight paths on the rail network is likely to be a function of government policy, which must balance the demand for rail passenger services with the demand for rail freight.

### 2.3. Impact on Road Infrastructure

LHVs are likely to have an impact on road infrastructure because of their increased volume and weight which could affect road wear, bridges, traffic junctions, pavements and rest areas. The size of these effects is a matter of discussion, with some studies predicting significant impact and others less so. In the case of some aspects, such as road wear, the reduced weight-per-axle of some LHV formations may even reduce road wear in comparison with LGVs.

The impact of LHVs on road infrastructure can be categorised into three main areas:

- The long-term impact of heavier weights on road wears and the additional maintenance costs arising from it;
- The impact on volume and space, both on roads (tunnels, carriageways, level crossings, roundabouts) and at off-site facilities (parking, terminals); and
- The impact on structures such as bridges, requiring one-off improvements to withstand the additional pressure exerted by LHVs.
2.3.1. Road Wear

Road wear is normally considered to be the result of strain-fatigue caused by load repetitions. Thus the total load of the vehicles on roads is an important factor to take into consideration. However, research by WSP (2010) and the Netherlands Ministry of Transport (2010) has shown that LHV’s do not have a significantly more negative impact on the conditions of pavement and road structure than conventional LGVs. This has been confirmed by research carried out in Germany (Glaeser et al. 2006).

Vehicle weight is not considered to be a sufficient indicator of strain for road wear. The actual weight-per-axle needs to be taken into account when assessing the impact of LHV’s. Despite their increased weight, LHV’s often have a greater number of axles across which weight can be distributed, therefore reducing the axle load. The importance of assessing axle load rather than vehicle load is emphasised both by TML (2008) and VTI (2008), both of which note that weight-per-axle might even be lower for LHV’s.

A similar point is made in the TRL (2008) study. Figure 12 shows the wear factors of eight types vehicle. The wear factor increases as vehicle weight increases, and decreases as the number of axles increases. The study differentiates between measuring road wear per vehicle and road wear per 100 tonnes of goods transported. When considering road wear per 100 tonnes of goods transported, the road wear factors of heavier vehicles with a higher number of axles are not very different from the base case (44 tonnes and 6 axles) analysed. The type of vehicle is also an important factor in determining road wear.

Figure 12: Road wear factors by gross weight and number of axles

The distance between axles should also be taken into account, because with narrow spacing complete strain release does not take place between load applications. The ETSC (2011) thus distinguishes between the ‘static loading’ and ‘dynamic loading’ impact of LHV’s, arguing that the latter has a greater impact on road wear, given the repetitive application of loads in a short timeframe. Research by Glaeser et al. (2006), however, shows the impact of a higher frequency of imposed stress to be “relatively small”. The Finnish Ministry
of Transport’s assessment of a potential reduction in maximum permitted dimensions concluded that this would lead to shorter distance between the front and rear axles of vehicles and increased loads per axle.

2.3.2. Volume

TML (2008) and the Netherlands Ministry of Transport (2010) both note that parts of the road network previously designed to accommodate traditional LGVs require work to accommodate the volumes of LHV. In particular, it is necessary to ensure that the roads used by LHV have wide enough carriageways and roundabouts, and that parking, rest and waiting facilities along motorways can cater for them. The issue of parking areas in particular is already being closely monitored by the European Commission and its social partners (IRU and ETF) given the lack of these facilities in many Member States.

Planning for roads that can accommodate LHV also involves planning for safety. The ETSC (2011) has warned that existing truck safety infrastructure facilities, such as runaway truck ramps, lay-byes and emergency lanes are not designed for LHV. Likewise, ISI (2008) and K+P (2011) highlight the risks arising from LHV approaching rail-road level crossings (where longer clearing times require a reconfiguration of signals and gate times) and road level crossings (where LHV may impact on the capacity of the nodes).

2.3.3. Structures

The impact of LHV on suspended structures is recognised as one of the most problematic issues by the majority of the studies reviewed here. Research by TML (2008) shows that, were LHV to be introduced, “some bridge lifetimes would be affected and higher investments in bridge maintenance and replacement would be needed”. Similar concerns are echoed by the Netherlands Ministry of Transport (2010), with a specific focus on steel structures and their resilience.

Bridges are designed to sustain a certain maximum load and may not be able to sustain the pressure of heavier vehicles, especially when there may be multiple vehicles crossing the same bridge simultaneously. This is why some studies have also explored the possibility of introducing traffic and access control mechanisms to protect bridges from major damage (OECD and ITF 2010), such as weigh-in-motion and GPS tracking.

Similarly, some tunnels would have to be adapted in order to ensure that safety requirements were met, especially if LHV are to carry dangerous goods. This is because the duration of a fire is determined by the combustible mass (Rapp 2011). In addition, ISI (2008) and K+P (2011) point to the need to reduce some gradients on hilly and mountainous road networks to reduce the risks of collisions and avoid dangerous slowing down of LHV.

2.3.4. The costs of adapting road infrastructure

Impact assessments have been carried out in Member States where LHV are not yet allowed or are on trial, with the aim of estimating the costs of adapting road infrastructure for LHV.
The German Ministry of Transport estimates that bridge rehabilitation and replacement costs for accommodating LHV s on the federal road network would be between €4 and €8 billion. This cost would be driven primarily by the work needed for bridge structures, with investment in parking areas being the second most important component.

A study on the impact of LHV s in Switzerland by Rapp (2011) provides detailed estimates of the costs that would be incurred to adapt a portion of the national road network (motorways and connected roads) for the circulation of LHV s. These cost estimates range from a minimum of €144 million to a maximum of €450 million, without taking into account the mitigation costs to prevent safety risks. The necessary investment for bridges ranges from 30% to 60% of the total infrastructure cost. A large portion of costs would come from investment in parking and waiting areas at customs and border crossings.

2.3.5. Empirical evidence of the impact of LHV s on infrastructure

Finland has a long history of using LHV s, and the road network has been built to satisfy these demands. In Finland there are no restrictions on the use of LHV s, except in areas where there are general prohibitions on freight traffic. Vehicles with lengths of up to 25.25m are used on long distance routes that are concentrated mainly on motorways and main roads, avoiding towns and city centres. A common procedure is to decouple the dolly and semi-trailer and use the truck as a distribution vehicle when unloading in city centres.

As Finland has always permitted LHV s, there have not been many studies on the impact of these vehicles on road infrastructure. The Finnish Ministry of Transport and Communications (1994) study discussed the potential impact of a reduction in the maximum authorized weights and dimensions permitted in road freight transport. It calculated that a reduction in maximum dimensions (to a maximum weight of 44 tonnes, length of 18.35m and width of 2.55m) would have a negative impact on road infrastructure, due to the shorter distance between the front and rear axles of vehicles and increased loads per axle. The extra cost was estimated to be FIM 300m (€50m).

The Ministry of Transport and Communications (2002) study focused on the calculation of the impact of LHV s in terms of road wear, with respect to the number of equivalent axles in the vehicle and the net load size. The results of the study showed that LHV s would have a lower impact than conventional LGV s.

Sweden has modern, well developed freight infrastructure. Since LHV s have historically been permitted on Swedish roads, infrastructure has been designed with this in mind.

VTI (2008) notes that since harmonisation of load-bearing standards across the EU in 1985, Sweden has undertaken an "extensive load-bearing capacity initiative" which has allowed the maximum gross vehicle weight on Swedish roads to be increased in stages from 51.4 tonnes (pre-1990) to 60 tonnes (since 1993). The initiative has cost approximately SEK 22bn (€2.7bn) in 2012 prices and was "largely funded by business through an increase in vehicle taxes."

The Swedish Ministry of Enterprise, Energy and Communications is constantly investing in the road network. Recent improvements over the last 10 years include the replacement of some intersections with roundabouts that are designed with additional paved run-off areas which allow for LHV s to turn efficiently. A priority for investment is to improve main freight routes by separating single carriageway roads into dual carriageways. This is particularly
important in the north of Sweden, where many freight routes are along small, single carriageway roads.

Throughout Sweden, roads are designated with weight limits. This generally restricts LHV movements to long distance travel as opposed to ‘final leg’ deliveries, since the weight limits on urban roads are much stricter than on highways. Bridges are considered to be the most vulnerable parts of the road infrastructure, and LGVs or LHVs which do not meet the conditions for crossing any one bridge are forced to use alternative routes. Weight limits are enforced by the use of weigh-bridges.

The Ministry of Enterprise, Energy and Communications noted that, were the very long and heavy vehicles (up to 90t in weight, and up to 30m in length) that are being trialled permitted more widely on Sweden's roads, resting places would need to be improved, as these can currently only accommodate LHVs of up to 25.25m in length.

Denmark has a well-developed freight infrastructure network, with a high density of motorways, ports, railway stations and airports. The geography of Denmark requires substantial investment in what are known as ‘fixed links’ - connecting roads and bridges between the mainland, the islands and other Scandinavian locations. Two of these links, the Great Belt and the Øresund bridges, are very modern structures which have attracted heavy investment in recent years.

Further investment has been triggered by the introduction of LHVs during the trial period started in 2008 and scheduled to run until the end of 2016. Approximately DKK 135m (€18m) has been invested in road infrastructure in order to allow LHVs to drive safely on the designated road network. This includes investment in intersections, roundabouts, motorway crossings and parking facilities. It is estimated that these investments will generate an additional annual expense for infrastructure maintenance of about DKK 1.3m (€0.2m).

The actual costs incurred in Denmark for the adaptation of road infrastructure are significantly lower than the estimates for other countries discussed above. Compared to a similar size network in Switzerland, for example, infrastructure costs in Denmark appear to be 14 times lower even when annual maintenance costs are summed over a period of 10 years. Anecdotal evidence suggests LHVs are mostly used for goods such as flowers and mail, where the limiting factor for loads is volume rather than weight. This indicates that larger vehicles may not necessarily be heavier too, depending on the type of goods carried, and thus infrastructure impacts will necessarily vary.

In Germany, LHVs have been allowed on a trial basis since January 2012. Strict requirements must be met in order to allow LHVs to be granted permission to circulate. To date, the number of LHVs on German roads is limited.

In 2007, the Federal Highway Research Institute (BASt) conducted extensive research on the technical impact of the introduction of LHVs on the German motorway network. They concluded that LHVs do not have a more negative impact on the conditions of pavement and road structure than conventional LGVs, partly because the impact is expected to be smaller due to lower tonnage per axle. The impact of the higher number of axles and the therefore higher frequency of imposed stress on the pavement was expected to be small. However, trials have only been carried out in laboratories.

The BASt also noted, however, that the current road infrastructure (e.g. roundabouts) is not designed for LHVs and that therefore pedestrians and cyclists could be harmed and
parts of the infrastructure damaged. In addition, parking facilities at service stations on motorways are designed for vehicles with a length of 18.75m. Therefore, the introduction of LHVs with a length of up to 25.25m would require substantial investment in infrastructure.

In the United Kingdom, the Department for Transport commissioned the TRL (2008) study, in which the effects of the potential introduction of LHVs on road infrastructure were assessed. It was concluded that LHVs would not have a very significant impact on structural road wear, that most bridges would be adequate to support them but that there would be increased risks from LHV collisions, and that the existing problems in relation to parking would be exacerbated. We understand that, partly as a result of the findings of the study, the government has decided not to allow LHVs in the UK.

However the British Road Haulage Association contends that the LHV vehicle ‘Denby Eco-Link’ that Denby Transport\textsuperscript{9} is promoting performs better than many longer semi-trailer combinations regarding EU turning circle standards. The axle weight improves with LHVs (due to a greater number of axles) – running at 60 tonnes, the axle weight on an LHV is smaller and less damaging than that of trucks currently operating on UK roads.

In Italy, the debate on the introduction of longer and heavier vehicles is influenced by the country’s geography and the conformation of its motorway network. National roads are characterised by the high number of bridges, tunnels and bypasses.

In the past, a trial to extend the maximum length allowed on Italian roads from 16.50m to 18m (‘Progetto Diciotto’) was welcomed by the industry associations. However this extension was still within the limits set out in Directive 96/53.

However, the decisions made by bordering countries with respect to LHVs have to be taken into consideration, especially in relation to cross-border traffic through the Alpine corridors. Local associations in the Alps are also voicing their concerns due to the safety and environmental impact of LHVs; these associations cite the example of Switzerland, which has banned LHVs altogether, to support their arguments.

The latest reactions to potential cross-border activity of LHVs have been mixed: ANITA, a national hauliers’ association, said they are in favour of introducing LHVs in Italy as this would particularly benefit smoother inter-modal transport at Italian ports. Fai Contrasporto, another industry association, have expressed their concerns regarding LHVs due to their negative impact on infrastructure in the Alpine corridors (the roads are too narrow to accommodate these vehicles) and on modal shift away from rail.

\textbf{2.3.6. Summary: Impact on Infrastructure}

The impact of LHVs can be divided into three main categories: impact on road wear, mainly caused by the greater weight of these vehicles; impact on space requirements, including the need to widen carriageways, curves and roundabouts and to provide additional parking spaces; and impact on structures and in particular bridges and tunnels where safety needs to be safeguarded.

\textsuperscript{9} The Denby Eco-Link is the British LHV prototype developed by Denby Transport. It is 25.25m long and can weigh up to 60 tonnes.
However, the likelihood and magnitude of these effects depends on a number of factors. These include: the relative modal share of LHV s over time; the actual maximum weight of the vehicles allowed; the number of axles and thus the relative distribution of such weight; the type of goods being carried; and the frequency and spacing in the traffic flows of LHV s.

Likewise, the need to invest in infrastructure is dictated by a careful assessment which can only be done at a national or even local level. The evidence collected suggests that the potential impact of LHV s on infrastructure translate into additional capital and maintenance costs depending on the quality and age of the roads and bridges, as well as on the specific regulations in place.

Given the uncertainty around the likelihood and magnitude of impact and the different experiences identified in Member States, it is difficult to provide an accurate estimate of the potential effect on European infrastructure, should LHV s be allowed across the EU.

Geography will also play an important role in determining the potential expansion of the use of LHV s and therefore their impact on infrastructure. In Member States with mountainous crossings such as Italy and Greece, the physical limits of roads, bridges and tunnels will dictate the extent to which LHV s could circulate.

The potential costs of infrastructure upgrades are thus likely to vary greatly across Member States. The ability to raise finance at the level of national and local government would be an additional constraint to LHV take-up across Europe. However, some examples of private financing have been highlighted in this chapter and could be replicated in other Member States.

In addition, the road construction and upgrade projects taking place in EU12 Member States (partly financed by the EU) could represent a cost-effective way of designing road networks that are able to accommodate LHV s in Central and Eastern Europe.

2.4. Road Traffic Flow

There are three main aspects of road traffic flow that could change as a result of the introduction of LHV s. These are:

- Potential increased time for LHV s to clear intersections and junctions, leading to increased congestion;
- The impact on overtaking manoeuvres performed by other motorists; and
- Potential reduction in congestion as a result of fewer vehicle movements.

In this section, all three of these aspects are investigated. There is far less evidence available on these impact than there is on other externalities of road freight such as safety, infrastructure wear and emissions. This is mostly as a result of the difficulty of measuring such impact in real traffic situations.

2.4.1. Junctions and Intersections

In considering the potential impact of LHV s on road traffic flow, one of the primary considerations is whether they would take longer to clear intersections and junctions due to their increased length and potentially slower acceleration. If LHV s take longer to clear junctions and intersections, this may require traffic light phasing to be altered to ensure the
safety of other road users. This in turn may lead to increased congestion by reducing the throughput of junctions and intersections.

TRL (2008) considered this aspect of the introduction of LHVs and noted a study by Ramsay (undated) which “assessed the interaction of multi-combination vehicles with the urban traffic environment and found that longer vehicles did take longer to clear intersections and railway crossings.” In addition, this study found that traffic light phasing generally left less time than would be required for a 25m vehicle to clear a junction. Addressing this by increasing the amount of time between traffic light phases “would eliminate this risk but would reduce the traffic flow capacity of the junction.”

In spite of this evidence showing the potential impact at a micro level such as at junctions, there is no observed evidence of the impact that this has on road congestion. The TRL study concluded that “the uncertainty in the data available regarding whether or not LHVs would be likely to cause more localised disruption to interacting traffic” made it impossible to include any such effect in its benefit cost analysis.

Looking to the experience of the LHV trials in Denmark, the Ministry of Transport reported that individual turning manoeuvres take approximately the same amount of time at an intersection for LHVs and standard LGVs, although LHVs take a bit longer to get through the intersection than a standard LGV. The acceleration times in the interval between 30 and 70 km/h of LHVs, when driving on main roads, have been registered and they seem to have a slower acceleration than conventional LGVs.

Within the two Member States that already permit LHVs (Finland and Sweden) there is limited evidence available of the impact of LHVs on junctions and intersections. The Finnish Ministry of Transport felt that there was no proof that the utilization of LHVs has a negative effect on road traffic and congestion. They also noted that LHVs are used primarily on highways and, as traffic levels in Finland are lower than the rest of Europe, there is no evidence that the utilization of LHVs has a negative effect on road traffic and congestion. Since LHVs have been permitted on Swedish roads for many years, it is difficult to isolate what impact they may have on road traffic flow. Effects related to traffic light phasing or the time taken for LHVs to clear junctions have not been estimated in Sweden.

Finally, the Netherlands Ministry of Transport report (2010) found that there were “very few traffic situations in the Netherlands that clearly require some kind of adjustment to the road layout and infrastructure to allow LHVs.”

2.4.2. Overtaking manoeuvres

In addition to concerns about the impact on road traffic flow of LHVs at intersections and junctions, consideration is given in some studies to the impact that LHVs have on overtaking manoeuvres. Longer vehicles would be expected to take longer for other road users to overtake, with a resultant impact on road traffic flow and safety (the safety aspect of this is discussed in section 2.5).

Similarly to potential impact at intersections and junctions, there is very little evidence available of the effect of introducing LHVs on overtaking manoeuvres. TRL (2008) referenced a 1976 study by VTI which monitored overtaking manoeuvres in Sweden by placing cameras on goods vehicles. This study found that “the longer vehicle tended to induce a greater number of overtaking moves defined as ‘hazardous’ but this was not statistically significant.”
TRL (2008) provide an explanation for the lack of evidence on the impact of overtaking on road traffic flow when they note that microsimulation of overtaking on single carriageway roads (where overtaking would be likely to be an issue) is particularly difficult, since “most microsimulation models in current use model overtaking on single carriageway roads badly, if at all.”

Taking together the limited evidence available on potential impact of LHVs on junctions, intersections and overtaking manoeuvres, there does not appear to be evidence of a significant worsening of road traffic flow conditions. WSP (2010) note that “there is no available body of empirical evidence on the impact on congestion of the length increase of the longer semi-trailers. Various strands of analysis when combined, suggested that under reasonably congested conditions most of the driving time would be in circumstances in which the difference in impact would be relatively small.” Whilst this study concerned the impact of longer semi-trailers as opposed to LHVs, the conclusion that in situations in which congestion could be a problem the length of the vehicle was unlikely to make a significant difference is nonetheless relevant.

2.4.3. Impact of reduced vehicle movements and modal shift on road traffic flow

The impact of a reduced number of vehicle movements as a result of the introduction of LHVs would be to relieve congestion, and many studies note this point. In attempting to quantify this effect, VTI (2008) considered the amount of additional traffic that would be predicted if Sweden were to remove LHVs and quantified the economic cost of the increased congestion. It found that removing LHVs would lead to increased traffic levels due to the larger number of LGVs required to transport freight. The impact of this on road traffic flow only would be an economic loss of SEK 50m (€6m) per annum if no freight could transfer to rail, and SEK 39m (€4.5m) per annum if freight could transfer to rail. VTI considered this likely to be an underestimate in both cases, since delays on some types of road could not be quantified.

JRC (2009) found that introducing LHVs would lead to “negative impacts as regards external costs [including congestion], as a result of the shift of traffic from other modes to road. Since trips with [LHVs] would replace trips with (cleaner and safer) rail, the external costs of the traffic shifted would rise. On average this would amount to €313 million/year, a significant amount but still lower than the decrease in external cost brought by the reduction of trips.” Hence, the congestion relief brought about by reduced vehicle movements was found to be a larger effect than the additional congestion caused by modal shift from other modes to road.

A study by K+P (2011) on the effects of the introduction of LHVs in Europe expects the potential reduction of congestion levels on the motorway network to be up to 5% in the case of a 20% share of LHVs in the road haulage market. However, this reduction would not be fully realised due to modal shift from rail to road and induced traffic, with associated increased trip lengths, due to the lower operational costs of LHVs compared with conventional LGVs. Taking account of this, the study expects the potential net reduction of congestion on the German motorway network to be up to 2%.
2.4.4. **Summary: Road Traffic Flow**

The lack of evidence regarding the potential impact of LHV on road traffic flow makes it difficult to draw conclusions on this aspect of their potential introduction. This is illustrated by TRL (2008) which noted that it “was not possible to quantify the effect of these localised phenomena [junctions, intersections and overtaking] on congestion, and for this reason, the final analysis of costs and benefits does not include a calculation of the congestion costs – effectively assuming that the net effect of the more efficient use of road space and the localised congestion that can be caused is zero.”

Where road traffic flow has been discussed with stakeholders in Member States which permit LHV or which have permitted them in trials, no significant effect has been found or studied. The likely greatest effect of introducing LHV on road traffic flow would be the change in vehicle movements this brought about – however, the extent to which this would occur depends upon the effect of modal shift and traffic generation as a result of reduced operating costs in road freight. Modal shift effects are covered in more detail in section 2.2, but here we note that there is no consensus on how significant these would be.

### 2.5. Impact on road safety

The impact of LHV on road safety is one of the key concerns surrounding the issue, notably as the severity of accidents where these vehicles are involved is expected to be higher than in the case of the vehicles currently in use, especially on certain types of infrastructure such as tunnels and bridges.

This section presents a review of the effects that a greater use of LHV could have on the occurrence and associated costs of road accidents (objective safety), the evidence of which is measurable and recorded through statistical data. It does not deal with the consequences that the presence of a higher number of LHV on the roads could have on the individual perception of safety risks (subjective safety), as this varies significantly across road users and does not ultimately affect the effective incidence and impact of road accidents.

For the purpose of this assessment we will focus our analysis on the following aspects:

- The short and long term impact of LHV on the total amount of road usage measured in vehicle-km;
- The impact of the introduction of LHV on the likelihood of occurrence of a road accident;
- The impact of LHV on the severity of road accidents (e.g. casualty rates) and associated external costs for society.

These effects of LHV on road safety will be assessed on the basis of the evidence reported in countries where they are already permitted (Finland and Sweden) or have been introduced on an experimental basis as part of trials, as well as on the findings of studies predicting future impact of their introduction under different scenarios. Where possible, a discussion of the extent to which different vehicle configurations (number of articulation

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10 A survey carried on by the Ministry of Transport in Denmark showed that cyclists felt more unsafe around LHV, though this is not necessarily reflected in accident rates.
points, wheel base, number of axles, etc.) and types of infrastructure (bridges, tunnels, etc.) affect the foreseen outcomes will be included.

### 2.5.1. Vehicle kilometres

Among the several studies on the topic there is consensus that introducing LHV\s would lead to a reduction in the number of vehicles required to haul the same amount of freight. The loading capacity of a 60 tonne LHV is 40-50\% greater than that of a conventional 40 tonne LGV (JRC 2009). The direct consequence of this is that, even were LHV\s to lead to increased safety costs per vehicle-km, the anticipated reduction in vehicle-km could lead to a reduction in per tonne-km safety costs and a proportional improvement in safety.

A quantification of the reduction in vehicle-km achieved by using LHV\s is provided by a series of studies (reported in ITF 2010) undertaken in Sweden, Canada and Australia in which the number of conventional trucks that would have been required, had these countries not adopted LHV\s, is estimated. In the Swedish and Canadian cases, the percentage of additional conventional trucks was estimated at 35-50\% and 80\% respectively.

However, this does not take into account potential modal shift from rail to road. The issue of modal shift is discussed in section 2.2 of this report. Some theoretical studies predict an impact on modal split so large as to be likely to cause overall negative safety impact associated with the introduction of LHV\s and with the consequent long-term increase of the road share of total freight traffic. However, this has not been observed by the empirical studies conducted in the Netherlands, Sweden and Finland. In particular, these last countries have very large modal shares for rail in spite of having historically allowed LHV\s (respectively 38.2\% and 25.8\% in 2011, compared to 18.4\% for the EU as a whole).

### 2.5.2. Likelihood of accidents

The different features of vehicles that may affect the likelihood of accidents are widely discussed in a series of both theoretical and empirical works. A number of safety issues with consequences on the likelihood of an accident occurring are usually analysed, these include: length, manoeuvrability, field of view, braking performance, and stability.

TML (2008) reports two opposing views regarding the issue of length of a truck and its correlation with accident risk during overtaking manoeuvres. The first one – to which reference is made to a Swedish study from 1976 – finds that there is no statistical evidence of an increased accident risk due to the excess length of a vehicle. According to this study, the increased time required for a car to overtake a longer truck is not a significant variable to explain accident risk. On the contrary, in two more recent German studies (Glaeser et al. 2006 and ADAC 2007) the safety risk is assumed to increase with the time needed to perform an overtaking manoeuvre. As a consequence, cars and other vehicles are thus subject to a greater risk in overtaking a longer truck such as an LHV than in overtaking a conventional LGV. Moreover, the safety exposure connected to overtaking operations is exacerbated when this kind of manoeuvre is undertaken by two LHV\s: due to their small relative velocity and their greater length, the time needed to undertake such a manoeuvre increases significantly compared to a conventional LGV.

The manoeuvrability of a vehicle is generally assumed to reduce with additional length. Poor manoeuvrability can cause problems to other road users and even represent an
additional accident risk factor. TRL (2008) address the issue of manoeuvrability comparing a baseline vehicle (a 44 tonne 6-axle articulated vehicle) currently used in the UK with some types of LHV, the introduction of which is proposed in the study itself. This study points out that the manoeuvrability of a vehicle is reduced during low speed off-tracking: when turning at low speed, the trailer may take a path several meters inside the path of the tractive unit, increasing the amount of road required when turning – with the risk of encroachment into an adjacent lane and collision with another road user (vehicle, pedestrian or cyclist) or object. Low speed off-tracking increases as the wheelbase increases, and decreases with the number of articulation points and with the use of steered axles. In this regard, two principal requirements are already fixed by EU law in order to limit the danger of a truck when manoeuvring: a maximum swept path of 7.2m is required under Directive 96/53/EC and a 800mm out-swing limit is set by Directive 97/27/EC. The study compares the performances of the currently used trucks with the types of LHV proposed for introduction in the UK and concludes that, while the existing length vehicles comply with both the requirements, the other LHV combinations could be in accordance with the EU legislative provisions only if they were equipped with additional components, specifically trailer steering systems.

The field of view from a vehicle is defined as the areas that a driver can either see directly, through glazed areas, or indirectly, via mirrors or other field of view aids. The presence of blind spots can contribute to the likelihood of accidents, in particular when carrying out low speed manoeuvres or when changing lanes. LHV are likely to have the same or similar cabs as existing LGV and therefore direct vision is expected to remain largely unaltered. However, indirect vision and the amount of the LHV that can be seen through additional devices will depend on the length and on the geometry of the combination. Two main conclusions are reached from an analysis of these indirect fields of view in TRL (2008). On one hand, while travelling straight ahead or changing lane, LHV’s field of view would be similar to that of the baseline vehicle. On the other hand, when cornering, most of the LHV combinations would suffer some additional blind spots. Therefore the accident risk associated with cornering could be slightly higher for LHV than for the baseline and currently used vehicles.

Another important feature that can affect the likelihood of an accident is the braking performance of a vehicle. When a vehicle is braking, it should achieve the highest level of deceleration possible without losing stability or directional control. This relies on avoiding the locking of any of the wheels, a situation which could increase the likelihood of an accident. TRL (2008) concludes that the increased length and weight of the vehicles could cause an additional accident risk during braking operations, but a requirement that all components of the vehicle should comply with current braking regulations – namely, ABS and requirements for the distribution of braking amongst the axles – would be expected to minimize these additional risks.

In this regard, tests by Daimler AG carried out on test tracks in Sweden and Germany – reported in TML (2008) – have proven the high braking performance of LHV. The result is that not only do LHV not suffer from additional risk in braking operations, but their performance is even better than that of traditional trucks. Compared with a conventional

11 TRL (2008), Appendix A: “[...] vehicle selections were made on the basis of the literature review and discussions with the vehicle manufacturing, freight and logistics industries”
The Impact of Megatrucks

truck trailer combination, an LHV could decrease the braking distance on a dry surface by up to 5%, and on a slippery surface by up to 17%. This is the result of LHVs having a reduced axle load due to more axles and a bigger footprint, allowing higher brake forces to be transmitted.

Vehicle stability is one of the main concerns related to LHVs and can involve either directional instability, where at least one part of the combination starts to follow a path different to that demanded by the driver, or roll instability, where at least one part of the combination begins to rollover. TRL (2008) synthesizes information from a number of different studies and reports a general framework for assessing the issue. A number of measures of the stability of vehicle combinations are examined and the implications are assessed for different types of LHVs:

- **Static rollover threshold (SRT), i.e. the lateral acceleration at which rollover occurs during cornering:** increasing gross vehicle weight is found to significantly reduce the level of fundamental safety with respect to SRT, while increasing the number of axles significantly improves this level.

- **Rearward amplification, i.e. the degree to which the trailer amplifies or exaggerates the sideways motion of the tractor unit:** this usually has a greater effect on vehicle combinations with more than one point of articulation and typically occurs when the vehicle performs an avoidance manoeuvre. The level of fundamental safety significantly degrades with respect to rearward amplification due to a number of factors: increased gross vehicle weight, increased number of articulation points, longer overhanges to rear hitches, increased number of axles and increased axle spreads. On the contrary, a longer wheelbase and a different type of dolly can significantly improve the level of fundamental safety with respect to rearward amplification.

- **High speed off-tracking, i.e. the speed at which the rear trailer may track outside of the path of the towing unit:** it is important to ensure that LHVs remain within their lane, because of the risk of collision with oncoming or overtaking traffic if the vehicle crosses the centreline of the road, and because of the risk of rollover if it crosses the edge of the road. Increasing trailer length significantly degrades the level of fundamental safety with respect to high speed off-tracking. A number of factors – increasing gross vehicle weight, increasing number of articulation points, longer overhanges to rear hitches, increasing number of axles, increasing axle spreads – moderately degrade the same level of safety, while a longer wheelbase and a different type of dolly can moderately improve it.

TRL (2008) concludes that the use of steered axles can greatly improve the low speed manoeuvrability and could enable many of the assessed LHV combinations to meet both the low speed off-tracking and outswing requirements. However, these can have an adverse effect on the stability criteria. These adverse effects can be avoided by ensuring that the steering mechanisms are locked in a straight-ahead position at higher speeds.

A last issue regarding LHV-specific accident risks is that of the possible impact on safety associated with LHVs travelling on particular road sections such as bridges, tunnels, and junctions. Glaeser et al (2006), cited in TRL (2008), concludes that increased safety risks are not found on motorways. However, some evidence of increased risks are found regarding non-motorway roads, in particular single carriageways rural roads, junctions and railway crossings. Increased risks are mainly due to the increased time a longer vehicle would take to execute a manoeuvre, such as clearing a junction. For instance, at traffic-light controlled intersections, the time needed by a LHV to clear the junction is likely to exceed the 'inter-green' time, causing problems to general traffic. TML (2008) concludes...
that “on motorways, new or aggravating problems are rather improbable [...] whereas in subordinated road networks such as intersections, level crossings or two-lane rural roads, negative effects might be expectable”.

There are specific road safety concerns relating to the impact of LHV on infrastructure. Certain bridges may not be able to sustain the higher pressure of LHV, especially in the case of multiple LHV crossing the same bridge at the same time. In the long run, bridge lifetimes could be affected, requiring additional maintenance, or the provision of traffic and access control mechanisms, in order to grant traffic security (OECD and ITF 2010). As regards tunnels, special concerns are raised if LHV were to be allowed to carry dangerous goods – since the duration of a fire is determined by the combustible mass (Rapp 2011) – a circumstance that would require additional safety provisions in order to minimize the additional risks. As pointed out by ETSC (2011), the adjustment of other existing safety facilities which are not designed for LHV, such as runway truck ramps, lay-byes and emergency lanes, should be taken into account.

A number of studies deal with the issue of accident likelihood from an empirical point of view. The Netherlands Ministry of Transport (2010) conducted an analysis of accidents occurring in the Netherlands from 2007 to mid-2009. In this period, eleven accidents involving LHV were recorded. Although it acknowledged that in seven out of eleven accidents one of the LHV-specific characteristics may have played a part, all of the accidents were found to be typical truck accidents. Additionally, three of the accident locations were known to be accident black spots, and two of the LHV accidents were attributed with certainty to a manoeuvre by the other party involved. Moreover, observations of the behaviour of LHV-drivers and interviews with experienced experts (such as road administrators and enforcement) confirmed no deterioration of traffic safety – in terms of accident likelihood – when LHV were permitted. LHV drivers were generally found to be more attentive and cautious than the average truck driver. In conclusion, the study rejects any evidence that an LHV creates a higher accident risk than a regular truck combination.

ITF (2010) also concludes that the safety performance of LHV is no worse than that of conventional LGV. On the contrary, on the key manœuvrevability and stability measures that most influence crash risks, LHV are often found to perform better than conventional LGV. In particular, this study refers to research in Canada which found that LHV are less often involved in accidents than conventional LGV. A study on the use of LHV in the province of Alberta showed that for a given quantity and density of freight transported by articulated trucks, each LHV replaces 1.5 - 2 standard five-axle semitrailers which, over the same period and on the same roads, had higher collision rates than LHV. Thus, according to this study, with appropriate regulatory controls LHV provided increased freight productivity and had significantly fewer collisions than would have occurred if standard configurations had been used to haul the freight.

The following table reports an overview of the different issues concerning the impact on likelihood of accidents and possible mitigation measures related to the circulation of LHV.
### Table 2: LHV and likelihood of accidents: a review

<table>
<thead>
<tr>
<th>Issue</th>
<th>Potential occurrence</th>
<th>Potential Impact</th>
<th>Mitigation measures</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>Overtaking manoeuvres.</td>
<td>Higher accident risk given the additional time needed to overtake a longer truck, especially in the case of a manoeuvre involving two LHVs overtaking themselves.</td>
<td>Limitations on overtaking operations by LHVs. Imposition of specific power engine requirements.</td>
<td>TML (2008)</td>
</tr>
<tr>
<td>Manoeuvrability</td>
<td>Low speed off-tracking.</td>
<td>Higher accident risk given the broader area needed by a longer vehicle while manoeuvring.</td>
<td>Imposition of specific equipment (trailer steering systems).</td>
<td>TRL (2008)</td>
</tr>
</tbody>
</table>

### 2.5.3. Severity of accidents

As pointed out by TRL (2008), accidents involving LGVs have, on average, more severe consequences than those involving only smaller vehicles. Although LGVs account for only 5.8% of all vehicle traffic in the UK, approximately 18.3% of all UK road accident fatalities occur in accidents involving at least one LGV.

The majority of fatalities in accidents involving LGVs are car occupants. The primary determinants of the energy released in an impact between two objects are the speed at which the objects collide (a factor that can be summarized in the measure of the relative closing speed, approximately the sum of the two vehicles’ speeds), their masses and the impact configuration.

In the theoretical literature there is no consistent view regarding the consequences on accident severity of allowing LHVs. TML (2008) argues that LHVs are likely to cause more
severe accidents, since the increase of accident severity relates to extended weights. Accidents with heavier trucks are stated to be more fatal, as the transfer of energy rises with increasing masses. TRL (2008), on the contrary, states that as the ratio of the masses of the two vehicles increases, the change in velocity sustained by the smaller of the two vehicles as a fraction of the closing velocity quickly increases. At mass ratios around 10:1, the lighter vehicle sustains virtually all of the change in velocity resulting from a collision. Since current mass ratios in truck-car collisions are significant – mass ratios of up to 50:1 are possible – this study concludes that there would be no perceptible increase in impact severity for the car if LHVs were to be allowed.

VTI (2008) focuses entirely on the empirical evidence of LHVs in Sweden and conducts an analysis of Swedish accident data. The study covers a period of ten years and considers injuries and casualties. It then derives a monetary evaluation of the total cost of a road accident.

Over the study period, on average every year 6.6 people in heavy trucks and 88 pedestrians and/or other vehicle drivers die in road accidents involving LGVs, giving a ratio of 1:13. The equivalent figures are 1:2 for light trucks, and 1:1.6 in the case of cars. This data suggests that, since average severity increases from car accidents to light truck accidents, and from light truck accidents to ones involving heavy trucks, it might be expected to differ also between different weights of heavy truck.

In order to find evidence from Swedish experience, a fuller analysis was undertaken for the period 2003 to 2005. It involved dividing accident data between categories of weight, length, number of axles and other characteristics (in particular the presence of the trailer). The conclusions did not confirm the starting assumptions. Indeed, no clear evidence was found to show that accident cost is influenced by weight or length among the various sizes of vehicle combinations. Moreover, no statistically significant difference in accident risk depending on the number of axles was found. Finally, no evidence that overtaking-related accidents are more common and more costly for longer vehicles was found. On the basis of these results, the study confirms that “there is nothing [...] to suggest that the accident cost per kilometre differs significantly between the various categories [of vehicle] concerned.”

2.5.4. Summary: Impact on Road Safety

From the review of different studies on the topic, we have not found evidence that there would be an inherent increase in road safety risks because of LHVs. Indeed, although it is sometimes considered that there may be a higher safety risk resulting from the presence of LHVs on the roads – in terms of increases in both accident frequency and severity – at the same time a reduction of the total vehicle-km of LGVs is generally foreseen, and this positive effect is thought to completely balance or even outweigh the increased risk factor per individual vehicle.

Neither in Sweden nor Finland, the two Member States were LHVs have been permitted for a number of years, has evidence of increased safety risks been found. The Swedish Ministry of Enterprise, Energy and Communications considers that the most significant safety risk associated with LGVs and LHVs is that of head on collisions caused by overtaking on single carriageway roads. Whilst accepting that in the case of an LHV this would involve greater kinetic energy, the Ministry did not believe that this had a significant impact on safety, since head on collisions were likely to be very serious in any case. The Ministry has not seen any evidence to suggest that LHVs present an increased safety risk.
In Finland, the 2005 Road Safety Profile reported that in 94% of accidents involving LGVs, the car driver was the cause of the accident and no significant difference between LHV and other vehicles was found in terms of both injuries and fatalities, although the accident with the most fatalities in Finnish history did involve an LHV.

Nevertheless, concerns about the issues of accident likelihood and severity are raised in the literature. The main concern is that some features of LHV, mainly the additional length and weight, could increase the number of accidents involving trucks and the severity of a single accident with respect to the current situation. However, mitigation measures could be introduced to reduce potential risks and, eventually, lead to safety improvements.

In its study, the ITF (2010) concludes that permitting LHV in traffic should actually result in a reduction in casualties per unit of goods moved. However, the potential for further safety benefits depends on operational controls and the extent to which new, available, safety technology is successfully introduced with these types of trucks.

2.6. Impact on Greenhouse Gas (GHG) Emissions

The impact of introducing LHV on greenhouse gas (GHG) emissions is analogous to the impact on infrastructure, road traffic flow and safety, in that most studies predict that GHG emissions per tonne-km of road freight will fall even though emissions per vehicle increase, due to efficiency gains associated with LHV. However, there is a great deal of disagreement over the net impact of introducing LHV on GHG emissions, since modal shift from (relatively cleaner) rail and waterborne freight to road, as well as induced demand, will lead to increased GHG emissions. The conclusions that are reached by different studies vary mostly according to the extent to which modal shift is predicted.

2.6.1. Relative fuel efficiency of LGVs and LHV

In estimating the anticipated change in GHG emissions resulting from the introduction of LHV, the increased fuel efficiency of LHV per tonne-km must be assessed, together with the anticipated changes in modal split and induced demand. Fuel efficiency is the driving factor behind GHG emissions. As noted by the Netherlands Ministry of Transport, “the emission of pollutants is directly linked to fuel consumption per transported weight. Thus, a decrease in fuel consumption directly leads to a reduction of CO₂ and NOx emissions. The production of fine particles (PM₁₀) is directly linked to the type of engine and fuel consumption.”

TRL (2008) considered 8 vehicle types and measured tailpipe emissions. The report based its conclusions on 120 typical LGV driving cycles (including part-laden and fully-laden journeys) in order to represent the range of different conditions in which LHV would be utilised, and applied the PHEM (Passenger car and Heavy-duty Emission Model13) in order to derive the estimated emissions per km for each vehicle type. The report found that “generally, the heavier the vehicle, the greater the exhaust emissions and fuel consumption [...]” However, when the emissions rates per tonne of payload carried were considered,
these heavier vehicles produce similar or lower relative emissions than the current 44 tonne vehicles."

Meanwhile, TML (2008) found “that 60t vehicles are 12.45% more efficient in terms of fuel consumption per tonne-km performed.” ITF (2010) drew together research from across the world, showing examples from outside Europe. It quoted a study in Alberta, Canada, which found that “the increased use of [LHVs] has enabled Alberta’s growing freight task to be serviced by a smaller number of heavy vehicles [which] amounts to a significant gain in transportation cost efficiency with a major reduction in fuel use and greenhouse gas emissions.” It also cited an Australian example, with the Victoria Department of Transport having estimated that the “use of B-Doubles [similar in dimensions to an LHV] is estimated to have reduced the fuel consumed by the articulated vehicle fleet by 11%.” ISI (2008) used a figure of 29 litres/1000t-km of fuel consumption for 40t LGVs and 24 litres/1000t-km for 60t LHVs in its modelling, implying an increased fuel efficiency for LHVs of between 14-20%.

2.6.2. Predicted impact of LHVs on GHG emissions

Given the widely supported finding that LHVs are more fuel efficient per tonne-km of transported goods, the variation in conclusions drawn by studies of the total net effect on GHG emissions that would arise from the introduction of LHVs is a result of differing assumptions on modal shift and induced demand.

TML (2008) found in their report that “energy consumption is predicted to go down when LHVs are introduced. The main reason for this is the fact that 60t vehicles are 12.45% more efficient in terms of fuel consumption per tonne-km performed. This effect is bigger than the predicted increase in tonne-km by road.” Combining this with the modal shift and induced demand effects predicted by the study, CO₂ emissions across Europe from freight transport are predicted to decline by 3.6% in their central case, which assumes LHVs would operate throughout Europe. In addition, NOₓ would decline by 4.03% and PM by 8.39%.

Conversely, ISI (2008), in a study which focussed on the GHG emissions impact of the introduction of LHVs, brought together all of its assumptions on fuel efficiency, loading efficiency, and potential modal shift effects, and found “strong evidence that the introduction of [LHVs] will most likely end up in a negative climate gas [GHGs] balance in the medium term.” Whilst the study anticipates a reduction in GHG emissions in the first 5 years after LHVs are introduced as a result of improved fuel efficiency per tonne-km, it then anticipates modal shift effects of sufficient magnitude to outweigh the benefits. This study has some of the most hawkish assumptions regarding potential modal shift, which is a contributing factor to its conclusion.

VTI (2008) considered the effect of removing LHVs in Sweden. In a scenario with no modal shift allowed, this led to economic disbenefits of SEK 363m (€40m) p.a. due to CO₂ emissions, SEK 186m (€20m) p.a. due to NOₓ emissions, and SEK 43m (€5m) p.a. due to PM emissions. In the scenario with modal shift allowed, removing LHVs led to economic benefits of SEK 159m (€18m) p.a. due to CO₂ emissions, SEK 62m (€7m) p.a. due to NOₓ emissions, and SEK 10m (€1m) p.a. due to PM emissions. It is important to note, however, that the study “did not take account of exhaust emissions from rail traffic” in the scenario involving modal shift. As such, modal shift effects from road to rail would significantly overestimate potential benefits. This restricts the level of inference that can be taken from these results.
2.6.3. Evidence of GHG emissions effects of LHV

Sweden has historically allowed LHV on its road network and has continued to do so since joining the EU. The Ministry of Enterprise, Energy and Communications is of the opinion that LHV reduces greenhouse gas emissions, since they consume less fuel per tonne-km compared to traditional LGVs.

In Sweden at present there is no spare capacity for additional rail freight, in spite of rail freight being in competition with LHV. Hence, from a Swedish perspective the only important consideration when evaluating LHV's current impact is their replacement of LGVs. In a situation in which rail freight does not have the capacity to accommodate all of its potential demand, LHV may therefore appear more attractive since modal shift effects are more likely to capture excess demand that rail is unable to fulfil, rather than actual realised demand. This is reflected in the work by VTI (2008) which modelled a scenario in which no modal shift was allowed as its most realistic scenario. Given these circumstances, the Swedish Ministry’s position cannot be assumed to hold in other geographies.

The trials currently being undertaken in Sweden for even longer and heavier trucks (with vehicles of up to 30m in length and 90 tonnes in weight) appear to show evidence of further improvements in fuel efficiency per tonne-km transported. Results from these trials show that fuel consumption per tonne-km fell by 16%-20% compared to normal LHV.

Finland has also historically allowed LHV and there are currently no restrictions on their use except in areas where there are general prohibitions on freight traffic.

A study by the Ministry of Transport and Communications (1994) found that a reduction of the maximum authorized weights and dimensions in road transport to European standards would have increased the fuel consumption of heavy goods transport by 92ml litres p.a. (an increase of 18%). This would have led to increases of 13% in CO emissions, 18% in CO₂ emissions, and 31% in hydrocarbon (HC) emissions.

A 2002 Ministry of Transport and Communications study calculated the differences between LHV and conventional LGV in terms of fuel consumption and emissions. It found that, per tonne-km, LHV can lead to savings of up to 20% in fuel and 20% in CO₂ emissions as well as around 40% in NOₓ emissions when compared to LGV.

This conclusion is confirmed by the study conducted by TFK (2007). The aim of the research was to evaluate the experience of using LHV in Sweden and Finland and to compare these findings with the trial in the Netherlands. It found that longer vehicle combinations improve fuel efficiency by an average of 20%, which also leads to an equivalent reduction in greenhouse gas emissions.

Eurostat statistics show\(^\text{14}\) that greenhouse gas emissions from road transportation in Finland have increased by less than the EU27 average. Furthermore, according to Eurostat, in 2010 the percentage of GHGs attributable to road freight (16%) was around 3% lower than the EU27 average (19%). Whilst this could be attributable to a number of different factors, the improved fuel efficiency of LHV is likely to have had an impact.

\(^{14}\) Eurostat database, Road Sector Greenhouse Gas Emissions (in CO₂ equivalent).
The results of these studies are supported by the Finnish Transport and Logistics Association (SKAL) which believes that LHVs have reduced the environmental impact of road transport.

In Denmark, where trials of LHVs are ongoing, the latest available data (Eurostat 2010) indicates that road transport was responsible for two-thirds of all transport CO\textsubscript{2} emissions, and around 20% of total emissions in Denmark. Road transport emissions were quantified at around 13m tonnes CO\textsubscript{2} equivalent p.a.\textsuperscript{15}

The evaluation carried out by Tetraplan and Grontmij for the Danish Road Directorate in 2011 estimated the potential environmental impact of the trial introduction of LHVs. In particular, the CO\textsubscript{2} benefits of the trial have been calculated as an annual reduction of 2,000 tonnes of CO\textsubscript{2} between 2007 and 2010.

These estimates are derived from the assumption that 2 LHVs can replace 3 traditional trucks with trailers, with an average efficiency saving of 15% per km. While a reduction of 2,000 tonnes is only marginal given that total emissions on the designated road network are around 820,000 tonnes per year, greater reductions in the order of 15% are anticipated if the take-up of LHVs increases. Much of the net increase/decrease in CO\textsubscript{2} emissions will also depend on the effects that LHVs have on modal share.

The sustainability impact of introducing LHVs has been studied extensively in the Netherlands. The Netherlands Ministry of Transport (2010) study found that LHVs produced 11% less CO\textsubscript{2} per tonne-km, and 14% less NO\textsubscript{x}, on the basis of a trip length of 150km. The study finds that, “if market potential for LHVs in the Netherlands is fully used, a reduction of 4% for CO\textsubscript{2} emissions and 6% for NO\textsubscript{x} emissions can be achieved.” It should be noted that the study has some of the lowest anticipated rates of modal shift predicted of any of those reviewed.

2.6.4. **Summary: Greenhouse Gas Emissions**

The findings emerging from the literature and the case studies offer a wide range of estimates of the impact of introducing LHVs on GHG emissions. Table 3 summarises the predicted effects on a per tonne-km basis and on net GHG emissions of the main studies reviewed (where numerical figures were available).

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\textsuperscript{15} This figure is for total road transport, including freight and passenger transport. Individual figures for freight transport are not available from Eurostat.
### Table 3: Impact of the introduction of LHVs – summary of studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Emissions per tonne-km</th>
<th>Net emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>TML (2008)</td>
<td>-12.45% fuel consumption.</td>
<td>-3.6% CO$_2$, -4.03% NO$_x$, -8.39% PM from freight transport across Europe.</td>
</tr>
<tr>
<td>TRL (2008)</td>
<td>-2% CO$_2$, -2.5% NO$_x$.</td>
<td>0.52-1.35% increase in CO$_2$ from freight transport in the UK.</td>
</tr>
<tr>
<td>ISI (2008)</td>
<td>-14-20% fuel consumption.</td>
<td>Additional 2Mt CO$_2$ p.a. in Europe within 5-20 years.</td>
</tr>
<tr>
<td>VTI (2008)</td>
<td>n/a</td>
<td>Reduction of 250k tonnes CO$_2$ p.a. in Sweden$^{17}$.</td>
</tr>
<tr>
<td>Netherlands MoT (2010)</td>
<td>-11% CO$_2$, -14% NO$_x$.</td>
<td>-4% CO$_2$, -6% NO$_x$ from freight transport in the Netherlands.</td>
</tr>
</tbody>
</table>

As can be seen, all of the studies that produced a figure for the difference in emissions per tonne-km between LGVs and LHVs found that the latter perform better on this measure, although there is a large range in the predicted size of this effect. There is therefore significant variation between the studies in terms of their estimates for the net impact on emissions of the introduction of LHVs. Comparing the two studies which aimed to calculate this effect across Europe, TML (2008) anticipate significant reductions in GHG emissions, whilst ISI (2008) anticipate significant additional emissions in the medium term (after an initial short term improvement before modal shift impact occur).

In addition to the factors discussed in this section, other factors are likely to affect the impact that introducing LHVs would have on GHG emissions. Of particular note is how the capacity of LHVs is used. If LHVs use a higher proportion of their loading capacity than LGVs, the efficiency gains per tonne-km can be assumed to be greater. The effect of loading capacities of LHVs on all externalities of road freight is discussed in more detail in section 2.2 (modal shift).

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$^{16}$ Figures derived from table 14 of the TRL report by comparing vehicle type 7 (Scandinavian LHV) with vehicle type 1 (typical UK single deck articulated vehicle).

$^{17}$ This is the figure for the scenario tested in which no modal switch was allowed, which the authors describe as being the closest scenario they tested to the current situation.
3. **MEGATRUCKS AND EU OBJECTIVES ON GREENHOUSE GASES AND ROAD SAFETY**

This section considers how LHVs would contribute to, or work against, the achievement of EU objectives in the areas of greenhouse gas (GHG) emissions and road safety. It then considers potential policy choices relating to LHVs and performs a SWOT analysis on these.

### 3.1. EU Objectives

EU targets with respect to GHG emissions are set by the so called ‘20-20-20’ climate and energy package of 2009 which lays down the following key objectives for 2020:

- A reduction by at least 20% in EU greenhouse gas emissions compared to 1990 levels;
- An increase of the share of EU energy consumption produced from renewable resources to 20%; and,
- A 20% improvement in the EU’s energy efficiency compared to 2007 forecasts.

These targets have been endorsed by the European Parliament and the Council through their joint Decision No 406/2009 “on the effort of Member States to reduce their greenhouse gas emissions to meet the Community’s commitments up to 2020.”\(^\text{18}\). This decision also refers to long term targets up to 2050, in accordance with the objective of the European Council “to reduce emissions by 80-95% by 2050 compared to 1990 levels”.

EU objectives regarding road safety have been laid down through the Commission's Communication of July 2010, *Towards a European road safety area: policy orientations on road safety 2011-2020*\(^\text{19}\) which set the target of halving road fatalities between 2010 and 2020. This objective has been endorsed by the European Parliament\(^\text{20}\) and the Council\(^\text{21}\).

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\(^{21}\) Conclusions of 2 and 3 December 2010 - (16951/10).
3.2. LHV\text{s and EU Objectives on Greenhouse Gases

Figure 13: GHG Emissions from transport (‘000s tonnes CO$_2$ equivalent)

Figure 13 shows how GHG emissions from transport in the EU27 countries have evolved since 1990. The trend is one of gradually increasing emissions from 1990 through to the peak in 2007. The decline in GHG emissions since 2007 represents some progress towards the 2020 target of reducing GHG emissions by 20% from 1990 levels. However, it should be noted that the economic slowdown that has affected Europe since 2008 has an impact on the transport sector and, therefore, on the reduction in GHG emissions: whereas the European Union’s GDP shrank by 4.2% between 2008 and 2009, the number of passenger-kilometres fell by 0.7% and the number of tonne-kilometres by 11.2%\textsuperscript{22}.

\textsuperscript{22} EU transport in figures, European Commission (2011).
As shown in Figure 14, GHG emissions from transport are dominated by emissions from road transportation. In order to achieve EU objectives, substantial reductions in the level of emissions from road are therefore required: even if all emissions from aviation, maritime, rail and other transport modes were reduced to zero, a reduction of 12% in road emissions would be necessary to meet the 2020 target.

The European Commission released its Road Freight Transport Vademecum in 2009, which estimated the CO₂ emissions of lorries in 2010 as approximately 270 Mt (million tonnes). Matching this with the data from the EEA shown in the figures above gives 29% of transport GHG emissions as being attributable to road freight. This figure is only a very rough calculation, intended to illuminate the potential scale of the impact of LHVs on reaching GHG emissions targets, and should not be considered to be robust.

Section 2.6 of this report details the evidence available on the potential impact of LHVs on GHG emissions. Whilst all of the studies reviewed found that road transport would become more efficient per tonne-km of transported goods, the size of this impact, coupled with differing assumptions on the potential modal shift and induced demand effects of LHVs, leads to the variation in conclusions on the net impact on GHG emissions of LHVs.

TML (2008) predicts a reduction of 3.6% of CO₂ emissions from road freight as a result of the introduction of LHVs. Using the figure of 29% of transport emissions as being attributable to road freight derived above, this would amount to approximately a 1% decline in transport GHG emissions, which would help in meeting the target of a 20% reduction of 1990 levels by 2020, but would not, in itself, make a significant impact. ISI (2008) was the only other study reviewed which provided an estimate for the Europe-wide impact of LHVs. The headline result is of LHVs leading to an “additional emission of 2 Mt
CO₂ per annum.” This is derived from its central case estimate which shows that the increase in annual emissions predicted peaks at 1.6Mt about four years after the introduction of LHWs, and then declines to a stable additional 0.3Mt annually about 8 years after their introduction. The largest impact (1.6Mt) would represent an increase in CO₂ emissions from transport of 0.2% p.a., with this declining to 0.03% 8 years after the introduction of LHWs.

Other studies have quantified the anticipated effect on a country specific basis. TRL (2008) predicts a 0.52-1.35% increase in CO₂ emissions from road freight in the UK, amounting to an increase in transport emissions of 0.15-0.4%. It should be noted however that this study used a significantly lower assumption for the improvement in fuel efficiency per tonne-km of transported goods with LHWs than all of the other studies reviewed – it only assumed a decline of 2% in CO₂ emissions per tonne-km, compared to a range of 11-20% across the other studies reviewed.

The Netherlands Ministry of Transport (2010) anticipated that the introduction of LHWs would reduce emissions from road freight in the Netherlands by 4%, amounting to a decrease in transport GHG emissions of 1.2%. Meanwhile, VTI estimated that removing LHWs from Swedish roads would increase GHG emissions by 250k tonnes per annum, equivalent to an increase in Swedish GHG transport emissions of 1.2% (compared to 2010 levels).

The range of predicted impacts of the introduction of LHWs on transport GHG emissions in the studies is from a decline of 1.2% to an increase of 0.4%. These are significant figures when compared with the EU’s target of a decline of 20% from 1990 levels by 2020, but they also illustrate the fact that LHWs alone will neither solve the problem of GHG emissions from transport, nor exacerbate it to a significant extent.

3.3. LHWs and EU Objectives on Road Safety

Unlike GHG emissions, there is only one EU objective relating to road safety, and this is to halve road fatalities between 2010 and 2020 (with the long term target to move close to zero fatalities in road transport by 2050). Figure 15 shows the trend in road casualties in the years 2000-2009, with casualties declining every year, and by 39% over the period.
There is some disagreement in the literature about the difference in safety risks associated with LHVs and conventional LGVs, with some studies (such as TML 2008) anticipating more severe accidents when LHVs are involved, and others (such as TRL 2008) finding that there is likely to be little difference. In any case, every study reviewed that provided an estimate of the net effect on safety of introducing LHVs found that a reduced number of vehicle movements would improve overall road safety, even if casualty rates per vehicle mile would increase.

It is unlikely that the introduction of LHVs will have a significant impact on the objective of halving road casualties. TRL (2008) estimated that this impact would amount to between 3 and 7 fewer deaths in the UK per annum, if 25.25m, 60 tonne LHVs were introduced. If we extrapolate this result on a per capita basis across the EU, the effect would be in the region of between 25 and 60 fewer deaths per annum, equivalent to a 0.1\%-0.2\% reduction from 2009 levels.

This extrapolation is only performed to give an indication of magnitude but it does show that, at best, LHVs could only make a small contribution to the improvement in road safety that the EU is trying to achieve. By comparison, the smallest reduction in fatalities per annum shown in Figure 15 is a 1.8\% fall between 2001 and 2002. This implies that other factors that are driving the improvements in road safety observed between 2000 and 2009 are of significantly more importance. **Whilst this does suggest that LHVs will not make a significant contribution to improving road safety, it is also true to say that they would be unlikely to work against the EU’s objective in this field.**
3.4. Policy Proposals

There is a wide range of potential policy choices that could be made in relation to the introduction of LHVVs. Here, we consider four policies and provide a SWOT analysis of each. The policies chosen reflect two extremes (from no liberalisation of the rules in the ‘do nothing’ scenario through to permitting LHVVs throughout the EU) as well as two intermediate scenarios reflecting different incremental approaches that could eventually lead to permitting LHVVs throughout the EU.

As discussed in Paragraph 2.1.4, the European Commission has recently clarified the position of LHVVs regarding international traffic and has also proposed to amend the related provisions of Directive 96/53/EC. We have therefore incorporated this new guidance into our base policy proposition (‘do nothing’). The four policies we have assessed are:

- (1) Do Nothing (continue with current regulations);
- (2) Allow a payload-neutral increase in length to 25.25m;
- (3) Define performance-based criteria and allow LHVVs which meet these criteria to operate in the EU;
- (4) Allow all LHVVs to operate in the EU.

3.4.1. Do Nothing

This policy would involve continuing with current regulations. Member States would still be able to apply for derogations under Article 4(3), (4) or (5) of Directive 96/53/EC allowing them to undertake trials of LHVVs. Pursuant to the current Commission's interpretation of the Directive LHVVs would be permitted to cross borders between states that allow them, assuming that they meet the criteria of any trials in any of the countries they pass through.

**Strengths** – This policy avoids any potential negative impact on rail modal share for freight. It does not restrict the opportunities for individual Member States to proceed with trials, which may provide more evidence for a further review of policy in the future. No additional requirements (above those already present) for improved infrastructure would be required, unless countries wished to trial LHVVs. There may be GHG benefits compared to allowing LHVVs, but this is not supported by most studies.

**Weaknesses** – In not taking the opportunity to reduce road freight operating costs by introducing LHVVs, this policy effectively imposes a cost on the road freight industry. By allowing Member States to trial and use LHVVs under derogations, it is possible that LHVVs will effectively be rolled out across Europe in any case, but with varied situations in different Member States. This may distort the single market. There may be improvements in road safety and GHG emissions that are not realised as a result of not allowing LHVVs more widely (although some studies suggest the opposite is the case with regards to GHG emissions).

**Opportunities** – The policy allows for more evidence to be obtained, which could lead to better policy decisions in future, without risking making mistakes as a result of insufficient evidence. By continuing to effectively restrict the opportunities for LHVVs to undertake long distance transport, competition with rail will be reduced in the market sector (long distance transport) in which LHVVs are most likely to be competitive with rail, thus limiting potential negative modal shift consequences.
The Impact of Megatrucks

**Threats** – If rail is already operating at capacity for freight, the modal shift effects of LHVs are less likely to materialise, as LHVs would capture excess demand for rail freight as opposed to realised demand. This would imply that significant benefits in terms of safety, infrastructure wear, road traffic flow and GHG emissions were being forfeited. In addition, many of the negative impact associated with LHVs that have been predicted in desk studies have not been observed in trials, or in Sweden and Finland. Hence, the real-world application of LHVs may be more beneficial than predicted in the literature.

### 3.4.2. Payload neutral increase in length to 25.25m

This policy would allow vehicles of the same spatial dimensions as LHVs to operate, but without the significant increase in permissible weight. In order to achieve a payload neutral length increase, the maximum permissible laden weight would need to be increased to about 50 tonnes. This would provide relief to industries for whom volume constraints dictate the requirement for LGVs as opposed to weight constraints. In addition, it would be likely to limit the competition between LHVs and rail, since rail is generally dominant in bulk, heavy goods. TRL (2008) noted that if LHVs “were restricted to around 50 tonnes, or less, the likely magnitude of mode shift would be much reduced and largely confined to the deep sea container market.”

**Strengths** – Allows for more efficient carriage of goods for which capacity is volume constricted, leading to reduced vehicle movements, and therefore reduced GHG emissions and improved road traffic flow. It would also encourage adaptations to be made to the road network throughout Europe to accommodate the longer vehicles, which would in turn allow for weight limit increases to be introduced more seamlessly in the future.

**Weaknesses** – The situation for goods for which capacity is weight restricted would be unaltered, which would mean that potential benefits arising from reduced operating costs would still be forfeited. Modal shift impact from rail to road would still be anticipated, especially in the deep sea container market, but these would be less severe than those anticipated if 60 tonne LHVs were to be permitted. Significant infrastructure improvements may be required in some countries, in particular at rest facilities.

**Opportunities** – This could be implemented as a first step towards allowing 25.25m, 60 tonne LHVs, allowing for infrastructure improvements to be undertaken in a staged manner. It would also allow for an assessment of any modal shift impact to see how these compare with the predictions of desk studies, which may then lead to a decision not to proceed to allowing 60 tonne vehicles. This policy would allow the same length vehicles to be used across the EU - even if weight restrictions would vary between the 50 tonne standard and countries with derogations up to 60 tonne.

**Threats** – Policing weight restrictions would be more difficult than policing length restrictions, since the loads would need to be weighed to check for adherence, whereas length can be observed visually. Modal shift effects may be significant enough to lead to increased GHG emissions, although this would be less likely than if 60 tonne vehicles were permitted. ISI (2008) considered that only allowing 50 tonne LHVs would lead to an even worse GHG emissions outcome than allowing 60 tonne vehicles, since the lower weight limit would restrict efficiency gains in the road sector, whilst “modal shift tendencies will only slightly be affected as most goods that have a potential for modal shift are volume critical.” This conclusion is not supported by other studies.
3.4.3. **Performance based standards for LHV**s

This policy would allow LHV to operate throughout Europe, but only if they adhere to defined performance based standards. This allows policy makers to better ensure that the outcomes of introducing LHVs are in line with policy objectives, as well as allowing commercial enterprise the freedom to design innovative vehicles which can lead to improvements in performance. However, it introduces an additional bureaucratic burden on the road freight industry and on national enforcement bodies.

**Strengths** – Performance standards can be specified to better ensure the objectives of the policy are met. This can include specifying an improved performance with regard to infrastructure wear, GHG emissions and safety. Performance standards could also include requirements for LHV to be utilized efficiently, reducing disbenefits that accrue from low utilisation of longer and heavier vehicles.

**Weaknesses** – In order to effectively police such a system, significant monitoring resources would be required. The commercial freedom to innovate that such performance standards encourage are also likely to lead (especially in the short run, before a preferred industry standard is established in the marketplace) to a large variety of different types of LHV, which would increase the complexity of any monitoring regime.

**Opportunities** – A performance based regime would incentivise the private sector to innovate, potentially producing significantly improved vehicles in terms of running costs and external costs. Performance based standards could also be used, as in Canada, as part of trials in order to inform prescriptive standards for a full roll-out across the EU.

**Threats** – Whilst performance based standards should improve the operation of the road freight market, the modal shift effects anticipated for the introduction of LHV would still be likely to occur, which could lead to negative outcomes in terms of GHG emissions.

3.4.4. **Permit LHV throughout Europe**

This policy would involve amending Directive 96/53/EC such that the maximum dimensions of LGVs permissible throughout the EU were 25.25m in length and 60 tonnes in weight. This would require Member States that are currently opposed to the use of LHV to allow these vehicles to operate on their roads. It would still be possible (and necessary) for countries to be able to restrict which parts of the road network LGVs could use, which would often involve restricting them from use within urban areas.

**Strengths** – The option allows for the full realisation of the productivity benefits in the road freight sector that are anticipated as a result of the introduction of LHV. A significant reduction in vehicle-kms would be anticipated, which would be likely to reduce accidents and GHG emissions and improve road traffic flow. This harmonisation of the road freight market across the EU would also improve the single market.

**Weaknesses** – This option would be the most likely to lead to significant modal shift effects. The reduced operating costs of road freight would make road a more attractive mode, which may abstract demand away from relatively clean rail and waterborne. Significant infrastructure costs would be anticipated, as rest areas, bridges, tunnels and junctions would need adapting. This problem could be particularly severe in areas of the EU that already have poor road infrastructure.
Opportunities – A proportion of the significant reduction in operating costs for the road freight industry would be expected to be passed on to consumers of final goods due to the competitive nature of the market, improving welfare. A successful adoption of LHV s would also be expected to reduce overall traffic levels, which may negate the need for new infrastructure in places.

Threats – Significant modal shift may erode the resource base for rail and waterborne, which would in turn increase the cost of these modes and further exacerbate the problem. The lack of available evidence regarding long distance LHV operation on a pan-European scale leads to high levels of uncertainty as to how large modal shift effects will be, increasing the difficulty of accurately assessing the impact of their introduction.
4. CONCLUSIONS

This study has drawn together evidence from available literature, discussions with stakeholders and statistical analysis in order to investigate the impact of megatrucks (LHVs). Whilst there are areas of broad agreement, such as the potential for LHVs to transport freight more efficiently, there are also issues that are more contentious, such as the likelihood of their improving the performance of freight in general with regards to GHG emissions.

The literature review exposed both areas of agreement and of contention. Most studies accepted as a starting principle the fact that two 25.25m, 60 tonne LHVs can replace three conventional LGVs. From this, differing assumptions about capacity utilisation, the characteristics of different LGVs/LHVs, and the markets in which LHVs would be deployed led to differing conclusions about the extent to which they would prove to be more efficient than conventional LGVs. However, no studies found that LHVs would be less efficient on a tonne-km basis.

The broad consensus that LHVs can transport freight in a more efficient manner implies a reduction in both operating costs and GHG emissions per tonne-km. The divergence between studies which were in favour of LHVs and those which were not can be explained by differing conclusions on the impact that reduced operating costs in the road freight sector would have on modal split and induced demand. Improvements in the efficiency of the road freight sector are expected to lead to modal shift from, in particular, rail to road, as well as inducing new road demand. Since rail is comparatively safe and clean, modal shift could be expected to lead to disbenefits, such as increased GHG emissions and road casualties.

Studies which found that the improvements associated with more efficient road freight would outweigh the disbenefits associated with modal shift and induced demand concluded that LHVs should be introduced; those which found the disbenefits would outweigh the benefits were opposed to their introduction.

The effects that concern policy makers (in particular infrastructure wear, road traffic flow, road safety and GHG emissions) can all be characterised as ‘externalities’ – external consequences of a transaction (the demand and supply of freight) that is not captured within the transaction itself. Externalities can only be addressed by some form of intervention – usually a tax or subsidy, or a form of regulation. The market for freight will not create the most beneficial outcome without well designed regulation to limit negative externalities.

This study has considered the principal externalities that are relevant to LHVs. The first of these is the impact LHVs would have on infrastructure. The evidence on this, both in terms of theoretical desk studies and the evidence of trials in the Netherlands and Denmark, as well as the experience of Sweden and Finland (which already permit LHVs) suggests that introducing LHVs will require capital investment in infrastructure. In particular, improvements to rest areas to ensure that they can accommodate the longer vehicles are an unavoidable cost: the Netherlands singled out this cost as one that would have to be met by Government, whilst expecting the industry to fund any other improvements required as a result of LHVs. There is debate about the extent to which LHVs would exacerbate road wear or necessitate bridge strengthening, with the improved distribution of weight across an LHV (as a result of the increased number of load-bearing axels) improving
the situation, against the additional total weight of LHVs worsening it. The costs of infrastructure improvements is likely to vary significantly across Member States, and impact assessments would need to be carried out to fully understand the scale of these. Countries such as Sweden pay for infrastructure improvements for road freight by charging a levy on road freight, and this may be a model that should be adopted elsewhere if LHVs are introduced.

The impact of introducing LHVs on road traffic flow is not well understood. Whilst traffic could be expected to decline as a result of the efficiency improvements offered by LHVs (even taking into account modal shift), concerns are raised by some research that LHVs will take longer to clear junctions and intersections, and that this may require re-phasing of traffic lights, worsening road traffic flow. There is, however, no empirical evidence to support this, and as a result benefits or disbenefits associated with road traffic flow have not been included in the assessments of the economics of introducing LHVs. Stakeholders in Sweden and Finland did not consider that LHVs had a negative effect on road traffic flow, but this may not necessarily be the case in other geographies.

The impact on road safety is a subject that is considered by most studies into LHVs. There is a broad acceptance that they are likely to cause more serious accidents than conventional LGVs as a result of their increased size, although some studies find this to only be a marginal difference. There is less agreement on whether LHVs are likely to be involved in accidents more frequently than conventional LGVs. Whilst some studies predict an increased incidence of accidents for LHVs as a result of manoeuvrability, field of view, braking performance and stability issues, empirical evidence from the Netherlands and Sweden does not support this. Where studies have been able to quantify the total impact on road safety of introducing LHVs, those reviewed have found that road safety should improve. This is as a result of the reduced number of vehicles on the road, which has a significant enough impact to outweigh the effect of potentially more serious accidents.

The final externality that has been assessed is GHG emissions. As is the case for other externalities, there is broad agreement that the efficiency improvements per tonne-km of transported goods of LHVs would lead to improvements in GHG emissions levels, but modal shift from rail to road may reduce these benefits, eliminate these benefits, or outweigh them. The extent of modal shift is the key parameter in determining the overall effect. Whilst some studies expect significant modal shift as a result of LHVs being able to compete in markets where rail freight is dominant, others expect a smaller modal shift effect, often as a result of different modes having natural advantages over one another. On balance, more studies expect the introduction of LHVs to lead to reduced GHG emissions, but some studies expect introducing them to lead to increased GHG emissions.

Empirical evidence is difficult to find with regards to many of the primary concerns regarding LHVs. As a general rule, where empirical evidence is available, it tends to show better outcomes than those predicted by desk studies, with lower modal shift observed and little evidence of any negative effects on road safety. However, introducing LHVs across Europe would introduce new, long distance markets for them, and it may be that if were possible more significant modal shift effects would occur.

There are clear benefits associated with LHVs, and the question for policy makers is whether the more uncertain disbenefits are likely to materialise, and if so whether they can be mitigated. Further monitoring of trials where possible, as well as impact assessments to consider local effects of LHVs, are recommended. Since the issues that are debated with regards to LHVs are mostly concerned with externalities, the role of good regulation is paramount in ensuring optimal outcomes.
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A.1. CASE STUDY SWEDEN

Sweden has a population of approximately 9.5 million people and covers an area of around 450,000 km². It borders Norway to the east and north, Finland to the west, and has been linked to Denmark since 2000 by the Øresund Bridge.

The Swedish road network covers approximately 145,000km, nearly 1,900km of which is classified as motorways and approximately 15,000km of which is classified as national or other main roads. The road freight industry employed around 57,500 people in Sweden in 2010 (Eurostat). The country’s stock of goods vehicles was around 500,000 in 2008.

A.1.1. Legislative Background

Large goods vehicles (LGVs) transporting goods in Europe must comply with weights and dimensions set by Directive 96/53/EC. Sweden, however, has an exemption from this Directive which allows it to set greater limits for maximum permissible length and weight. The Road Traffic Ordinance (1998:1276) sets weight limits for LGVs according to the permitted axle, bogie or triple axle loads not being exceeded and by the size of the distance between the first and last axle of the vehicle or road train. The maximum gross combined weight (GCW) permitted is 60 tonnes, and the maximum length is 25.25m.

Swedish roads are classified according to their load bearing capacity. There are three classes (BK1, BK2 and BK3), with the permitted weight of vehicles depending on the load bearing capacity class. BK1 includes approximately 95% of the public road network, and allows for the heaviest vehicles. In built-up areas, there is a larger proportion of BK2 and BK3 roads.

A.1.2. Data analysis

A.1.2.1. The road freight market

Freight transport volumes in Sweden have remained broadly static over the period 2002-2011, growing from just below 36.7m tonne-km in 2002 to just over 36.9m tonne-km in 2011. Volumes had been growing until the financial crisis of 2008 and the subsequent economic slowdown: between 2008 and 2009 there was a sharp contraction of 16% of total tonne-km in Sweden. This is very similar to the picture across Europe, as shown in Figure A. 4.1.
Sweden, being the only country in the EU apart from Finland to permit the normal use of LHV s of over 40 tonnes in weight, has long run data showing the share of the market that these vehicles have. As can be seen in Figure A. 4.2, the market is dominated by LHV s, which carry some 90% of goods in terms of tonne-km. Figure A. 4.2 also shows that the economic slowdown in 2008/09 only impacted on the volumes transported by LHV s: there was very little change in the size of the freight market for vehicles with a GCW under 40 tonnes. This could imply that the types of goods transported by smaller vehicles are less sensitive to market conditions. Alternatively, it may imply that, with the reduction of the size of the road freight market brought about by the economic situation, hauliers reacted by using smaller vehicles for shipments where possible. This second explanation assumes a large degree of flexibility within the haulage industry, which is unlikely due to the dominance of small firms with a small number of vehicles.
As can be seen in Table A. 4.1 below, whilst LHVs carry almost 10 times as many goods as conventional LGVs in tonne-km terms, they only transport about 2.5 times as many goods in terms of tonnage. This implies that the average journey length is significantly longer for LHVs (131km) than for conventional LGVs (34km), which is in line with anecdotal evidence that LHVs are better suited for long distance transport.

Table A. 4.1: National road goods transport with Swedish registered lorries, 2011

<table>
<thead>
<tr>
<th>GCW (tonnes)</th>
<th>Quantity of goods (tonnes, thousands)</th>
<th>Transport work (tonne-km, millions)</th>
<th>Average journey length (km)</th>
</tr>
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<tr>
<td>6 – 11.9</td>
<td>1,274</td>
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<td>96</td>
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<td>12 – 17.9</td>
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<td>50 – 54.9</td>
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<td>&lt;40</td>
<td>94,777</td>
<td>3,207</td>
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<tr>
<td>=&gt; 40</td>
<td>230,270</td>
<td>30,210</td>
<td>131</td>
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</tbody>
</table>

Source: SDG analysis of Table 2, Lastbilstrafik 2011.
The Swedish freight market is dominated by domestic transport, with international transport by Swedish registered trucks only accounting for 1% of total shipments. Within the market for international freight transport, imports and exports account for the majority (87%) of tonne-km carried, with the remainder consisting of cabotage and cross trade. Imports and exports to Norway account for more tonne-km than all other countries combined, as shown in Figure A. 4.3.

**Figure A. 4.3** Total imports and exports between Sweden and other countries, 2011 (million tonne-km)

![Figure A. 4.3 Total imports and exports between Sweden and other countries, 2011 (million tonne-km)](image)

**Source:** SDG Analysis of Table 11, Lastbilstrafl 2011.

According to Lastbilstrafik 2011, only 42m tonne-km of international traffic was carried by conventional LGVs, with just under 3,500m tonne-km (99%) carried by LHVs with a GCW above 40 tonnes. Whilst LHVs are permitted in Norway and Finland, they are not permitted in France, and are only permitted on a trial basis in Denmark, the Netherlands and Germany. Given the amount of tonne-km transported to France alone, this implies that LHVs are leaving Sweden before being decoupled to run on European roads as conventional LGVs for export, and vice versa for import.

Specific data on traffic on the Øresund bridge between Sweden and Denmark can be found in the Danish case study.

Sweden is also currently conducting trials looking at permitting even longer and heavier vehicles. Two of these trials have been conducted under the collective name ‘ETT Modular System for Timber Transport’, with vehicles of up to 30m in length and 90 tonnes in weight. The trials commenced in 2009, and have found that these vehicles can significantly reduce fuel consumption (by 16%-20%) whilst having no observed impact on road safety or road wear.
The majority of freight transport takes place by road in Sweden (approximately 60% of the total tonne-km in 2010). Rail has a modal share of around 40%, significantly higher than the EU27 average of less than 17%, and the fourth highest in the EU, behind only Estonia, Latvia and Lithuania. There are only negligible levels of freight transported by other modes than road and rail in Sweden.

Figure A. 4.4 Modal share of freight transport, Sweden and EU27 (%)

Rail’s large modal share of freight transport in Sweden occurs in spite of the fact that LHVs are permitted throughout Sweden. Many studies assume that the introduction of LHVs across Europe would lead to significant modal shift from rail to road. The Swedish experience does not directly contradict this supposition, but it does show that LHVs can coexist with a strong rail freight sector. Whilst the geography of Sweden plays a part in the high modal share for rail (rail covers large distances, with the network having been strategically planned to cater for Sweden’s mines and logging industry), the Ministry of Enterprise, Energy and Communications note that the demand is there for rail’s modal share to be even higher, but that this is not possible due to capacity constraints on the rail network.

Sweden has invested heavily in both its rail and road networks in order to improve the efficiency of freight transport. The Ministry of Enterprise, Energy and Communications feel that this allows for combined freight transport to utilise the most suitable mode for each part of a journey, and that rail and road are essential parts of this. Using LHVs is seen as

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worthwhile on environmental grounds as well as cost grounds, due to the reduction in emissions per tonne-km compared to LGVs.

A.1.3. Operational Analysis

A.1.3.1. Freight Infrastructure

Sweden has a modern, well developed freight infrastructure. Since LHVVs have historically been permitted on Swedish roads, infrastructure has been designed with this in mind.

VTI’s study *The Effects of Long and Heavy Trucks on the Transport System* (2008) notes that since harmonisation of load-bearing standards across the EU in 1985, Sweden has undertaken an “extensive load-bearing capacity initiative” which has allowed the maximum gross vehicle weight on Swedish roads to be increased from 51.4 tonnes (pre-1990) to 60 tonnes (since 1993). The initiative has cost approximately SEK 22bn (€2.7bn) in 2012 prices and was “largely funded by business through an increase in vehicle taxes.”

The Ministry of Enterprise, Energy and Communications is constantly investing in the road network. Recent improvements over the last 10 years include the replacement of some intersections with roundabouts that are designed with additional paved run-off areas which allow for LHVVs to turn efficiently. A priority for investment is to improve main freight routes by separating single carriageway road into dual carriageways. This is particularly important in the north of Sweden, where many freight routes involve using small, single carriageway roads.

Throughout Sweden, roads are designated with weight limits. This generally restricts LHV movements to long distance travel as opposed to ‘final leg’ deliveries, since the weight limits on urban roads are much stricter than on highways. Bridges are considered to be the most vulnerable parts of the road infrastructure, and LGVs or LHVVs which do not meet the conditions for crossing any one bridge are forced to use alternative routes. Weight limits are enforced by the use of weigh-bridges.

The Ministry of Enterprise, Energy and Communications noted that, were the very long and heavy vehicles (>60t, >25.25m) that are being trialled permitted more widely on Sweden’s roads, resting places would need to be improved, as these can currently only accommodate LHVVs of upto 25.25m in length.

A.1.3.2. Road Traffic Flow

Since LHVVs have been permitted on Swedish roads for many years, it is difficult to isolate what impact they may have on road traffic flow. Effects related to traffic light phasing or the time taken for LHVVs to clear junctions have not been estimated in Sweden.

The impact of the change in volume of traffic on road traffic flow has been estimated by VTI (2008), in which the effect on road traffic flow of removing LHVVs from Swedish roads was considered. VTI’s analysis found that removing LHVVs would lead to increased traffic levels due to the larger number of LGVs required to transport freight. The impact of this on road traffic flow only would be an economic loss of SEK 50m (€6m) if no freight could transfer to rail, and SEK 39m (€4.5m) if freight could transfer to rail. VTI considered this to likely be an underestimate in both cases, since delays on some types of road could not be quantified.

A.1.3.3. Road Safety

Given that LHVVs have historically been permitted on Sweden’s roads, it is difficult to separate the safety impact of LHVVs from LGVs. The Ministry of Enterprise, Energy and
Communications feel that there is no significant difference between the safety impact of LHV and LGV.

Guard rails at the side of roads are all adapted to be able to cope with a 60t, 25.25m LHV, and Sweden requires modern safety technology to be fitted on all LGVs and LHV. The Ministry of Enterprise, Energy and Communications believe that the most significant safety risk associated with LGVs and LHV is that of head on collisions caused by overtaking on single carriageway roads. Whilst accepting that in the case of an LHV this would involve greater kinetic energy, the Ministry did not believe that this had a significant impact on safety outcomes, since head on collisions were likely to be very serious in any case. The Ministry has not seen any evidence to suggest that LHV present an increased safety risk.

The Ministry accepts that cars overtaking LHV need longer to complete the manoeuvre, but feel that this risk is best mitigated by investing in upgrading single carriageway routes to dual carriageway standard.

A.1.3.4. Greenhouse Gas Emissions

The Ministry of Enterprise, Energy and Communications is of the opinion that LHV reduce greenhouse gas emissions, since they consume less fuel per tonne-km. Given the large modal share of freight for rail, and the fact that there is latent demand for rail that cannot be accommodated due to capacity constrictions, this is likely to be the case. Studies which anticipate LHV leading to increases in emissions all expect this to occur as a result of modal shift, whilst accepting that LHV replacing LGV directly reduces emissions.

The trials currently being undertaken in Sweden appear to show evidence of this phenomenon even when extended to very long and heavy (over 60t and 25.25m) vehicles. Results from the ETT trials show that fuel consumption per tonne-km is falling by 16%-20%.

A.1.4. Summary for Sweden

Sweden, along with Finland, already permits LHV on its roads, and has done so historically. The experience in Sweden is that LHV lead to reduced GHG emissions and vehicle operating costs per tonne-km, with no observed decline in road safety or infrastructure wear. In addition to this, Sweden boasts one of the largest modal shares for rail in its freight market of any EU member state.

The large modal share for rail freight, in conjunction with Sweden’s history of permitting LHV, shows that allowing LHV does not necessarily lead to a low modal share for rail. In fact, the Swedish rail freight system is already operating at capacity and would carry more freight if it were able to. It is important to recognise that this is a result of many factors, some of which cannot easily be transferred to other Member States. In particular, the geography of Sweden, with significant natural resource industries located distantly from population centres but with good links to the rail network, encourages a high modal share for rail.

Whilst it is not possible to quantify in economic terms the precise impact of LHV in Sweden, the VTI (2008) study attempted to quantify what the economic cost would be of reverting to European standards and removing LHV. The study found that the total economic cost to Sweden would be SEK 12.5bn (€1.5bn) per annum (2012 prices) assuming no possible transfer of freight to rail, which in the current conditions is the likely scenario. If transfer to rail were possible, the effect would be less, at SEK 5.5bn (€0.7bn), but this would not be possible unless significant investment were made in the Swedish rail network to deliver more capacity.
A.2. CASE STUDY FINLAND

1. Finland is located at the edge of North-East Europe. It has an area of 33,800 km², which is similar to the area of Germany. An estimated 5.4 million people live in Finland, with the majority concentrated in its southern regions. It shares a 540km border to the west with Sweden, a 720km border to the north with Norway, and a 1,270km border to the east with Russia.

2. In terms of area, it is the eighth largest country in Europe and the most sparsely populated country in the European Union. Finland was a relative latecomer to industrialization, remaining a largely agrarian country until the 1950s. Thereafter, economic development was rapid, such that today Finland is one of the world's wealthiest nations: in 2011 Finland recorded one of the highest levels of GDP per capita, with a value 15% above the EU27 average.

3. Both domestic and international transport in Finland often cover very long distances. Due to the dispersed population, road transport is the main mode of transportation (85% of passenger transport and 75% of goods transport). The rail network, covering 6,000km, can only effectively serve the larger cities.

A.2.1. Legislative Background

Until the late 1960s, due to its low population density and the large distances involved in transport, the length of LGVs in Finland was unrestricted. This gave rise to long and heavy vehicles transporting goods more profitably. As traffic increased, dimensions became more of a concern. In 1975 the Finnish authorities proceeded to limit the maximum vehicle length to 22m, which nonetheless remained more generous than in the rest of Europe. Contrary to the length legislation, the permitted maximum gross combination weight (GCW) in Finland, as in Sweden, has increased in steps as infrastructure has improved and demand has increased. In 1993, the permitted maximum GCW was increased to 60 tonnes.

At Finland’s accession to the EU, the country was required to adopt EU legislation. Directive 96/53/EC would have reduced maximum lengths from 22m to 18.75 m, and maximum GCW from 60 to 40 tonnes (44 tonnes for combined transport). This was met with resistance, and a study published by the Finnish Ministry of Transport concluded that there would be an increase in freight transport costs of 23% (equivalent to around €300 million/year) if Finland were to apply the Directive. A compromise was reached in 1997 and Finland (as well as Sweden) was permitted to retain longer and heavier vehicles for operation in national traffic.

A.2.1.1. Technical standards in Finland

The European Modular System (EMS), used in Finland and Sweden since 1997, is based on the European Committee for Standardization (CEN) standardized 7.82m unit load carrier and 13.6m semi-trailer – the longest vehicle allowed in the EU. The maximum length of this combination of modules is 25.25m. All cargo units in the system are adapted for rail transport in combined transport either as single vehicles or as separate load carrier units.

The EMS is based on existing vehicles and load carriers prevalent in continental Europe. Foreign hauliers are able to compete by extending their road trains with an available extra trailer for additional capacity at the border of Sweden or Finland.

Although Finland and Sweden both allow LHV’s, Finnish and Swedish legislation differs in a number of ways. For example, in Finland it is possible to run a 13.6m full trailer within the
25.25m limit. Finnish hauliers benefit from this, since a full trailer weighs less than a semi-trailer with dolly, thus allowing for a heavier cargo load. A trailer is also somewhat easier to maintain than a semi-trailer and dolly.

A.2.2. Data analysis

A.2.2.1. The road freight market

4. Road is the most popular mode of transportation in Finland, particularly in rural areas that do not have connections to the railway network. As of 2011 there are 78,162km of public roads, of which 51,016km are paved. The trunk road network covers over 13,300km of road.

5. Main roads traffic accounts for 64% of all traffic on public roads. These main roads are divided into class I and class II trunk roads. Motorways are relatively uncommon since traffic volumes are not large enough to warrant their construction, they are 779km in length and, with some minor exceptions, they are all dual carriageways. There are six motorways radiating from Helsinki, totalling 585km in length. The remaining motorways are short sections close to the biggest cities. Most other roads are single carriageways roads. The most notable exceptions to this are the ring roads around Helsinki and Turku.

Figure A. 4.5 Land transport connections and ports in Finland

The amount of road freight in Finland totalled approximately 25bn tonne-km in 2010. From 2001 to 2010, the total size of the road freight market decreased, although road’s share of the market remained broadly constant, as shown in Figure A. 4.6 below.
According to Statistics Finland, the proportion of road freight in tonne-km that is currently carried by LHVs (a maximum permissible weight equal to or more than 60 tonnes) in national transport is around 73%.

**A.2.2.2. Competing freight modes**

Freight transport in Finland is dominated by road transport (about 75%) with the rest taken up by rail transport (almost 25%) and a very small share (less than 1%) by inland waterways. This represents one of the largest proportions of modal split for rail in Europe, comparing with an EU 27 average of less than 17%. Despite Finland’s domestic rail freight market being open to competition since the beginning of 2007, this has not had an appreciable impact on modal split.

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According to Statistics Finland, LHVs are most prevalent in the transport of agriculture, metal, food and textiles products. Most road freight transportation in Finland is undertaken by private hauliers. Most of them are small (generally with 1 to 5 employees), operating only few vehicles. In 2011, there were 10,733 road haulage companies in operation, possessing 27,431 trucks. In the same year, employment reached a total of 39,967 people in road freight transport enterprises, increasing from 34,322 in 2007.

A.2.3. Operational Analysis

A.2.3.1. Freight Infrastructure

Finland has a long history of using LHVs, and the road network has been built to satisfy these demands. In Finland there are no restrictions on the use of LHVs, except in areas where there are general prohibitions on freight traffic.

Vehicles with lengths of up to 25.25m are used on long distance routes that are concentrated mainly on motorways and main roads, avoiding towns and city centres. A common procedure is to decouple the dolly and semi-trailer and use the truck as a distribution vehicle when unloading in city centres.

As Finland has always permitted LHVs, there have not been many studies on the impact of these vehicles on road infrastructure. The Finnish Ministry of Transport’s 1994 study *Harmonization of Vehicle Weights and Dimensions; Consequences in Finland* discussed the

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potential impact of a reduction in the maximum authorized weights and dimensions permitted in road freight transport. It calculated that a reduction in maximum dimensions (to a maximum weight of 44 tonnes, length of 18.35m and width of 2.55m) would lead to a greater impact on road infrastructure, due to the shorter distance between the front and rear axles of vehicles and increased loads per axel. The extra cost was estimated to be FIM 300m (€50m).

The Ministry of Transport and Communications study (2002)\textsuperscript{26} focused on the calculation of the impact of LHVs in terms of road wear, with respect to the number of equivalent axles in the vehicle and the net load size. The results of the study showed that LHVs would have a lower impact than conventional LGVs.

A.2.3.2. Road Traffic Flow
7. As LHVs are used primarily on highways, and as traffic levels are lower than the rest of Europe, there is no evidence that the utilization of LHVs has a negative effect on road traffic and congestion.

A.2.3.3. Road Safety
8. The public roads are owned by the state and maintained by the Finnish Road Administration (FinnRa) that is responsible for the safety of public roads. FinnRa promotes road safety in cooperation with other stakeholders. The National Traffic Police are responsible for enforcement. To fulfil EU requirements, the National Traffic Police are obliged to:

Check 1,500 freight movements of dangerous goods per year;
Perform 14,000 road side checks per year; and,
Check that LGV drivers are adhering to the rules on daily rest.

As shown in Figure A. 4.8 below, road safety has improved considerably in the last 40 years, although the improvement has slowed down in recent years. Road traffic fatalities have fallen from 433 in 2001 to 292 in 2011. The number of injuries has also decreased markedly. Despite this positive development, the interim target outlined in the Finnish government’s road safety vision (less than 250 fatalities per annum by 2010) was not met.

\textsuperscript{26} Ministry of Transport and Communications, \textit{Nordic Vs. Central European vehicle configuration : fuel economy, emissions, vehicle operating costs and road wear}, 2002.
11% of all fatalities involved LHVs, compared to 8% for conventional LGVs. Between 2006 and 2011, the number of fatalities in accidents involving LHVs declined by approximately 14%, and the number of injuries by almost 22%. Similar declines were found for conventional LGVs.

The 2005 Road Safety Profile for Finland (European Commission) reported that in 94% of accidents involving LGVs, the car driver was the cause of the accident. This observation is supported by the Ministry of Transport and Communications study (1994) that showed that in Finland the risk of heavy vehicles being involved in accidents is proportional to the mileage driven and not to the size of the vehicle.

Generally, there is no significant difference between LHVs and other vehicles in terms of both injuries and fatalities, although the accident with the most fatalities in Finnish history did involve an LHV. Figure A. 4.9 below shows the distribution of accident types for regular and long vehicle combinations.

Source: Statistics Finland (2012)
A.2.3.4. Greenhouse Gas Emissions

Finland recorded an increase in greenhouse gas (GHG) emissions of 12.8% in 2010 compared to 2009, which is the second highest increase of all EU Member States (see Figure A. 4.10 below). The rise was mainly due to fuel related emissions from public electricity generation and from manufacturing industries. In addition, process related emissions from mineral products and iron and steel production also increased. This was mostly due to the recovery from the economic recession and the cold winter in Northern Europe.

**Figure A. 4.9** Distribution of accident types for regular and long vehicle combinations

Source: Statistics Finland (2012).
By contrast, Figure A. 4.11 above demonstrates that greenhouse gas emissions from road transportation in Finland have increased by less than the EU27 average. Furthermore, according to Eurostat Statistics, in 2010 the percentage of GHGs attributable to road freight (16%) is around 3% lower than the EU27 average (19%).

The Ministry of Transport and Communications study (1994) assessed that a reduction of the maximum authorized weights and dimensions in road transport would have increased the fuel consumption of heavy goods transport by 92m litres (an increase of 18%). This would have led to increases of 13% in CO emissions, 18% in CO₂ emissions, and 31% in hydrocarbon (HC) emissions.
The 2002 Ministry of Transport and Communications study calculated the differences between LHV and conventional LGV in terms of fuel consumption and emissions. The study assessed that, per tonne-km, LHV can lead to savings of up to 25% in fuel and 25% in carbon dioxide emissions as well as around 65% in nitrogen oxides emissions when compared to LGV.

This conclusion is confirmed by the study conducted by TFK (2007)\textsuperscript{28}. The aim of the research was to evaluate the experience of using LHV in Sweden and Finland and to compare these findings with the trial in the Netherlands. It found that longer vehicle combinations improve fuel efficiency by an average of 20%, which also leads to an equivalent reduction in greenhouse gas emissions.

The results of the studies are supported by the Finnish Transport and Logistics Association (SKAL), which believes that LHV has reduced the environmental impact of road transport.

**A.2.4. Summary**

Finland has had experience of LHV since the late 1960s and introduced the European Modular System (EMS) in 1997. In 2010 the proportion of road freight (in tonne-km) carried by LHV in national transport was around 73%.

Finnish experience of using LHV combinations has been generally positive. At the end of November 2012, according to a Finnish Ministry press release\textsuperscript{29}, the Finnish government obtained parliamentary approval to allow LHV of up to 76 tonnes gross weight on its roads, increasing also of the maximum legal height of trucks (from 4.2m to 4.4m).

The Finnish Ministry of Transport and Communications has always supported LHV, and has carried out several studies showing the benefits of LHV.

With respect to freight modal split there is no evidence to suggest negative impact as the market share of rail transport is higher than the EU 27 average (25% vs. 19%).

As regards safety, the available data gives no indication that long vehicle combinations are less safe than regular vehicle combinations. In spite of consistent expansion of LHV’s presence on Finnish roads, safety has generally improved in Finland over the long term. The most serious accident involving a LHV vehicle (in 1994) caused 23 fatalities; as a result of this, the level of winter maintenance of roads has been improved, and since then no serious accidents involving a LHV vehicle have been registered in Finland.

The modular concept has a positive environmental impact, with a substantial reduction of CO, CO\textsubscript{2} and HC emissions per tonne-km transported.

With regards to infrastructure costs, the critical factor has been found to be the weight per axle. The 2002 study conducted by the Finnish Ministry of Transport and Communications showed that LHV with the maximum load per axle permitted still have a lower impact than LGV.

Critical to these findings is the importance of even load distribution. Almost all of the advantages gained by using LHV in terms of emissions, cost savings and road infrastructure wear are contingent on loading capacity being well utilized.

\textsuperscript{28} TransportForsK TFK, *European Modular System for road freight transport – experiences and possibilities*, 2007

\textsuperscript{29} Ministry of Transport and Communications, *Ministerityöryhmä linjasi raskaan liikenteen mittoja ja massoja*, 2012
A.3. CASE STUDY NETHERLANDS

The Netherlands has a population of approximately 16.8 million people and covers an area of around 40,000 km². It borders Belgium to the south and Germany to the east.

The Dutch road network covers approximately 131,000km, over 2,600km of which is classified as motorways. The country’s stock of goods vehicles was around 930,000 in 2010 (Eurostat).

A.3.1. Legislative Background

Large goods vehicles (LGVs) transporting goods in Europe must comply with weights and dimensions set by Directive 96/53/EC. The Netherlands has undertaken trials of LHVs, in accordance with the rules set out in this Directive. These trials have been conducted in three phases. The first phase, in which only four participants were involved, started in December 2001 and lasted until May 2003. The second phase ran from August 2004 until November 2006 with an increased participation: by the end of the second phase, 76 companies were participating, with 162 LHVs in use\(^3\). The third phase ran from November 2007 to November 2012 and allowed for an unlimited number of companies to use LHVs. As of 1\(^{st}\) January 2013, there is a permanent regulation providing exemptions for LHVs in the Netherlands, allowing for their continued use now that the trial period is over.

A.3.2. Data analysis

A.3.2.1. The road freight market

Freight transport volumes in the Netherlands have declined over the period 2002-2011, falling from just over 77.4m tonne-km in 2002 to just over 73.4m tonne-km in 2011. Volumes grew significantly in 2004, increasing from 79.8m tonne-km in 2003 to 89.7m in 2004. However, after 2004, volumes gradually declined, as shown in Figure A.3.1.

\(^3\) Figures quoted from Netherlands Ministry of Transport, *Longer and Heavier Vehicles in the Netherlands*, 2010
There has been a gradual increase in the percentage of the freight market that LHVs account for since the beginning of the Dutch trials in 2001. This is to be anticipated given the highly restricted nature of the first trial, and the less restricted second trial, which have given way to a third trial in which no restrictions were placed on which companies could use LHVs or how many they used. The increase in LHV numbers and in the total tonne-km transported by LHVs is shown in Table A.3.1 below.

**Table A. 4.2: LHVs in the Netherlands, 2001 - 2011**

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of LHVs</th>
<th>Transported tonne-km (millions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>2002</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>2003</td>
<td>12</td>
<td>49</td>
</tr>
<tr>
<td>2004</td>
<td>42</td>
<td>178</td>
</tr>
<tr>
<td>2005</td>
<td>89</td>
<td>372</td>
</tr>
<tr>
<td>2006</td>
<td>106</td>
<td>445</td>
</tr>
<tr>
<td>2007</td>
<td>141</td>
<td>592</td>
</tr>
<tr>
<td>2008</td>
<td>208</td>
<td>875</td>
</tr>
<tr>
<td>2009</td>
<td>315</td>
<td>1,323</td>
</tr>
<tr>
<td>2010</td>
<td>397</td>
<td>1,668</td>
</tr>
<tr>
<td>2011</td>
<td>513</td>
<td>2,155</td>
</tr>
</tbody>
</table>

*Source: Eurostat.*
Whilst there has been a substantial increase in both the numbers of LHV and the tonne-km they transport, they still only account for a small proportion of the total Dutch freight market. As can be seen in Figure A.3.2, by 2011 (three years after the start of the third phase of the trial with no restrictions on usage of LHV) only 3% of tonne-km in the Netherlands was transported by LHV. Whilst this figure is clearly increasing, the Netherlands Ministry of Infrastructure and the Environment produced a report examining the third phase of the trials and the evidence that could be obtained from them on modal split, titled ‘Monitoring Modal Shift’. It concluded that “over the coming years, [the increase in modal share of LHV] is expected to continue, albeit on a relatively small scale.”

Figure A. 4.13 Percentage of tonne-km transported in the Netherlands by LHV

The Dutch freight market is split fairly equally between national and international traffic, with 55% of tonne-km international transport and 45% national. As shown in Figure A.3.3 below, this represents the largest share of international transport among the group of countries that either permit or have trialled LHV (shown in red).

Source: SDG analysis of Eurostat and ‘Monitoring Modal Shift’

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31 Netherlands Ministry of Infrastructure and the Environment, Monitoring Modal Shift, 2011
A.3.2.2. Competing freight modes

A significant majority of freight transport takes place by road in the Netherlands (approximately 60% of the total tonne-km in 2010). Rail has a modal share of just under 5%, one of the lowest in the EU, and significantly lower than the EU27 average of around 17%. The Netherlands has the highest proportion of freight carried by inland waterways in the EU at 33%.\(^{32}\)

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The Impact of Megatrucks

Figure A. 4.15 Modal share of freight transport, Netherlands and EU27 (%)

The report by the Netherlands Ministry of Infrastructure and Environment, Monitoring Modal Shift, is an important piece of work regarding the possible impact that LHVs would have on modal split, since it assess the change that has occurred in the Netherlands over the course of 10 years of trialling LHVs. Such an analysis is not as easy to perform in Sweden or Finland, since there is no base position of ‘no LHVs’ to work from, and hence to establish the impact of their introduction.

The report found that competition between the modes was strongest in the container sector, and that the introduction of LHVs had coincided with growth in this sector for both road and rail. It noted that “the road transport sector [...] generated more growth in absolute terms. However, this has not had any significant influence on the modal split.” In addition to analysing the macroeconomic impacts of LHV introduction, the report also found insights by conducting market research, and found that “it is relatively difficult to compile suitable combinations of containers for transport via LHV” and that “because of limited market potential, logistics parties barely show any interest in deploying LHVs for container transport.”

A.3.3. Operational Analysis

A.3.3.1. Freight Infrastructure

The Netherlands Ministry of Transport report, Longer and Heavier Vehicles in the Netherlands notes that “the basic principle that guides the LHV Dutch policy is that LHVs should fit the existing road infrastructure and not the other way round.” This in particular means that LHVs should not have any particularly adverse effect on pavements, bridges, tunnels and viaducts. The Ministry does accept, however, that rest areas have to be adapted for use by LHVs, due to the significant extra size.
As part of the LHV trials, a route network was established allowing LHVs on defined routes. A digital map of the routes that LHVs can use is also available.

In a 2010 presentation, *Experiences with Longer and Heavier Vehicles (LHVs) in the Netherlands*, the Ministry of Transport details the enforcement of regulations designed to ensure the Dutch road freight infrastructure is not adversely affected by LHVs. There is “periodic, retrospective monitoring through administrative systems by Inspectorate for Transport, Public Works and Water Management (IVW),” and the IVW has found that LHV exemption holders generally comply with the rules and does not expect any problems going forward in this regard.

The report also mentions that in addition to enforcement by the IVW, the police monitor everyday road use and have found that “LHVs stand out in a positive way” with equipment generally being in order, and drivers that are responsible.

### A.3.3.2. Road Traffic Flow

The study *LHVs in Practice* finds that “based on the current preconditions and the current use of LHVs, a reduction of around 20 million kilometres will be attained annually.” This reduction in traffic would be expected to improve road traffic flow.

There is not a significant amount of evidence available in the reports that have been published on the Dutch trials regarding the impact of LHVs on road traffic flow. *Longer and Heavier Vehicles in the Netherlands* notes that, for example, “railroad crossings may only be used [by LHVs] if they have an extension of red light duration and when there is sufficient space after the crossing.” However, whether such alterations to traffic light phasing have had a negative impact on road traffic flow is not closely investigated.

### A.3.3.3. Road Safety

In the report *Experiences LHV’s in the Netherlands: Typical Dutch or Valid for Europe?*, the specific nature of Dutch road infrastructure is cited as a reason for the introduction of LHVs not having a negative impact on road safety. The report notes that “main road are mostly planned outside urban areas” making it “easy to keep LHVs away from local urban roads.” Segregation for cyclists and mopeds, which is already widespread in the Netherlands, reduces the potential negative impact of introducing LHVs since they are less likely to come into contact with these vulnerable road users. “The performance of the Netherlands on road safety in general and with regard to the safety of LHVs in particular, cannot be dissociated from the spatial planning and road network design.”

*Longer and Heavier Vehicles in the Netherlands* finds that “observations of the behaviour of LHV-drivers and interviews with experienced experts (such as road administrators and enforcement) suggest no deterioration of traffic safety when LHVs are admitted.” There has been no observation during the three trials undertaken of any deterioration of the safety performance of the road network.

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A.3.3.4. Greenhouse Gas Emissions

The Dutch LHV trials have been closely monitored to assess their impact on greenhouse gas emissions. The Ministry of Infrastructure and Environment noted in their report *LHVs in Practice* that “this more efficient form of transport contributes towards better environmental performance.” By considering the evidence from the trials, it found that “the total reduction in CO$_2$ emissions resulting from the use of LHV currently amounts to 16 million Kg per year.”

This improvement in environmental performance as a result of the introduction of LHVs is due to the limited impact that their introduction has had on modal split in the Netherlands. *Monitoring Modal Shift*, another report by the Ministry of Infrastructure and Environment, found that “based on economic, terminal and market analysis it can be concluded that no reverse modal shift effects have occurred following the introduction of LHV in the Netherlands.” Since this effect may not be replicated in different countries with different geographical features, and since the primary mechanism through which LHV could cause a worsening of greenhouse gas emissions is through modal shift from rail or inland waterways to road, the Dutch result of LHV leading to a reduction in greenhouse gas emissions may not be applicable elsewhere.

A.3.4. Summary for the Netherlands

The Netherlands has undertaken the most extensive set of trials for LHV in the EU, which have culminated in a permanent exemption being granted for LHV use in the country. In effect, this means that the Netherlands is now similar to Sweden and Finland in terms of the availability of LHV. However, LHV are not as prevalent in the Netherlands as they are in Sweden and Finland. This is likely a result of the shorter distances involved in travel in the Netherlands, which reduces the advantage of using LHV.

The extensive nature of the trials, which continued for 10 years, allows for a controlled examination of the impact of their introduction. The Dutch Government has produced a number of reports examining the results of the trials, which have been favourable to the continued use of these vehicles. One of the most significant findings from these reports is that no modal shift from rail or inland waterways to road has been observed. This is highly significant as the negative impact that may be expected as a result of the introduction of LHV mostly stem from modal shift occurring from cleaner and safer modes to road transport.

It should be noted that the results of the Netherlands trials, whilst encouraging in terms of the impact that introducing LHV has had in this country, cannot be considered necessarily to be applicable in other parts of the EU. Furthermore, LHV may be more competitive in international traffic, and the Dutch trials are by their nature only for national traffic.
A.4. **CASE STUDY DENMARK**

Denmark has a population of approximately 5.5 million people and covers an area of around 44,000 square km. It borders Germany to the south and has been linked to Sweden since 2000 by the Øresund Bridge.

The Danish road network is 73,197km long, more than 1,128km of which are classified as motorways and 2,711km of which are national or other main roads. The road freight industry employed around 38,700 people in Denmark in 2008 (Eurostat). The country’s stock of goods vehicles was around 531,000 in 2008, 7% of which were lorries of 16 tonnes or more.

A.4.1. **Legislative Background**

Heavy goods vehicles transporting goods in Europe must comply with rules on weights and dimensions for road safety reasons and to avoid damage to roads, bridges and tunnels. These weights and dimensions are currently regulated by Directive 96/53/EC which sets a maximum length of 18.75m and a maximum weight of 40 tonnes (44 tonnes for combined transport) for a truck with trailer in the European Union.

Directive 96/53/EC is in place to ensure that Member States cannot restrict the circulation of vehicles which comply with these limits from performing international transport operations within their territories. As mentioned in the Directive’s preamble, to avoid national operators benefiting from undue advantages over their competitors from other Member States (MSs), they must comply with the standards set for international transport when performing national transport.

However, there are exceptions to this, including in Denmark. Since 24th November 2008 the country has been operating a trial allowing Longer and Heavier Vehicles (LHVs) than the limits set by Directive 96/53/EC. The maximum dimensions set by the Danish government for this trial are 25.25m for the truck’s length and 60 tonnes for its weight (48 t and 54 t, respectively, for six- and seven-axle combinations, with a maximum axle-load of 10 t).

There are no specific requirements for operators wishing to use LHVs in Denmark and no registration is required. Nonetheless, LHVs can only be operated along certain sections of the national road network. These are designated by the Road Transport Authority and as of July 2011 covered around 1,700km of roads - the equivalent of 44% of all motorways and main roads, as shown in Figure A.4.1.

The national trial in Denmark was initially set to last for three years, running until November 2011. However, in 2010, the Ministry of Transport decided to extend the trial until 1st January 2017. This was intended to provide a better evaluation of the initiative. The approval of new routes, the regulations of the trial road network and the evaluation of the trial (from Dec. 2011) is handled by the Danish Road Directorate, whereas matters regarding vehicle standards are the responsibility of the Danish Transport Authority. Both are agencies under the Ministry of Transport.

Similar trials of LHVs are in place in other Member States, such as Germany and the Netherlands. Sweden and Finland were allowed longer and heavier trucks on their roads before joining the EU, and negotiated an exemption from the rules on accession. Thus both MSs with road links to Denmark have some LHVs operating in their territory.
An unresolved controversy relates to the issue of cross-border traffic and in particular whether L HVs are allowed to operate internationally under the current law. In 2010, the European Commission indicated that cross-border traffic would not be permitted under Directive 96/53/EC. In spite of this, since 1st December 2009, L HVs have been used between Denmark and Nützen-Kampen in Schleswig Holstein in Germany, crossing the border at Ellund.

This has prompted protests by local German hauliers associations, and the matter has been referred to the European Commission in the form of a parliamentary question to the Commissioner for Transport. In March 2012, the Commission altered its stance, indicating that cross-border traffic would be permitted. The rationale for this was that EU rules were intended to prevent Member States from keeping foreign vehicles that met the standards set out in Directive 96/53/EC out of their markets. It was not intended to prevent Member States accepting vehicles larger than the maximum set out in the directive.

**Figure A. 4.16  The designated road network for L HVs in Denmark**

![Road network for L HVs in Denmark](source.png)

*Source: Danish Road Authority (2012).*
A.4.2. Data analysis

A.4.2.1. The road freight market

Freight transport volumes in Denmark have contracted in recent years. The total volume of tonne-km by national hauliers in 2010 was only 64% of the 2004 peak. The decline has been recorded mainly in international movements; domestic activity by Danish hauliers has remained fairly constant between 2005 and 2010.

From 2008 (when the trial began) to 2010 the share of tonne-km transported on road by LHVVs has risen to 3.6% (in 2010). The load factors of Megatrucks in Denmark is equal to or higher than that of other LGVs, therefore the Ministry estimates that the total number of new LHVVs should be lower than the number of conventional trucks that are being replaced\(^\text{34}\).

The number of LHVVs on Danish roads was around 450 at the end of 2010 and industry estimates suggest this has grown to 600 at the beginning of 2013\(^\text{35}\). The latest statistics available for the total number of LGVs over 16 tonnes operating in Denmark was 37,000 (ACEA 2008). Assuming this has remained broadly constant, LHVVs make up around 7% of the total fleet of LGVs.

The survey of the transport patterns of LHVVs carried out by the Ministry during the trial period showed that LHVVs are primarily used on long distance trips of 200km or more. One of the most popular routes for LHVVs is the east-west axis between the major transport hubs of Zealand and Jutland. Anecdotal evidence suggests LHVVs are mostly used for goods such as flowers and mail, where the limiting factor for loads is volume rather than weight. Four different types of LHVVs can be used in the Danish trial. Types 1 ("dolly") and 3 ("link-trailer"), shown in Figure A.4.2, are the most popular.

Figure A. 4.17  Most common types of LHVVs in Denmark

![Figure A. 4.17 Most common types of LHVVs in Denmark](image)

Source: Danish Road Authority (2012).

The nationality of LHVVs operating in Denmark has been recorded in surveys, both at Elsinore and at the Great Belt Bridge. The vast majority of vehicles going via the Great Belt Bridge are Danish (approximately 90% according to the Ministry). On the Elsinore-

\(^{34}\) Danish Ministry of Transport (2012): The Danish Eco-Combi Trial

\(^{35}\) Stakeholders submission to Steer Davies Gleave consultation
Helsingborg ferry between Denmark and Sweden, the majority of vehicles are also Danish (70%), with a significant proportion of tractors registered in Poland.

LHV traffic volumes grew by 22% between 2011 and 2012 on the Great Belt Bridge, making up 5.3% of heavy vehicles crossing the bridge. Traffic on the Øresund Bridge between Denmark and Sweden has also been monitored. Around 60% of the traffic on this link takes place by road. Figure A.4.3 shows the number of LHV movements on the bridge in 2009 and 2010, showing that around 50 vehicles per day operate in each direction between the two countries. This is equal to 5.3% of total traffic on the bridge.

**Figure A. 4.18  LHV traffic on the Øresund Bridge 2009-2010**

![Chart showing LHV traffic on the Øresund Bridge 2009-2010](chart.png)

*Source: Danish Road Authority (2012).*

A study for the INTERREG Programme has found that the capacity of the Øresund road network is expected to be insufficient to handle the expected growth in freight traffic, unless the network and associated nodes are expanded. The growth in the number of LHV across the Øresund link in 2011 (a 24% increase on 2010 levels) indicates that part of this freight traffic growth is likely to come from LHV. A forecast of the expected traffic flows in 2020, compared to 2003, is shown in Figure A. 4.19.

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36 [http://www.interreg-oks.eu/en/Menu/Projects/Project+%C3%96resund/%C3%96resund+Infrastructure+and+Urban+Development](http://www.interreg-oks.eu/en/Menu/Projects/Project+%C3%96resund/%C3%96resund+Infrastructure+and+Urban+Development)
No comparable data is available for international trips between Denmark and Germany. Regulation plays an important role in limiting the movement of LHVs across the German border. The industry association ITD explains that, while Sweden has a similar regulatory environment for road freight to Denmark, Germany has stricter rules at the regional level and registration of LHVs is required prior to entry. This issue emerged as part of the legal controversy referred to in paragraph A.4.1. Consequently, very few vehicles appear to operate between the two countries.

A.4.2.2. Competing freight modes

The majority of freight transport takes place by road in Denmark (87% of the total tonne-km in 2010). Rail has a modal share of around 13% (compared to an EU27 average of less than 17%)

These modal shares have remained constant over time, despite the overall reduction in freight transport between 2000 and 2009.

As the LHV trial in Denmark only started in 2008, and these vehicles only comprise a small proportion of traffic, it is not possible to evaluate the potential impact on modal shift at present. It is reasonable to assume that LHVs can compete with rail over longer distances (>250km), however this competition would be likely to be most prevalent on international routes, given the small size of the country.

According to the ITD, it is possible to optimise inter-modality as a result of the introduction of LHVs: freight trains and especially cargo ships coming into Denmark are able to unload their goods onto larger trucks, minimising the number of vehicles involved in intermodal operations.

A.4.3. Operational Analysis

A.4.3.1. Freight Infrastructure

Denmark has a well-developed freight infrastructure network, with a high density of motorways, ports, railway stations and airports. The geography of Denmark requires substantial investment in what are known as ‘fixed links’ - connecting roads and bridges between the mainland, the islands and other Scandinavian locations. Two of these links, the Great Belt and the Øresund bridges, are financed by user charges. In 2020, a 19 km

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long tunnel under the Fehmarn Belt between Denmark and Germany is expected to open, significantly improving connectivity between Germany and Zealand.

These links have progressively improved international accessibility for road and rail freight transport. Further investment has been triggered by the introduction of LHVs. Approximately DKK 135m (€18m) has been invested in road infrastructure in order to allow LHVs to drive safely on the designated road network. It is estimated that these investments will generate an additional annual expense for infrastructure maintenance of about DKK 1.3m (€0.2m).

The Danish Road Directorate has supported this by investing DKK 112m. There has been additional investment as a result of the ‘Enterprise Programme’ – a partnership between shippers and municipalities for improving local road conditions. Subject to local planning rules and consultation requirements, by the end of 2011 they had invested a sum of DKK 1.4m in infrastructure renewals.

The Ministry of Transport has carried out a cost-benefit analysis for the years 2009 – 2011, showing a benefit to cost ratio of 1.1:1. Given the relatively short period of time over which this was assessed, in which large infrastructure costs have been incurred, a scenario assessment has also been carried out up until the year 2016. This shows a benefit to cost ratio of 2.6:1, highlighting the long-term benefits of improved infrastructure.

The majority of the infrastructure investment has been directed to widening existing roads and creating better conditions at roundabouts and interchanges. The focus has been on accommodating for larger volumes rather than heavier weights. The evidence collected so far suggests that the average total weight of LHVs is about 40 tonnes with an average axle-load of about 6 tonnes, and no significant infrastructure wear effect has been detected on Danish roads yet.

**A.4.3.2. Road Traffic Flow**

The Ministry has reported that individual turning manoeuvres take approximately the same amount of time in an intersection for LHVs and standard road trains, although LHVs take a bit longer to get through the intersection than a standard road train. The acceleration times in the interval between 30 and 70 km/h of LHVs, when driving on main roads, have been registered and they seem to have a slower acceleration than other large, heavy vehicles.

Overall, the Ministry expects the number of LHVs on Danish roads to grow in the years to come. This assumption is based on the fact that more and more locations and routes are approved for LHVs, making this particular mode of transport increasingly flexible and competitive compared to standard road trains. The Ministry also believe that both industry partners and local municipalities are willing to invest in adapting local infrastructure.

**A.4.3.3. Road Safety**

With respect to road safety, the Ministry has conducted surveys among road users to understand their perception of LHVs during 2009-2010. In general, motorists and cyclists did not appear to have noticed the changes in size and weight of the new trucks. However, while motorists did not consider LHVs more dangerous than smaller trucks, cyclists felt more unsafe around LHVs. Around 60% of those surveyed believed that there are traffic-related benefits from the introduction of LHVs, and 75% believed there are environmental benefits. However, 10% of road users thought that LHVs should be banned from Danish roads.
A total of four accidents involving LHV have been reported between 2009 and 2010. This is proportionally less than the average for LGVs, but is not statistically significant enough to derive any conclusions from.

The industry body ITD has investigated the circumstances under which these accidents have taken place. Their conclusion is that none of these can be attributed to the specific characteristics of LHV. In two of the accidents the involvement of LHV was misreported; one of the accidents was caused by a driver in tired conditions and the fourth accident appeared to have been caused by a car driver.

The Danish Cyclist Federation has voiced concerns with respect to the impact of LHV. Not only do they believe that larger vehicles pose an increased risk to cyclists, but also that the widening of roads and roundabouts is an incentive for cars to drive faster than before, making them less able to respond to cyclists and pedestrians. In addition, the Federation opposes the use of LHV closer to urban centres. Given the high modal share for cycling in commuter journeys (20%), the interface between cyclists and LHV needs to be carefully managed in Denmark.

### A.4.3.4. Greenhouse Gas Emissions

The latest available data (Eurostat 2010) indicates that road transport was responsible for two-thirds of all transport CO\(_2\) emissions, and around 20% of total emissions in Denmark. Road transport emissions were quantified at around 13m tonnes CO\(_2\) equivalent.

The evaluation carried out by Tetraplan and Grontmij for the Danish Road Directorate in 2011 estimated the potential environmental impact of the introduction of LHV. In particular, the CO\(_2\) benefits have been calculated as an annual reduction of 2,000 tonnes of CO\(_2\). These estimates are derived from the assumption that 2 LHV can replace 3 traditional trucks with trailers, with an average efficiency saving of 15% per km.

While a reduction of 2,000 tonnes is only marginal given that total emissions on the designated road network are around 820,000 tonnes per year, greater reductions can be expected if the take-up of LHV increases. Much of the net increase/decrease in CO\(_2\) emissions will also depend on the effects that LHV have on modal share.

### A.4.4. Summary for Denmark

Denmark introduced a temporary trial period for LHV at the end of 2008, and has recently prolonged it until 2017. Vehicles can operate on a designated road network and there are no registration requirements. Around 600 LHV are currently estimated to operate in the country, especially on longer-distance routes and for the carriage of voluminous goods. An important share of these movements is cross-border between Denmark and Sweden.

The impact of LHV have been extensively assessed by the Danish government, which has contributed €17m to infrastructure improvements to the road network, and forecasts some increased long-term investment in maintenance. However, the infrastructure costs are, in the opinion of the Road Transport Directorate, more than balanced by the benefits in the

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39 Emissions from 3 truck with trailers (twt): 735g CO\(_2\)/km x 3 twt = 2,205g/ CO\(_2\)/km

Emissions from 2 LHV: 932g CO\(_2\)/km x 2 LHV = 1,864 g/ CO\(_2\)/km
long-term. Benefits include efficiency savings for transport companies, and reduced environmental impact.

Industry associations are broadly supportive of the trial and some shippers have developed local partnerships with municipalities to accommodate for the growth of LHV. Some concerns remain as to the viability of long-distance routes (where LHV becomes more competitive), currently restricted by regulatory arrangements in Germany. Cyclists seem to be the most vulnerable group which is against the introduction of LHV, due to perceived increased safety risks.
A.5. CASE STUDY GERMANY

Germany has a population of approximately 81.9m (2011) and a population density of 229 inhabitants per km$^2$. It shares borders with nine countries (Denmark, Netherlands, Belgium, Luxembourg, France, Switzerland, Austria, Czech Republic and Poland).

The road network comprises approximately 12,800 km of motorways and 39,700 km of national roads. Approximately 20% of the traffic on motorways are LGVs – this is higher than the national average, with LGVs accounting for less than 10% of vehicles across the entire German road network.

The number of road transport enterprises in Germany in 2010 exceeded 50,000 with a total of 586,000 employees. Its vehicle fleet totalled approximately 367,000 light and heavy trucks. The majority (57%) of all operators are small enterprises with up to 5 employees, whereas 14% of operators exceed 20 employees.

A.5.1. Legislative Background

Across Europe, maximum dimensions and weights for LGVs are established by Directive 96/53/EC, and are therefore also applicable for road haulage carried out in Germany. The maximum permissible length of LGVs is 18.75m, and the maximum permissible weight is 40 tonnes (44 tonnes for combined transport).

After a series of trials with LHV in several German regions, the conference of transport ministers of the German federal regions decided in 2007 to stop all current trials and not to carry out any new trials.

Following the parliamentary elections in late 2009, the new German government changed its view on LHV and aimed at assessing opportunities and risks associated with the introduction of LHV in Germany through a nationwide trial. The trial was initially planned to start at the beginning of 2011 allowing vehicles with a maximum length of 25.25m and weight of 40 tonnes. For transport forming part of combined transport, the maximum permissible weight was set at 44 tonnes.

In response to the planned trial, the conference of transport ministers of the German federal regions expressed its opposition. They claimed that the introduction of LHV in Germany would lead to negative impact on road safety and the environment. In addition, the German federal regions would face substantial costs for improving infrastructure such as freight interchange and parking facilities.

On 19 December 2011, the German Ministry of Transport issued the ordinance on exemptions from road traffic regulations for LHV (LKWÜberStV AusnV) to create the legal framework for the trial of LHV, which came into force on 1 January 2012. Given that this ordinance was issued without the involvement of the Parliament (Bundestag) and the Federal Council (Bundesrat), the opposition brought an appeal against this ordinance before the Federal Constitutional Court.

Source: Bundesverband Güterkraftverkehr Logistik und Entsorgung (BGL)
On 1 January 2012, the Ministry of Transport, on behalf of the German government, started a trial with LHV s permitting a maximum length of 25.25m and a maximum weight of 40 tonnes. The trial will take place over a period of five years and will be scientifically assessed by the Federal Highway Research Institute (BASt). The trial does not envisage a maximum number of participating transport operators or vehicles.

The ordinance defines the road network to use, the permissible type of vehicles, maximum permissible dimensions, additional technical requirements for the vehicles, regulations related to combined transport, limitations in relation to the transported goods, and individual requirements towards the drivers.

The permissible road network is mostly formed by the motorway network, and national roads with more than one lane per direction. However, the Verkehrsclub Deutschland (VCD) highlights that only seven out of 16 federal regions allow LHV s to use the national road network within their territory. In addition, North Rhine-Westphalia and Bremen prohibit LHV s that are taking part in the trial from crossing their territory.

Transport operators willing to participate in the trial need to register at the BASt and agree to participate in the scientific assessment. Drivers must have five years’ experience as professional drivers of goods vehicles, and must have held an EU driver’s licence for at least five continuous years.

**Figure A. 4.20  Permissible vehicle types in the German nationwide LHV trial**

![Diagram of permissible vehicle types](Image)

Source: BASt (2012) in accordance with Article 3 of LKWÜberlStVausnV.
A.5.2. Data analysis

A.5.2.1. The road freight market

Figure A. 4.21 sets out the evolution of the German domestic road haulage market between 2005 and 2011. Until 2008, the amount of transported tonnes steadily increased, before experiencing a substantial drop of 7.2% from 2008 to 2009. In the following years the market grew again, without, however, fully recovering 2008 levels.

Figure A. 4.21 Evolution of the German national road haulage market


To date 21 transport operators with a total of 38 LHVs have registered at the BASf to participate in the trial. Therefore the share of goods currently transported by LHVs in Germany is negligibly small.

A.5.2.2. Competing freight modes

In 2010, a total of 621.3bn tonne-kms of freight were transported in Germany. The majority (about 65%) was transported by road. The second most important mode was rail with a share of 22%, followed by inland waterways with a share of 13%. 41

Figure A. 4.22 shows the relative change in market shares of the different modes in the German freight transport sector. In all three of the five year periods between 1995 and 2010, road increased its share in the total market, though between 2005 and 2010 the increase appeared to be very small. In contrast, rail’s share declined slightly between 1995 and 2000, but improved its position compared to other modes and increased its share between 2000 and 2005. Between 2005 and 2010 rail showed the strongest increase in modal share apart from air. Over the whole period, air showed substantial increases and almost doubled its share - which despite this evolution remains at a low level (0.2% in 2010).


111
The gains of road and rail in modal share over the last 15 years can be attributed to losses in goods transported on inland waterways and pipelines, both in relative and absolute terms.

**Figure A. 4.22  Change of modal share in the German goods transport market**

![Graph showing the change of modal share in the German goods transport market.](image)

**Source:** SDG analysis of BMVBS (2012).

### A.5.3. Operational Analysis

#### A.5.3.1. Freight Infrastructure

In 2006, the BASt conducted extensive research on the technical impact of the introduction of L HVs on the German motorway network. They concluded that L HVs do not have a more negative impact on the conditions of pavement and road structure than conventional LGVs. Also, in the case of L HVs with a weight of up to 60 tonnes, the impact is expected to be even smaller due to lower tonnage per axle. The impact of the higher number of axles and the therefore higher frequency of imposed stress on the pavement was expected to be relatively small. However, trials have only been carried out in laboratories. A final conclusion on the impact can therefore not be reached.

However, the BASt claims that the impact on infrastructure should not be assessed comparing individual vehicles. They suggest that due to the decreasing operational costs as a result of the introduction of L HVs, space that has been freed on the motorways will be interpreted as additional transport capacity and therefore filled with additional transport activity. Although the deterioration per transported tonne would be expected to decrease, the result is a higher overall tonnage transported on the motorway network, and therefore an accelerated deterioration of the pavement and road structures.

In the case of an introduction of L HVs with a maximum permissible weight of 60 tonnes, the Ministry of Transport estimated the cost to increase loading capacities of bridges on the German motorway network as being up to €8 billion.

Due to the increased load volume of L HVs, safety systems in tunnels need to be revised. This is a particular requirement for fire safety systems.
The BASt further pointed out that the current road infrastructure (e.g. roundabouts) is not designed for LHV s and that therefore pedestrians and cyclists could be harmed and parts of the infrastructure damaged. In addition, parking facilities at service stations on motorways are designed for vehicles with a length of 18.75m. Therefore, the introduction of LHV s with a length of up to 25.25m would require substantial investments in infrastructure.

A.5.3.2. Road Traffic Flow

A study by IVV and Brilon\(^{42}\) on behalf of the German Ministry of Transport expects 31% to 42% of the German motorway network to be heavily congested by 2020. A recent study by K\(^+\)P\(^{43}\) on the effects of the introduction of LHV s in Europe expects the potential reduction of congestion levels on the motorway network to be up to 5% in the case of a 20% share of LHV s in the road haulage market. However, this reduction will not be fully realised due to modal shift from rail to road and induced traffic, with associated increased trip lengths, due to the lower operational costs of LHV s compared with conventional LGV s. Taking account of this, the study expects the potential net reduction of congestion on the German motorway network to be up to 2%.

In contrast to several research institutions and the Federal Environment Agency (UBA), the Federal Association of Road Haulage, Logistics and Disposal (BGL) believes that lower transport costs would not induce additional traffic, but that goods traffic is rather purely dependent on industrial production and household consumption.

A.5.3.3. Road Safety

The BGL believes that LHV s can make a contribution to improved safety on roads in Germany. Based on the notion that two LHV s would replace three conventional LGV s, they claim that the statistical risk of an accident would decrease simply through a lower number of vehicles on the road network.

Although maximum permissible weight has not been increased in the trial, the average payload of LHV s is expected to be substantially higher than that of conventional LGV s. This is simply due to the fact that LHV s will mostly be deployed for commodities where the limiting factor is volume rather than weight. Therefore, a higher percentage of trucks on German roads will carry a payload close to the maximum allowance of 40 tonnes. From a purely statistical point of view, the impact on other road users in the case of an accident is expected to be worsened. This doesn’t, however, take account of the anticipated reduction in the number of freight movements. Uncertainty over the scale of reduction in the number of freight movements makes it difficult to be sure of the impact the introduction of LHV s may have on overall safety on German roads.

A.5.3.4. Greenhouse Gas Emissions

In comparison with conventional LGV s, LHV s provide 50% additional loading capacity, allowing them to transport 52 instead of 34 palettes. As a result of this, fuel consumption per palette can decrease by up to 25%, assuming 100% capacity utilisation. However, the UBA claims that when less than 40 palettes are transported by LHV s (equivalent to a 77% capacity utilisation), their fuel consumption per palette is higher than for conventional


LGVs. In current long haul goods transport, capacity utilisation averages only 54%\textsuperscript{44}. Related to fuel consumption, improvements in levels of greenhouse gas emissions are only anticipated when capacity utilisation is very high.

The costs of road haulage per transported tonne-km are expected to decrease by up to 25% compared to conventional LGVs when using LHVs. The additional available volume may allow for the removal of some journeys, with 3 journeys by conventional LGVs anticipated to be replaced by 2 journeys by LHVs, leading to a decrease in staff and operating costs.

According to long-term market observations\textsuperscript{45}, a 1% reduction of operating costs of road haulage leads to a decrease of 1.8% in transported volumes by rail and of 0.8% in transported volumes by inland waterways. Extrapolating these findings, a decrease in operating costs of 20% would lead to a decrease in transported goods by rail of up to 38% in affected market segments.

The UBA expects that mainly goods transported in combined transport (up to 55%) and the port hinterland market (up to 44% in national transports) would be shifted from rail to road. A recent study prepared by K+P assessed the potential for modal shift from rail to road following the introduction of LHVs on five main international freight corridors involving Germany. They concluded that on all corridors this modal shift would be between 10 and 15% for combined transport, and between 20 and 40% for single wagonload transport. The assessment was prepared for LHVs with a maximum length of 25.25m and a maximum weight of 44 tonnes. In the case of LHVs with a maximum weight of 60 tonnes, K+P expects the modal shift to be slightly smaller for all assessed scenarios. K+P attributes this latter effect mainly to the expected higher toll rates for LHVs with a maximum weight of 60 tonnes, compared to the other assessed vehicle combinations.

Due to the weight limitation of 40 tonnes, the Federal Association of Road Haulage, Logistics and Disposal (BGL) does not expect any modal shift from rail to road. They claim that the high payloads used in combined and rail transport are not feasible for transports with LHVs.

The UBA calculated that an average freight train in Germany emits less than one third of greenhouse gases per transported tonne-km (23.4 g/tkm) compared to conventional LGVs (97.5 g/tkm). In terms of nitric oxides, freight trains only emit 0.07 g/tkm compared to 0.49 g/tkm for LGVs. These values include the production of the respective used energy source.

In 2010, the total energy consumption of the freight transport sector in Germany reached 914.5bn mega-joules. Road haulage accounted for 80% of this consumption, despite its share of only 70% of transported tonne-kms. In contrast, freight transported by rail only accounted for 12% of the total consumed energy, despite rail’s larger share of total transported tonne-kilometres of 17%.

Due to the greater number of axles and more powerful engines, LHVs produce higher noise emissions compared to conventional LGVs. According to a survey carried out by the UBA,

\textsuperscript{44} KBA (2012) Goods Transport Statistics
\textsuperscript{45} UBA (2007) Länger und schwerer auf Deutschlands Straßen: Tragen Riesen-Lkw zu einer nachhaltigen Mobilität bei?
11% of the population are heavily affected by noise emitted by road transport, whereas only 2% are heavily affected noise emitted by rail.

In 2007, Infras\(^{46}\) prepared a study to estimate the external costs of transport in Germany for the year 2005. In freight transport, the external costs per 1000 tonne-kms of road haulage are four times as high (€38.9/1000 tkm) as those of goods transported by rail (€9.5/1000 tkm). The most significant portions of these costs in road haulage can be attributed to noise emissions (€9.9/1000 tkm), air pollution (€8.2/1000 tkm), climate costs (€7.5/1000 tkm), and accidents (€7.2/1000 tkm). The respective costs of freight transport by rail are €3.3/1000 tkm, €1.9/1000 tkm, €0.4/1000 tkm and €0.1/1000 tkm.

### A.5.4. Summary for Germany

Following a series of trials in several German regions, in January 2012 the Federal Ministry of Transport launched a nationwide trial allowing LHVs with a maximum length of 25.25m and a maximum weight of 40 tonnes to operate on the German motorway network and major national roads. Although the number of participating LHVs or operators is not limited, to date there are only a small number of registered LHVs (38). In Germany, the trial faces strong political and popular opposition. A number of regional governments prohibit LHVs from crossing their territory.

According to extensive research work carried out by the Federal Highway Research Institute, the introduction of LHVs would lead to increased deterioration of road infrastructure. Although the deteriorating impact of a single vehicle is expected to decline due to an increased number of axles, the total tonnage transported on the German motorway system is expected to increase due to a modal shift from rail to road and induced traffic due to lower transport costs. The study further found that secondary infrastructure like roundabouts, parking facilities and tunnels are not adapted for LHVs.

Stakeholders in Germany have different views on the impact of the introduction of LHVs on congestion levels. An industry association stated its opinion that road traffic levels are purely dependent on household consumption and industrial production. On the other hand, several research institutes came to the conclusion that reduced costs per transported unit would induce additional journeys and increase average trip lengths.

The small number of LHVs on the German road network, and the resultant lack of data, makes it difficult to assess the impact of the introduction of LHVs on road safety. Although a small reduction in congestion is expected, the average payload is likely to increase for goods where the limiting factor is volume rather than weight.

LHVs have the potential to reduce greenhouse gas emissions per transported unit compared to conventional LGVs. However, the Federal Environment Agency highlights that to achieve this goal an average capacity utilisation of 77% is required. In current long haul goods transport, capacity utilisation averages only 54%. In addition, the lower transport costs per unit are expected to induce additional trips, increase trip lengths and lead to a modal shift from rail to road, which in total would lead to an increase in greenhouse gas emissions. In particular, the modal shift from rail to road will increase not only greenhouse gases, but also have negative impact on noise, air pollution and road safety.

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\(^{46}\) Infras (2007) Externe Kosten des Verkehrs in Deutschland - Aufdatierung 2005
### A.6. LIST OF STUDIES CONSIDERED FOR LITERATURE REVIEW

For the literature review in part 1 of the main report, 29 studies were considered. The following criteria guided the selection of studies to review:

- Studies which covered a broad range of issues (safety, modal shift, infrastructure wear, etc) were preferred;
- Studies with an appropriate geographical coverage (ideally covering the European Union as a whole, although some studies focusing on individual Member States were useful for the depth of their analysis) were preferred; and,
- Given the sensitivity of the issues being considered, it was considered appropriate to try and select a balanced range of studies, including both studies which support the introduction of LHVs, and whose which do not.

The following table shows the full list of studies considered. The table shows how each study performed in term of the criteria given above. The eight studies that were selected are shown in bold.

#### Table A. 4.3: List of Studies Considered for Literature Review

<table>
<thead>
<tr>
<th>Author</th>
<th>Study</th>
<th>Topics</th>
<th>Coverage</th>
<th>For/Against</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danish Ministry of Transport (2012)</td>
<td>The Danish Eco-Combi Trial</td>
<td>Infrastructure, Climate, Economic, Safety</td>
<td>Denmark</td>
<td>For</td>
</tr>
<tr>
<td>EcoPlan (2011)</td>
<td>Gigaliner auf Schweizer Strassen: Auswirkungen auf Verkehr, Umwelt, Sicherheit und Verlagerungspolitik</td>
<td>General</td>
<td>Switzerland</td>
<td>Neutral</td>
</tr>
<tr>
<td>ETSC (undated)</td>
<td>ETSC position on Longer and Heavier Goods Vehicles on the roads of the EU</td>
<td>General</td>
<td>EU</td>
<td>Neutral</td>
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<tr>
<td>Glaeser et al</td>
<td>Effects of new vehicle</td>
<td>Infrastructure</td>
<td>Germany</td>
<td>For</td>
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<tr>
<td>Reference</td>
<td>Title and Description</td>
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<td>(2006)</td>
<td>concepts on the infrastructure of the Federal trunk road network</td>
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<td><strong>ISI (2008)</strong></td>
<td>Long-Term Climate Impacts of the Introduction of Mega-Trucks</td>
<td>Climate General</td>
<td>Europe</td>
<td>Against</td>
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<tr>
<td><strong>JRC (2009)</strong></td>
<td>Introducing Mega-Trucks: A Review for Policy Makers</td>
<td>Economic Climate Modal Split</td>
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<td>MTRU (2008)</td>
<td>Heavier lorries and their impacts on the economy and the Environment</td>
<td>Economic Climate</td>
<td>UK</td>
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<tr>
<td>Netherlands Ministry of Transport (2010)</td>
<td>Experience with LHVs in the Netherlands</td>
<td>Infrastructure Economic Climate General Safety</td>
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<td>No Mega Trucks (2009)</td>
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<td><strong>OECD + ITF (2010)</strong></td>
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<td>Efecto de la</td>
<td>Infrastructure</td>
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<td>Pérez-Martínez (2011)</td>
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<td>South Baltic Oversize - Transport Strategy</td>
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<td>Tetraplan + Grontmij (2011)</td>
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<td>Effects of adapting the rules on weights and dimensions of heavy commercial vehicles as established within Directive 96/53/EC. Final report</td>
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<td>Longer and Heavier on German roads - Do Megatrucks contribute to sustainable transport</td>
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