Impact Assessment:
High Capacity Vehicles

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Document Preparation Details

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Executive Summary

In the United Kingdom (UK), the length of a goods carrying vehicle is limited to a maximum of 16.5m for a standard articulated vehicle and 18.75m for a draw-bar combination. In October 2011, the Department for Transport announced trials of extended length semi-trailers with the aim of investigating the impact of increasing the length of an articulated vehicle up to a new maximum of 18.55m, an increase of 2.05m.

A number of countries in the European Union (EU) have opted to either permit or trial vehicles that are substantially longer than those currently permitted or under trial in the UK, with the extension of length often accompanied by an increase in the maximum gross weight of the vehicle. The European Commission is currently undertaking a review of the EU Directive that governs the weights and dimensions of vehicles operating in the EU.

This study assesses the environmental, economic, safety and practical impacts of increasing the maximum length of vehicles in the UK to 25.25m, while maintaining the maximum gross weight at the current UK limit of 44 tonnes (with such a vehicle herein referred to as a 'High Capacity Vehicle' or 'HCV'). The scope is limited to the consideration of 25.25m vehicle variants that are currently in use in the Netherlands.

An increase in vehicle length, without any corresponding increase in gross weight of the vehicle is of particular benefit to transporters of low density goods that regularly fill the cubic capacity of a vehicle without accessing its full weight carrying capacity. The costs of transport of low density goods, when measured on a per tonne or per tonne kilometre basis, are significantly higher than for more dense goods.

Analysis of UK road freight transport flows in this research suggests that there are significant opportunities for the use of HCVs for the carriage of low density goods. Such opportunities include;

- Transport of full loads of lightweight goods in roll cage or palletised form;
- Lightweight container transport; and;
- Other niche operations.

The above opportunities are estimated to equate to an annual flow of approximately 1,425 million articulated vehicle kilometres, accounting for 15% of the total distance travelled by articulated vehicles.

Commodities that have greatest potential for use of HCVs are found to be Packaging, Perishable Foodstuffs, Non-perishable Foodstuffs, and Other Manufactured Goods.

At vehicle level, fuel consumption and carbon emissions of an HCV are greater than for a standard length vehicle, however, this report finds that when the additional carrying capacity of an HCV is considered, the fuel consumption and carbon emissions per unit of load decrease by between 11% and 19% (on a per pallet kilometre basis). Transport costs are found to decrease by approximately 19% on a per pallet kilometre basis.

The potential benefits of the use of HCVs within case study companies are explored in this research through detailed modelling of transport operations, focusing on organisations that carry large quantities of low density goods. This analysis finds that the total carbon emissions of these transport operations would reduce by up to 10%, and that total transport costs would fall by up to 12%, were HCVs to be integrated within transport operations alongside other fleet options. Percentage reductions would be greater if compared against large vehicle emissions / costs only – with reductions of up to 13% and 17% respectively. These results demonstrate the significant benefits to be gained by shippers of low density goods.

While most rail freight traffic is too heavy to make use of the volumetric carrying capacity of an HCV, this study finds that a maximum of 20% of rail intermodal / deep sea container traffic would be at risk of modal shift from rail to road. As rail freight

has comparatively lower carbon emissions than road freight, modal shift would result in an increase in the emissions associated with transferring freight. This would partially offset the emissions savings from transfer of conventional road traffic to HCV, but, on balance, this study finds that there would be a significant net reduction in carbon emissions.

In the event that all identified low density road and rail freight traffic migrated to HCV transport, annual transport cost savings are estimated at £226 million, with total carbon emissions reducing by an estimated 96 thousand tonnes per annum. Use of HCVs would be likely to reduce the number of large goods carrying vehicles using the UK road network, with total distance travelled by large vehicles reducing by up to 4%, making a useful contribution to the relief of congestion.

A review of the evidence presented in a number of key reports and publications on the safety of longer vehicles and the actual experience of operation of such vehicles in the EU, finds that the introduction of HCVs that have been configured to comply with UK turning circle standards would have no significant impact on safety in terms of road traffic accidents. This is subject to the vehicles being purpose built to a suitable specification and incorporating advanced technological features including steer axles, advanced braking systems, stability technology and suitable visibility aids. Appropriate driver training is also critical.

Practical considerations will reduce the potential use of HCVs. HCVs can be configured to comply with currently applicable manoeuvrability standards but restrictions on usage on some parts of the road network would still be required (as is the case for conventional large vehicles). At some smaller transport origin and destination points, access to the site and operation on site may be problematic. The ability to decouple sections of the vehicle close to the delivery point and to transport each part separately can overcome such access issues.

It is estimated that practical constraints would limit HCV use to approximately 40% to 60% of the total opportunity and net economic and emissions benefits would reduce accordingly, however, substantial benefits would remain. At this level of use, annual transport savings would be between £90 million and £135 million, with a reduction in carbon emissions of between 38 thousand and 58 thousand tonnes per annum.

In summary, this study finds that permitting the use of HCVs in the UK under controlled conditions would reduce transport costs, has the potential to reduce carbon emissions and will not compromise the safety of road users. Practical constraints will limit application in some circumstances, but there is a significant opportunity to improve the efficiency and sustainability of freight transport and to achieve cost reduction in the transport of low density goods.

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1. Project Background

1.1 Introduction

There has been considerable debate in the United Kingdom (UK) and across the European Union (EU) as to the merits of permitting an increase in the maximum weight and / or dimensions of goods carrying commercial vehicles. Maximum weights and dimensions applicable in each EU Member State are defined by a combination of EU and domestic road transport regulations.

Several EU Member States have opted to trial or permit the use of vehicles that are longer and / or heavier than those currently permitted in the UK, on the grounds that such vehicles offer potential environmental, economic and operational advantages over conventional fleet. In other countries adverse opinion has led to the delay of trials of longer or heavier vehicle configurations.

In the UK, a major Department for Transport (DfT) commissioned report by the Transport Research Laboratory (TRL, Knight et al., 2008) found that while there were significant benefits of permitting use of longer and / or heavier vehicles in the UK, there were also areas of concern. Consequently, the DfT opted not to progress with any significant changes to UK regulations, instead choosing to consult on proposals for a minor increase in the maximum length of semi-trailers (of up to 2.05m). Trials of such longer semi-trailers were announced in October 2011.

Many of the arguments in favour of or against an increase in weight or dimensions relate directly to the consequences of increased weight. There is limited research that focuses solely on the option of significantly extended length without any corresponding increase in gross vehicle weight. As a result, the University of Huddersfield has been commissioned to undertake an independent review of the environmental, economic, safety and practical impacts of operating extended length goods carrying vehicles in the UK that are compliant with current maximum gross vehicle weight limitations.

This research considers only one length of extended vehicle (of 25.25m and a maximum gross vehicle weight of 44 tonnes), herein referred to as a “High Capacity Vehicle” (“HCV”), in recognition of the increased volume carrying opportunity that such a vehicle offers. There are a number of different variants of 25.25m length vehicles in use within or outside the EU or that are theoretically possible – for simplicity this report considers only 25.25m variants that are currently authorised for use in the Netherlands.

1.2 Project Scope

This review incorporates the following elements:

- Background research on the regulatory environment, EU experience of longer and / or heavier vehicles and alternative options for the configuration of HCVs.
- Identification of the potential opportunity for the use of HCVs in the UK and segments of the potential population by type of product / business.
- Assessment of the environmental and economic impact of using HCVs on a per vehicle basis and within case study companies.
- Prediction of the potential environmental and economic impact of moving “cubed out” operations in the UK from conventional vehicles to HCVs, including consideration of the risk of reverse modal shift.
- Review of the safety risks and benefits of HCVs as compared to currently permitted vehicles.
- Review of the practical considerations and potential limitations of the use of HCVs in the UK.

From the above, conclusions are drawn as to the feasibility and desirability of permitting HCV usage in the UK.

1.3 Project Methodology

This research is based on both qualitative and quantitative information drawn from primary and secondary sources. The methodology employs the following techniques:

- Literature review – focusing on governmental and non-governmental organisation reports, academic journals and reliable industry sources concerning the use of longer and / or heavier vehicles and related topics.
- Analysis of published and unpublished transport data drawn from government statistics (primarily DfT and Office of Rail Regulation (ORR) transport statistics) and industry sources.
- Detailed modelling and analysis of the transport operations of case study organisations carrying low density goods to determine the economic and environmental impact of use of HCVs.
- Observation of use of longer, heavier vehicles in the Netherlands.
- Round table discussion with hauliers and users of longer, heavier vehicles in the Netherlands.

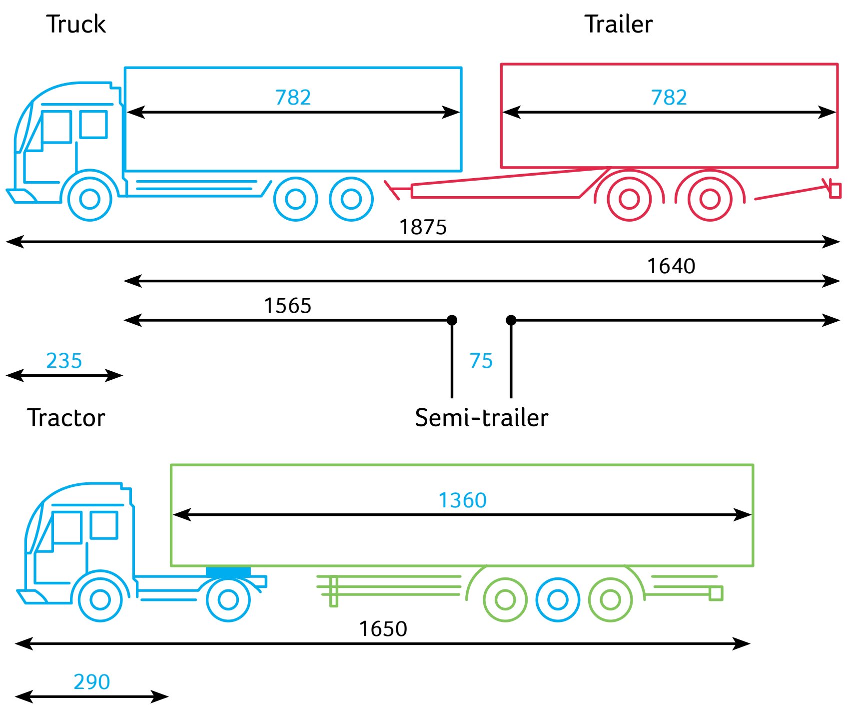
The methodology underpinning each section of this study is summarised in Appendix A.

2. Use of Longer and / or Heavier Vehicles in the EU

2.1 Regulatory Framework

EU Council Directive 96/53/EC limits the length of goods carrying vehicles to a maximum of 18.75m for a drawbar combination or 16.5m for an articulated vehicle combination (comprising tractive unit and semi-trailer). Directive 96/53/EC does not set a maximum height or weight that may be used domestically within Member States, but States must allow free circulation of vehicles with a height of up to 4m and a gross vehicle weight limit of up to 40 tonnes (on 5 axles) (EC, 1996).

Currently applicable maximum vehicle lengths are illustrated in figure 2.1 below.



Legal size limits and derived size limits (sizes in centimeters)

Figure 2.1: Legal size limits for commercial vehicles (EC/96/53).
Source: CROW, LHVs on Secondary Roads, cited by MTPWWM, 2010.

The Directive further stipulates that vehicles must be able to turn within a circle having an outer radius of 12.5m and inner radius of 5.3m – the difference representing the "swept path" of the vehicle – a maximum of 7.2m (EC, 1996).

In the UK, Council Directive 96/53/EC applies to limit maximum vehicle length. Domestic regulations permit a maximum gross vehicle weight of 44 tonnes (on 6 axles) and do not place a limit on vehicle height. Individual EU Member States may allow vehicles longer than 96/53/EC limits (or that do not comply with turning circle requirements) where this does not 'significantly affect international competition in the transport sector' (EC, 1996). Several countries within the EU have opted to trial or implement longer and / or heavier vehicles with a maximum length of 25.25m and a gross vehicle weight of up to 60 tonnes.

The term 'Longer, Heavier Vehicle' (LHV) is generally used to describe vehicles that exceed the maximum vehicle lengths set out in Directive 96/53/EC, or exceed the gross vehicle weight that Member States must allow to freely circulate (40 tonnes). In a UK context the term refers to longer vehicles that have a gross vehicle weight greater than 44 tonnes. In UK terms an HCV is therefore a longer but not heavier vehicle.

There are several different vehicle combinations in use or on trial in EU Member States that yield a total vehicle length of 25.25m (refer to section 2.3 for an overview of the principal variants).

Longer vehicles in use in the EU are constructed around the European Modular System (of standard vehicle, trailer and semi-trailer components) that can be combined to yield an extended length vehicle. The European Modular System (EMS), also referred to as the "modular concept", is defined in Directive 96/53/EC, Article 4, § 4 (b) as follows:

"the Member State which permits transport operations to be carried out in its territory by vehicles or vehicle combinations with dimensions deviating from those laid down in Annex I also permits motor vehicles, trailers and semi trailers which comply with the dimensions laid down in Annex I to be used in such combinations as to achieve at least the loading length authorized in that Member State, so that every operator may benefit from equal conditions of competition (modular concept)." (EC, 1996)

The European Commission 2011 Transport White Paper announced that legislation on vehicle weights and dimensions should be reviewed to adapt to new technologies and needs. This review is ongoing as at the time of publication of this report.

2.2 Experience of Longer and / or Heavier Vehicles in the EU

Table 2.1 summarises the experience of use of longer and or heavier vehicles in selected EU member states.

Country	Status
The Netherlands	In the Netherlands vehicles of up to 60 tonnes / 25.25m have been extensively trialled since 2001. There has been a ten year phased trial period (2001 – 2011) with increasing numbers of LHVs during each phase. In May 2011 the Dutch Ministry of Transport announced that longer and heavier vehicles would be permitted for use in the Netherlands on a permanent basis.
Sweden	In Sweden, longer, heavier vehicles have been in use since 1972 (prior to joining the EU). Vehicles are currently permitted to operate at a maximum gross vehicle weight of 60 tonnes and a maximum length of 25.25m. There have also been small scale trials of vehicle combinations of up to 32m in length and a gross weight of up to 90 tonnes.
Finland	Vehicles are currently permitted to operate at a maximum gross vehicle weight of 60 tonnes and a maximum length of 25.25m.
Denmark	Initial three year trial period (commenced 2008) of vehicles up to 25.25m / 60 tonnes. Subsequent extension of trials until at least 2017.
Belgium	Trials under consideration.
Germany	In January 2012, trials commenced in some Federal States of vehicles up to 25.25m in length and a maximum gross weight of 40 tonnes (44 tonnes for combined transport). A minority of States are continuing to oppose Federal Government plans for national trials.

Table 2.1: Experience of longer and/ or heavier vehicles in the EU.
Sources: Vierth et al. (2008), MTPWWM (2010), ITF/OECD/JTRC (2010), IFW (2011), CV Engineer (2012).

Longer and / or heavier vehicles are also in use in other countries outside the EU, including Norway, Australia (up to 53.5m / 125 tonnes GVW), Canada (up to 38m / 62.5 tonnes GVW) and the United States (ITF/OECD/JTRC, 2010).

2.3 Longer Vehicle Configurations

There are many alternative potential configurations of longer, heavier and higher vehicles that could be used to increase the capacity (in terms of payload weight or volume) of goods carrying vehicles. A report by the Transport Research Laboratory (TRL, Knight et al., 2010) identified a non-exhaustive list of 36 different permutations.

This report is focused on increased vehicle length only, and for the purposes of simplicity, limits scope of potential vehicles to vehicles of 25.25m length that are currently permitted for use within the Netherlands and that are typical of configurations either used or trialled within the EU.

Table 2.2 illustrates different LHV configurations that are currently permitted for use in the Netherlands. Further information on the axles, dimensions and carrying capacity of these vehicles can be found in table 2.3, with additional detail in Appendix B.

In the Netherlands, gross vehicle weight for LHV configurations is a maximum of 60 tonnes. Domestic regulations allow greater tolerance than 96/53/EC for the turning circle of LHVs – with an outer radius of 14.5m and an inner radius of 6.5m, yielding a maximum swept path of 8m (MTPWWM, 2010).

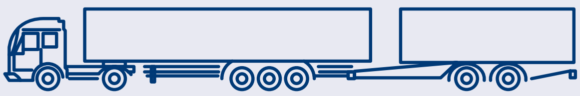
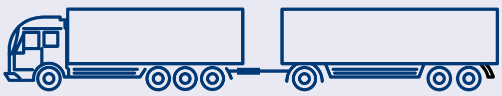
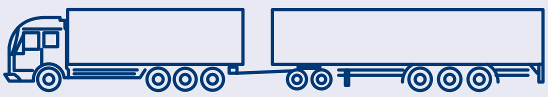
Type	Illustration	Description
A		Tractive unit + semi-trailer + centre axle trailer
B		Tractive unit + semi-trailer (inter-link) + semi-trailer. Also known as the B-double configuration
C		Truck (rigid) + trailer
D		Truck (rigid)+ dolly + semi-trailer
E		Truck (rigid) + two centre axle trailers

Table 2.2: LHV configurations permitted in the Netherlands.
Source: Adapted from MIE, 2011b.

Vehicle configuration C (as shown in table 2.2) is used in very limited numbers in the Netherlands and is not normally configured to a length of 25.25m. It is therefore not further considered in this document.

Vehicle Type	Vehicle Configuration	No. articulation points	No. of trailers	No. of axles	First body load length (m)	Second body load length (m)	Third body load length (m)	Max pallet capacity (ISO)	No. Forty-foot Containers	No. Twenty-foot Containers
A	Tractive unit + semi-trailer + centre axle trailer	2	2	7/8	13.6	7.83	0	40	1	3
B	Tractive unit + semi-trailer (inter-link) + semi-trailer. Also known as the B-double configuration	2	2	8	0	8.23	13.6	40	1	3
D	Truck (rigid)+ dolly + semi-trailer	2	2	8/9	7.83	13.6	0	40	1	3
E	Truck (rigid) + two centre axle trailers	2	2	7/8	6.8	6.8	6.8	36	0	3

Table 2.3: Dimensions and capacity of 25.25m LHVs in use in the Netherlands.
Source: Adapted from Knight et al., 2010.

2.4 Relative Advantages of Vehicle Configurations

2.4.1 Capital Cost

Configuration A, D and E can be assembled from standard vehicle components that have been suitably modified, with configuration D requiring an additional dolly with fifth wheel. The capital cost of these configurations is above the investment level of conventional vehicles due to required modifications and higher specification, but not significantly so.

The B configuration (B-double) requires investment in a specialised ‘interlink’ trailer, with a short body and fifth wheel. Its capital costs will be higher than for other configurations due to the non-standard nature of the equipment.

2.4.2. Container Transport

Configurations A, B and D (when configured with container carrying skeletal trailers) have the ability to transport either three twenty-foot (20’) shipping containers or one forty-foot (40’) container and one 20’ container.

Configuration E is less flexible, but can carry three 20’ containers.

2.4.3. Manoeuvrability

Vehicle manoeuvrability can be improved through the addition of steer axles. Detailed research and operational trials have demonstrated that the fitting of steer axles to the inter-link trailer of the B-double configuration can enable such a vehicle to comply with existing EU regulations on swept path width and out-swing performance (BTAC, 2005, Knight et al., 2008, Roebuck, Odhams & Cebon, 2010).

It may be possible to develop steering systems to enable configurations other than the B-double to become compliant with relevant EU legislation concerning manoeuvrability. However, this is not yet fully developed.

2.4.4. Vehicle Flexibility

Configurations A, B and E have the advantage that the vehicle can be decoupled, with the motive unit able to tow either the first or second trailer on a standalone basis. This ability is central to the B (B-double) configuration design where the first and second trailers are attached via a fifth wheel and the second trailer can be:

- dropped to allow operation with the first (interlink) trailer only;
- coupled directly to the tractive unit for single trailer running;
- coupled at the rear of the first trailer for full length operations.

In configuration A, a similar capability can be achieved through the addition of a draw bar coupling point to the tractive unit, enabling the second trailer to be towed either by the tractive unit or in full configuration. In configuration E, the first and second trailers can be dropped or interchanged enabling the vehicle to operate with none, either or both trailers. Configuration D does not have such flexibility.

The ability to decouple is a useful feature where access constraints make it impractical to drive the fully configured vehicle from door to door – the final access can be made using a vehicle no longer than a standard vehicle.

There are complexities when loading / unloading the first (interlink) trailer of the B-double configuration through the rear trailer doors – these are further discussed in section 7.6.

City Trailer Variant

A recent development in the Netherlands has been the introduction of a B-double (type B) variant featuring two interchangeable "City trailers", each with a length of 10.6m and a carrying capacity of 20 pallets (pictured in figure 2.2). This configuration has attractions as it would enable loads to be constructed in multiples of twenty pallets (either twenty or forty pallets) and, when split for single trailer running, allow easier access with a shorter vehicle to overcome access constraints.

Figure 2.2: B-double featuring two "city" trailers.
Picture source: D-TEC BV, no date.

In the pictured example the rear bogie of the front trailer is divisible, allowing the rear doors of the front trailer to be more easily accessed.

3. HCV Opportunity Assessment

3.1 High Capacity Vehicles

In this report, the maximum HCV length of 25.25m has been selected for consistency with vehicles currently in use elsewhere in the EU and for compatibility with the European Modular System, although it should be noted that consideration should be given to standardisation of vehicle body lengths that are more precisely aligned to multiples of standard pallet dimensions.

Table 3.1 presents the key weights, dimensions and payload carrying capacity of an HCV as compared with a conventional UK specification 16.5m articulated vehicle. The HCV considered is a B-double configuration, although it should be noted there are other possible variants with similar maximum weights, dimensions and load carrying capacity (see section 2.3).

Attribute	Conventional Articulated Vehicle	High Capacity Vehicle (B-double)	Change %
Length (m)	16.5	25.25	
Gross Vehicle Weight (kg)	44,000	44,000	
Unladen Weight (kg)	14,890	20,650	
Payload Weight (kg)	29,110	23,350	-19.8%
Volume (Cubic Metres)	100.9	158.9	+57.5%
Floor pallet positions (ISO pallets)	26	40	+53.9%
Container carrying capacity	1 x 40’ or 2 x 20’	1 x 40’ + 1 x 20’ or 3 x 20’	+50.0%

Table 3.1: Weight and capacity of an HCV.
Source: Adapted from Knight et al. (2008), based on single deck vehicles, 4m high.

Table 3.1 demonstrates that the increased length of an HCV results in an increase in the volume of the vehicle (by 57.5%), and an increase in the pallet carrying capacity from 26 pallets (or pallet stacks) to 40 pallets (or pallet stacks), an increase of 53.9%. Container carrying capacity increases by 50% but the payload weight reduces as a result of the increased unladen weight of the longer vehicle (a reduction of 19.8%).

A combination of reduced payload weight and increased pallet capacity means that the average weight per pallet (or pallet stack) carried when fully laden must not exceed 583kg (23,350kg payload weight / 40 pallets). The cubic capacity of an HCV can therefore only be fully utilised when carrying relatively low density products, otherwise it will ‘weigh out’ before it ‘cubes out’. This restricts the type of products that can practically be carried by an HCV.

In addition, goods must be transported in sufficient quantity to justify the usage of an HCV – transporting a consignment that uses only part of the capacity of an HCV would generally be better effected in a smaller vehicle (unless consolidated with other consignments to create a multi-drop trip so as to utilise the full HCV capacity).

At the raw material end of the supply chain, commodities consumed in the production process tend to move in large quantities but are high density in nature. As product moves through the supply chain the density tends to decrease during the production and packaging processes, creating opportunities for use of HCVs. The transportation of finished consumer goods in bulk from point of manufacture through to retailer distribution centre provides particularly fertile ground for HCV use.

3.2 Low Density Goods

When measured on a weight basis (either in terms of tonnes lifted or tonne kilometres), low density goods incur high transport costs, are fuel intensive to transport and generate high emission levels when compared to high density goods. The example below illustrates this effect.

Example:
To transport 26 pallets of tinned food weighing one tonne per pallet (26 tonnes total weight) would require one load of a 44 tonne articulated lorry. The average cost and carbon emissions per kilometre of such a vehicle would be £0.97 and 0.91kg CO_2 (FTA, 2011). The cost / emissions per tonne kilometre of such product would therefore be £0.037 and 0.035kg CO_2 respectively (ignoring any empty running).

To transport the same weight (26 tonnes) of low density goods (e.g. potato crisps), weighing 250kg per pallet stack would require four vehicle loads of a standard articulated vehicle. Assuming an average 33 tonne vehicle with an operating cost of £0.94 per kilometre and carbon emissions of 0.82kg per kilometre (FTA, 2011), the cost / emissions to move one tonne kilometre would be £0.145 and 0.126kg CO_2 respectively (again ignoring empty running).

In this example it is demonstrated that on a tonne kilometre basis, it is 3.9 times more expensive and 3.6 times as polluting to transport the low density product as compared to high density goods.

The above example illustrates how statistics that aggregate the cost or emissions associated with the transportation of goods on a tonne kilometre or tonne lifted basis significantly understate the cost and emissions of transporting low density goods and overstate those of high density goods.

3.3 Identification of the Scale of Opportunity for HCV Usage

Unpublished data drawn from the DfT 'Continuing Survey of Road Goods Transport' (DfT, 2011a), together with data drawn from DfT UK Maritime Statistics (DfT, 2011b, DfT, 2011c) has been used to identify road transport flows where goods are sufficiently lightweight and are transported in sufficiently large quantities to be suitable for carriage by HCV. Full details of this analysis can be found in Appendix C (section C1).

Table 3.2 summarises existing road transport flows that have been identified as suitable for carriage by HCV.

Opportunity	Opportunity Scale (2009) Million Articulated Vehicle Kilometres
Full loads of lightweight goods in palletised or roll cage form	1,160
Lightweight container traffic	127
Full loads carried in 'Other' modes of appearance (low estimate)	138
Grand Total	**1,425**
Notes: Distances travelled include an allowance for empty running. Based on 2009 volumes (developed from DfT (2011a,b,c))	

Table 3.2: Summary of opportunities for HCV use.

The above opportunities represent approximately 15% of total articulated vehicle distance travelled in 2009 but only 9% of articulated vehicle tonne kilometres undertaken in that year (due to the lightweight nature of goods).

It should be noted that the above volumes exclude any allowance for current rail freight volumes that may transfer to road as a result of the introduction of HCVs – this is further discussed in section 4.4.

3.4 Identification of Low Density Commodity Groups

Analysis of data drawn from the Continuing Survey of Road Goods Transport (DfT, 2011a) demonstrates that seven commodity types (out of a total list of 73 commodities) represent 80% of the potential opportunity for use of HCVs for the carriage of goods in roll cage or palletised form (details of this analysis can be found in Appendix C, section C2). These commodity groups are found to be:

Packaging; Perishable Foodstuffs; Non-perishable Foodstuffs; Other Manufactured Goods; Parcels; Other Manufactured Articles; and; Paper / Paperboard Manufactures.

Companies in the four commodity groups with greatest potential are used as case studies to explore the impact that use of HCVs would have on their operations (see Appendix E, and sections 4.3 and 5.2).

4. Environmental Impact

4.1 Literature Review

There are a number of significant negative externalities associated with road freight transportation, including noise, accidents, congestion, consumption of non-renewable fuels / materials and pollution. There has been progress over time in reducing some types of pollution through improvements in engine technology and associated standards, but there remain serious concerns in relation to Carbon Dioxide (CO_2), Oxides of Nitrogen (NOx) and Particulate Matter (PM). The emission of these pollutants is linked to the amount of fuel consumed – in the case of CO_2 there is a direct linear relationship.

Over the last decade there have been numerous studies, commissioned by governmental and non-governmental bodies, which examine the effects of increasing the maximum allowable weight and / or dimensions of goods carrying vehicles. There is a general consensus that, given a fixed level of demand for road freight transport, an increase in maximum weight and / or dimensions will result in a decrease in the total number of vehicle kilometres travelled and a reduction in fuel consumption and corresponding vehicle emissions. Table 4.1 presents selected findings from key studies within various EU Member States.

Source & Country	Findings
Transport Research Laboratory (Knight et al., 2008) UK	Comparison of a 60 tonne, 25.25m long vehicle with a conventional 44 tonne, 16.5m long articulated vehicle after allowing for typical loading factors and empty running. CO_2 emissions on a tonne kilometre basis reduced from 71.955g/tkm to 62.631g/tkm (a reduction of 13%).
IVH (2007) Germany	Trials in Germany (Saxony) of vehicles of 25.25m length and maximum gross weight of 40 tonnes found that fuel consumption per vehicle kilometre increased by between 10% and 15%, however, the carrying capacity (in cubic metres) increased by 40% to 50% yielding average fuel savings of 25% when measured on a cubic volume basis.
Arcadis (2006) The Netherlands	In the Netherlands vehicles of up to 60 tonnes / 25.25m have been extensively trialled since 2001. Arcadis found that when compared with standard vehicles (18.75m length, 50 tonnes gross vehicle weight), extended length vehicles (with no increase in weight) experienced a 5% increase in fuel consumption per kilometre, whereas fuel consumption increased by 22% for vehicles that were both heavier (60 tonnes) and longer. Both vehicle types generated emission reductions on a per pallet / cubic metre basis.
Vierth et al. (2008) Sweden	In Sweden, vehicles are currently permitted to operate at a maximum gross vehicle weight of 60 tonnes and a maximum length of 25.25m, more than 60% of all tonnage lifted and more than 70% of all freight tonne kilometres are transported on vehicles exceeding 18.75m in length or 40 tonnes gross vehicle weight. Vierth et al. calculate that were limits to revert to 18.75m maximum length / 40 tonne maximum gross vehicle weight, vehicle kilometres would increase by 24%, CO_2 emissions would increase by 6.4% and NOx emissions would increase by 6.6%, assuming that displaced freight volume continues to be transported by road.

Table 4.1: Summary environmental findings from key LHV studies.

The above reports illustrate the general consensus that the use of longer and / or heavier vehicles will reduce the fuel consumption and emissions associated with the transport of a unit of freight by road.

Fuel consumption and emissions benefits accrue from longer and/ or heavier vehicles because, although fuel consumption increases as the size of the vehicle increases, the carrying capacity of the vehicle increases by a larger percentage and hence the fuel consumption decreases on a per unit carried basis.

4.2 Fuel Consumption and CO_2 Emissions of High Capacity Vehicles

The fuel consumption of a fully laden 44 tonne HCV will be higher than the fuel consumption of a fully laden 44 tonne conventional 16.5m vehicle operating under the same conditions. This is principally as a result of additional aerodynamic drag and additional rolling resistance caused by the increased number of axles.

Most potential HCV variants have an additional point of discontinuity (the gap between vehicle body sections / trailers) that creates additional air recirculation (turbulent air flow) and friction zones (Leduc, 2009). In addition, the increased number of axles creates further air friction zones and the increased body surface area creates further skin friction drag. All these factors contribute to increased aerodynamic drag.

Rolling resistance is influenced by the number of axles, but also by the mass transmitted through each axle. Despite the reduced mass per axle achieved by spreading the weight over more axles, the net impact for an HCV would be to increase rolling resistance as compared to a standard vehicle of equivalent weight.

The extended length of an HCV results in an increase in the unladen vehicle weight (due to the additional vehicle section) and a corresponding reduction in maximum payload weight, which serves to limit the maximum density of goods that can be transported.

To assess the fuel consumption and emissions of operating HCVs on a per vehicle basis, the fuel consumption or emissions of a fully loaded HCV should be compared with those of a conventional vehicle that has been fully loaded with goods of equivalent density. Three alternative data sets are available for analysis (see tables 4.2 and 4.3) - the first two data sets meet this test, with the third providing additional useful context.

Study	Comparison
MIRA / BTAC Trials	Comparison of a standard 44 tonne GVW articulated vehicle carrying a full payload of lightweight product (6 tonnes) and the same vehicle components extended into a 25.25m B-double configuration (by addition of an interlink trailer), carrying a full payload of the same product (9.45 tonnes).
TRL Estimate. (Knight et al., 2008)	Comparison of a standard 44 tonne articulated vehicle (adjusted to a payload of 15.2 tonnes), with a 25.25m B-double vehicle with a payload weight of 23.35 tonnes. (Note fuel consumption data is derived from published TRL CO_2 emissions data for each vehicle type using standard conversion factors).
NL Operator data (2011) compared to FTA (2011)	Comparison of the average actual fuel consumption of a fleet of 8 25.25m vehicles (configuration D) carrying very lightweight product with the fuel consumption of a 33 tonne standard articulated vehicle (derived from Freight Transport Association (FTA) data – "high" (below average fuel consumption) figure used due to nature of product).

Table 4.2: Overview of fuel consumption data sets.

	Standard 16.5m vehicle l/100km	HCV l/100km	Fuel Consumption variance	Fuel per pallet km variance	CO_2 per pallet km variance
MIRA / BTAC Trials	24.1	31.9	32%	-14%	-14%
TRL Estimate	32.4	44.2	36%	-11%	-11%
NL Operator data	27.7	34.3	24%	-19%	-19%

Table 4.3: Comparison of fuel consumption data for standard articulated vehicle and HCV.

A more detailed analysis of the MIRA / BTAC data and TRL data can be found in Appendix D.

The different data sets demonstrate varying levels of recorded fuel consumption for each type of vehicle – this is to be expected given that each data set will be derived under different conditions (of payload weight, proportion of empty running, traffic conditions, speed, driver style etc).

While the TRL and BTAC data may appear dissimilar in terms of the fuel consumption of the base vehicle and longer vehicles, the variance can largely be attributed to the increased payload of the TRL vehicle. Coyle (2007) states that fuel consumption for distribution trucks increases by 0.112 miles per gallon (0.04 km per litre) for each additional tonne of payload – application of this factor would indicate that more than 60% of the difference in fuel consumption between the two longer vehicles is related to the difference in payload weight.

All data sets show an increase in fuel consumption for longer vehicles as compared to the base vehicle, with the fuel consumption of a fully loaded HCV in the magnitude of 24% to 36% greater than a standard articulated vehicle carrying a full load of equivalent density goods.

As fuel consumption increases at a lesser rate than the corresponding increase in pallet capacity (53.9%), the fuel consumption and CO_2 emissions per pallet decrease, by between 11% and 19%.

It should be noted that the rate of fuel consumption of LHVs operating in the EU (generally between 40 and 50 tonnes) is regularly reported at levels below those recorded by BTAC / TRL. The data shown in table 4.3 above for the Netherlands operator is compared against the FTA figure for a standard 33 tonne articulated vehicle (showing a 24% increase), however, when compared against the operators fleet of 18.75m draw bar vehicles performing similar activity and carrying similar goods, the increase in fuel consumption is only 5%. Arcadis (2006) and IVH (2007) report similarly low rates of increased fuel consumption (Arcadis 5%, IVH between 10% and 15%). It is not possible to verify whether these figures have been calculated on a fully like for like basis and therefore analysis in this report is based only on the BTAC figures as a reasonable high end estimate, recognising that the true position may be that a lesser rate of fuel consumption increase applies to HCVs.

4.3 Case Study Analysis

The transport operations of four large manufacturing organisations carrying lightweight goods have been modelled in detail to determine the impact of allowing the use of HCVs within their respective distribution networks. Full details of the case study companies, methodology and modelling results can be found in Appendix E.

Case studies have been selected that focus on the carriage of commodities that are shown in section 3.4 of this document as having greatest potential for use of HCVs.

Two scenarios for use of HCVs are investigated within case study companies:

- **A. Unrestricted Use** — Use of HCVs as a substitute for rigid / articulated vehicles for all transport operations where this is more cost effective (including full load and part load operations).
- **B. Restricted Use** — Use of HCVs to replace current full load articulated vehicle movements only, where this is more cost effective.

The modelled results of the two HCV scenarios are compared with a "base" case, modelled using conventional vehicles only. From the model, total distance travelled, fuel consumption and emissions of transport operations are calculated.

For all case companies, a 'typical' full load of product is sufficiently lightweight to be carried by a 33 tonne articulated vehicle. Such vehicles, along with 17 tonne rigid vehicles are therefore used as the base vehicle fleet within the modelling exercise. Fuel consumption is based on the average fuel consumption for these vehicles reported by the FTA (2011).

The fuel consumption of HCVs has been based on the FTA average for a 33 tonne articulated vehicle, uplifted by the fuel consumption increase recorded by BTAC for 25.25m vehicles (32%). CO_2 emissions are derived from fuel consumption using standard conversion factors.

The application of these factors results in the fuel consumption and emissions figures for each type of vehicle shown in table 4.4.

Vehicle Type	Fuel Consumption per 100km (litres)	CO_2 per km (kg)
17t Rigid	24	0.62
33t, 16.5m Artic	31	0.82
HCV (44t)	41	1.07

Table 4.4: Modelled fuel consumption factors.

Tables 4.5 & 4.6 detail the changes in modelled total distance travelled, fuel consumption and CO_2 emissions for each of the case study companies and for each of the HCV scenarios.

HCV (A): Unrestricted use				
Case Ref:	1	2	3	4
% Change	Manufactured Goods	Food Manufacturer A	Food Manufacturer B	Packaging Supplier
No. Kilometres	-23.0%	-17.3%	-21.0%	-10.2%
Fuel consumed	-7.9%	-7.6%	-10.0%	-4.0%
CO_2 Emissions	-7.9%	-7.6%	-10.0%	-4.0%

Table 4.5: Summary results from case study analysis – HCV (A) Unrestricted use.

HCV (B): Full load only use				
Case Ref:	1	2	3	4
% Change	Manufactured Goods	Food Manufacturer A	Food Manufacturer B	Packaging Supplier
No. Kilometres	-19.1%	-13.3%	-19.5%	-8.3%
Fuel consumed	-6.7%	-4.8%	-9.4%	-3.6%
CO_2 Emissions	-6.7%	-4.8%	-9.4%	-3.6%

Table 4.6: Summary results from case study analysis – HCV (B) Restricted use.

It can be seen that total fuel consumption / CO_2 emissions decrease by between 4.0% and 10.0% in the unrestricted scenario and between 3.6% and 9.4% in the scenario where HCVs are restricted in use for full loads only. In each case the change in fuel consumption / emissions is compared to the total modelled fuel consumption / emissions of the transport operation. If compared to the fuel consumption / CO_2 emissions of articulated vehicle transport only, the percentage reduction would be higher (between 4% and 13% in the unrestricted scenario).

The greatest level of benefit in terms of distance reduction is achieved for companies with the highest proportion of full loads suitable for transport by HCV. The unrestricted HCV scenario results indicate that there is additional environmental benefit in using HCVs for part loads as well as for full load movements, however, the majority of the benefit in case study organisations would be gained through application of HCVs to full load operations.

4.4 Modal Shift Risk

Section 4.1 notes the general consensus in reviewed literature that use of longer and / or heavier vehicles has the potential to yield lower fuel consumption and lower emissions on a per unit of payload basis. Section 4.2 demonstrates this effect at vehicle level (for HCVs) and section 4.3 provides an indication of the level of benefit of HCV use within case study companies. The evidence and analysis contained in section 5 of this document confirms that the use of HCVs will result in reduced road transport costs when measured on a per unit of load basis.

Despite the strength of evidence of reduced fuel consumption and emissions at vehicle and operation level, there are considerable variations in views as to the impact of longer and / or heavier vehicles on total carbon emissions from freight transport activity. This is a result of concerns that the reduced cost of road transport would lead to modal shift from other modes that are considered to be more sustainable.

In the Netherlands, concerns were raised that the introduction of longer, heavier vehicles would lead to modal shift from rail to road and as a result this has been closely monitored throughout the trial period. A report examining this issue states that;

"No reverse modal shifts have occurred following the introduction of LHVs in the Netherlands. According to expectations these effects will not occur in the near or distant future either". (MIE, 2011a, p7).

TRL (Knight et al., 2008) considered the issue in relation to the UK and concluded that permitting longer and / or heavier vehicles to operate in the UK would be likely to induce modal shift from rail but not from waterborne transport. The study notes that this risk is substantially reduced with longer but not heavier vehicles (HCVs) as there would be little or no risk of transfer of bulk rail transport volumes. The study identified that risks remain in relation to the deep sea container market and to the future growth of domestic intermodal transport and that between 2.5% and 5.5% of all rail tonne kilometres could be at risk of transfer to road were HCVs allowed to operate in the UK.

Analysis of 2009 rail freight data in Appendix C (section C3) concurs with TRL findings, concluding that the only significant category of rail freight transport at risk of transfer to HCV is the 'domestic intermodal category' - comprising 28% of rail tonne kilometres in 2009 (ORR, 2011) and of which only a proportion would be sufficiently lightweight to transfer.

The major flows associated with domestic intermodal transport relate to the transport of deep sea containers between port and inland rail terminal. To economically use the capacity of an HCV requires either one 20' container and one 40' container or three 20' containers, the combined payload weight of which must not exceed 23.5 tonnes. Analysis of the weight of inbound containers arriving at the port of Felixstowe demonstrates that there is a limited pool of sufficiently lightweight 20' containers and this will act as a constraint to the possible transfer of container freight from rail to HCV, with a maximum possible transfer of 20% of container freight traffic (see Appendix C, section C4).

This finding equates to a maximum transfer volume of less than 6% of all rail volumes (consistent with the upper end of Knight et al, 2008 findings). This amounts to around 1,060 million tonne kilometres per annum (equivalent to 153 million conventional articulated vehicle kilometres or 102 million HCV kilometres). In practice the actual rate of transfer would be considerably lower as rail would continue to retain an economic advantage over long distances and practical operational constraints specific to rail as well as those that would generally apply to HCV operations would restrict transfer rates.

4.5 Net Emissions Impact

Table 4.7 below summarises the transport streams identified in sections 3.3 and 4.4 that could potentially be carried by HCVs, and the associated carbon impact of 100% of each stream migrating to carriage by HCV. The table shows, that if all such streams were to transfer, there would be a net reduction in CO_2 emissions equivalent to 96,000 tonnes per annum.

Opportunity	Opportunity Scale	Carbon Factors	Net Impact of 100% volume transfer to HCV (thousand tonnes CO_2)
Transfer of full loads of lightweight goods in palletised or roll cage form from standard articulated vehicles ('SAV') to HCV.	1,160 million SAV km	0.82 kg CO_2 per km standard articulated vehicle 1.07 kg CO_2 per km HCV	(144)
Transfer of lightweight container traffic from standard road vehicles to HCV (20% of road container volumes)	880 million tonne km / 127 million SAV km	0.118 kg CO_2 per tonne km - standard articulated vehicle 0.103 kg CO_2 per tonne km – HCV	(13)
Transfer of lightweight loads with other modes of appearance from standard road to HCV (low estimate)	138 million SAV km	0.82 kg CO_2 per km standard articulated vehicle 1.07 kg CO_2 per km HCV	(17)
Transfer of lightweight container traffic from rail to HCV (20% rail intermodal volumes)	1,060 million tonne km / 153 million SAV km	0.0285 kg CO_2 per tonne km - rail 0.103 kg CO_2 per tonne km – HCV	79
Net Impact (based on 100% transfer of all volumes)			(96)

Notes:
Rail CO_2 emissions: modelled at 0.0285kg per tonne km (ORR, 2011). ORR figures include allowance for electricity consumption (adjusted for grid losses) for electric traction and diesel consumption for diesel traction.

Standard road vehicle CO_2 emissions: 0.82kg per km / 0.118kg per tonne km (based on emissions of 0.82 kg per km, a payload of 15.67 tonnes, 61% lading factor, uplift of 38% for empty running).

HCV CO_2 emissions: 1.07 kg per km / 0.103kg per tonne km (based on emissions of 1.07 kg per km, a payload of 23.5 tonnes, 61% lading factor, uplift of 38% for empty running).

CO_2 emissions are calculated on a 'tank to wheel basis' for diesel powered road vehicles, including the emissions resultant from combustion of fuel only – emissions associated with the extraction, production and distribution of fuel are excluded from the calculation.

Table 4.7: Net carbon impact of HCV implementation at 100% take up rate.

It should be noted that the above analysis is based on average carbon emission levels per rail tonne kilometre as reported by the ORR, taking in to account emissions for both electric and diesel traction (in practice the vast majority of container traffic by rail is by diesel traction). For reasons discussed in section 3.2, this average figure will understate the emissions associated with transport of low density goods, where as the road figures take in to account the lightweight nature of the load.

Constraints such as;

- road network restrictions;
- ability of sites to receive / despatch larger loads;
- site access restrictions; and
- availability of backloads;

will reduce the rate of transfer below 100% of the available opportunity - with a similar impact likely to be experienced by all types of transfer (these constraints are discussed in section 7). In addition, the rate of transfer of rail volumes will be further

constrained as a result of the continuing economic advantage of rail over long distances, complexity in assembly of suitable lightweight container loads with common geographical requirements and potential congestion at ports if additional volumes move by road.

Table 4.8 presents the impact of various differing levels of HCV substitution for lightweight road and rail transport flows.

Table showing carbon emissions impact (in thousand tonnes) of differing rates of HCV take up in road and rail transport

		% Transfer of lightweight articulated road vehicle kms to HCV (carrying loads in pallet / roll cage and containerised form and 'other MOA')					
		0%	**20%**	**40%**	**60%**	**80%**	**100%**
% Transfer of rail lightweight container volumes to HCV.	**0%**	0	(35)	(70)	(105)	(140)	(175)
	20%	16	(19)	(54)	(89)	(124)	(159)
	40%	32	(3)	(38)	(73)	(109)	(144)
	60%	47	12	(23)	(58)	(93)	(128)
	80%	63	28	(7)	(42)	(77)	(112)
	100%	79	44	9	(26)	(61)	(96)

Table 4.8: Net carbon impact of HCV implementation at different take up rates.

Actual take up rates are more likely to be in the region of 40% to 60% of the available opportunity for usage, equating to a saving of between 38 thousand and 58 thousand tonnes of CO_2 per annum.

Table 4.8 demonstrates that, provided the proportion of lightweight containerised rail traffic transferring to HCV is broadly equivalent to the proportion of lightweight road traffic transferring to HCV, CO_2 emissions will reduce.

There is a small risk that the reduced cost of carriage of low density goods achievable through use of HCVs could stimulate additional demand for such transport. There is little evidence to support that this would be the case as demand levels for transport of large consignments of low density goods will be driven by largely fixed network infrastructure rather than the cost. Against a backdrop of a rising trend in fuel prices, network changes that increase transport requirements are not probable. There is also a possible benefit if goods that were previously transported as part loads are consolidated in to full HCV loads to access the cost advantage of HCV transport.

In conclusion, the net CO_2 emissions from goods transport are highly likely to reduce as a result of introduction of HCVs in the UK. There is a small risk that, if transfer rates of lightweight traffic from rail exceed the uptake in general lightweight road haulage, there could be an increase in carbon emissions. This is believed highly unlikely as the advantages for both modes are similar, but the constraints surrounding migration from rail to HCV are greater.

In addition to CO_2 emissions, road and rail transport are responsible for a range of other pollutants that are either harmful to health or are linked to climate change. Whilst there is a direct linear relationship between fuel consumption and CO_2 emissions that allows ease of calculation, emissions of other pollutants can be affected by other factors including engine technology as well as fuel consumption. It is, however, reasonable to conclude that if fuel consumption and hence CO_2 emissions reduce, emissions of other pollutants will also decrease.

5. Economic Impact

5.1 Vehicle Level Cost Comparison

There is consensus that the use of longer and / or heavier vehicles will reduce the total cost of freight transport by road on a per unit basis (Knight et al. (2008); Vierth et al. (2008); ITF/OECD/JTRC (2010); MTPWWM (2010); Arcadis (2006); TIM Consult (2006)).

TRL (Knight et al., 2008) calculate that the capital costs of a 44 tonne B-double HCV would be 137% of those of a standard 44 tonne articulated vehicle. Operational costs would be 113% of those of such a standard vehicle. Factoring in the significant increase in pallet carrying capacity of an HCV leads to the conclusion that on a per pallet carried basis, a fully loaded HCV has significant cost advantages over a conventional vehicle.

Appendix F contains a detailed estimate of the cost of operating a 44 tonne HCV. This is developed from the cost of a standard 44 tonne articulated vehicle as reported by the FTA (2011), and adjusted where appropriate to factor in the additional costs of operating an HCV. For the purposes of costing, the HCV is assumed to be a B-double configuration.

A low and high estimate has been made for each adjustment from the base 44 tonne cost, with the average then taken to develop a cost per kilometre. Transport management and business overheads are excluded from the analysis.

Key areas of adjustment to the FTA reported cost of running a 44 tonne standard articulated vehicle are as follows:

- **Capital cost** – incremental capital cost of the additional trailer and associated technical upgrade to the base vehicle, depreciated over an estimated ten year life.
- **Fuel** – fuel consumption derived from the FTA reported consumption of a 33 tonne vehicle, uplifted by 32% (for consistency with the findings on fuel consumption noted in sections 4.2 and 4.3, fuel cost of £1.13 per litre).
- **Maintenance and tyres** – uplifted to account for the additional trailer component and additional axles.

Refer to Appendix F for a detailed account of adjustments.

Collectively these adjustments result in an estimated increase in cost from £0.84 per kilometre for the standard 44 tonne vehicle to £1.01 per km for the HCV, an increase of 20.2%. Increased fuel costs are responsible for approximately half of the increase.

These findings are broadly consistent with TRL operational cost per kilometre figures when adjusted to include capital costs in the cost per kilometre.

As with fuel consumption, to fairly assess the cost impact of using HCVs, the costs of a fully loaded HCV should be compared with those of a conventional vehicle that has been fully loaded with goods of equivalent density. This would equate to a fully loaded 33 tonne conventional articulated vehicle. Cost per kilometre, per pallet kilometre and per 20' container kilometre are compared in table 5.1.

	33 tonne Vehicle	44 tonne HCV	Change %
Cost per km	£0.81	£1.01	25%
Capacity (pallets)	26	40	54%
Capacity (20' containers)	2	3	50%
Cost per pallet km	£0.031	£0.025	-19%
Cost per 20' container km	£0.405	£0.337	-17%

Table 5.1: Cost Comparison - HCV vs 33 tonne 16.5m articulated vehicle.

As illustrated in table 5.1, while the cost per km of an HCV is shown to be 25% higher than that of a 33 tonne articulated vehicle, the cost per pallet km is found to be 19% lower and the cost per 20' container km is 17% lower.

5.2 Case Study Analysis

As described in section 4.3, the transport operations of large manufacturing organisations carrying lightweight goods have been modelled in detail to determine the impact of allowing the use of HCVs within their respective distribution networks (refer to Appendix E for full details).

Resource requirements necessary to economically meet distribution requirements have been modelled both with and without use of HCVs. Two HCV scenarios have been modelled. The (A) case allowing use of HCVs wherever it is cost effective and the (B) case restricting HCV use to full loads only. From modelled resource requirements, a cost per kilometre is applied to generate the total cost of each scenario.

For the purposes of this modelling exercise, costs of operating 17 tonne rigid and 33 tonne articulated vehicles are based on the average cost per kilometre for such vehicles reported by the FTA (2011). Cost per kilometre of operating an HCV are based on the cost per kilometre derived in section 5.1 (incorporating fuel consumption figures established in section 4.3). All costs are based on a diesel price of £1.13 per litre.

This results in the cost per kilometre figures for each type of vehicle as summarised in table 5.2.

Vehicle Type	Cost per km (£)
17 tonne Rigid Vehicle	0.71
16.5m 33 tonne Articulated Vehicle	0.81
25.25m 44 tonne HCV	1.01

Table 5.2: Modelled vehicle cost per km factors.

Table 5.3 presents the changes in modelled operating costs for each of the case study companies for each of the HCV scenarios as compared to operations without HCVs.

Case Ref:	1	2	3	4
% Change	Manufactured Goods	Food Manufacturer A	Food Manufacturer B	Packaging Supplier
HCV Case A (Unrestricted)	-11.1%	-9.6%	-12.3%	-5.4%
HCV Case B (Full loads only)	-9.4%	-6.7%	-11.4%	-4.6%

Table 5.3: Summary results from case study analysis – % cost change.

It can be seen that total costs decrease by between 5.4% and 12.3% in the unrestricted scenario and between 4.6% and 11.4% in the scenario where HCVs are restricted to use for full loads only. In each case the change in cost is compared to the total modelled cost of the transport operation. If compared to the costs of articulated vehicle transport only, the cost reduction would be higher (between 5.6% and 16.6% for the unrestricted scenario).

The highest level of benefit is achieved for companies with the highest proportion of full loads that are available for transport by HCV. The unrestricted scenario results indicate that there is additional cost reduction benefit in using HCVs for part load as well as full load movements, however, the majority of the benefit in the case study organisations would be gained through use of HCVs for full load operations.

5.3 Estimation of Net Economic Impact

The transfer of goods from standard road vehicle to HCV will only take place if there is a cost saving to the vehicle operator and ultimately to the procurer of freight transport services.

Table 5.4 below summarises the transport streams identified in sections 4.4 and 3.3 that could potentially be carried by HCVs and the associated economic impact of 100% of each stream migrating to carriage by HCV, estimating the total benefit to be £226 million per annum.

Opportunity	Opportunity Scale	Cost Factors	Annual Net Impact of 100% volume transfer to HCV (£'million)
Transfer of full loads of lightweight goods in palletised or roll cage form from standard articulated vehicles ('SAV') to HCV.	1,160 million SAV km	£0.81 per km standard articulated vehicle £1.01 per km HCV 54% capacity increase	178
Transfer of lightweight container traffic from standard road vehicles to HCV (20% of road container volumes)	880 million tonne km / 127 million SAV km	£0.81 per km standard articulated vehicle £1.01 per km HCV 50% capacity increase	17
Transfer of lightweight loads with other modes of appearance from standard road to HCV (low estimate ~ 5%)	138 million SAV km	£0.81 per km standard articulated vehicle £1.01 per km HCV 54% capacity increase	21
Transfer of lightweight container traffic from rail to HCV (20% rail intermodal volumes)	1,060 million tonne km / 153 million SAV km	Based on 50% of the financial benefit that would accrue for standard articulated vehicle to HCV transfer (as above)	10
Net Economic Impact (based on 100% transfer of all volumes)			226

Notes:
Conversion from tonne km to km based on 15.67 tonne container weight, 0.61 lading factor, 38% empty running.

The economic benefit to shippers / transporters of containerised goods shifting to road transport is difficult to estimate as the comparative cost of transport by rail is not known. However, shippers will only transfer to road as a result of HCV introduction if cost reductions arise and a net economic benefit is therefore assured. Estimates have been based on 50% of the economic benefit that would accrue were the equivalent volume to move from conventional road to HCV. This is likely to be an underestimate of the economic benefit.

Table 5.4: Estimated economic benefits.

As noted in section 4.5, 100% transfer of identified volumes is unlikely as a result of practical constraints, with a best estimate of transfer levels of between 40% and 60%, indicating an annual net economic benefit of between £90 million and £135 million.

These figures exclude any investment in infrastructure or regulatory costs that may be necessary to accommodate HCVs. All estimates are based on a diesel fuel price of £1.13 per litre - as fuel prices increase, the level of economic benefit would also increase.

6. Safety Considerations

6.1. Literature Review

There is largely consensus in key reports that the use of longer and / or heavier vehicles will have a generally neutral impact on road safety when considered on a per unit of goods moved basis. Table 6.1 presents selected findings from key studies.

Source & Country	Findings
TRL (Knight et al., 2008)	An increase in length to 25.25m (using vehicles that comply with current manoeuvrability requirements and have low levels of rearward amplification) would result in slightly increased levels of risk. Many of the additional risks can be mitigated by advanced vehicle design and new technologies. The study found that for all longer and heavier vehicle types considered the casualty rate per unit of goods decreased slightly.
ITF/OECD/JTRC (2010)	Many high capacity vehicles have equivalent or better intrinsic safety characteristics in some respects than most common workhorse trucks.
TML (De Ceuster et al., 2008)	Assessment of road safety aspects when adapting Directive 96/53/EC and permitting LHVs in general did not reveal an inherent increase of safety risks.
VTI (Vierth et al., 2008)	Costs of road traffic accidents would increase if Sweden reverted back to EU standard vehicles from current longer, heavier vehicle operations.

Table 6.1: Summary safety findings from key LHV studies.

6.2 Accident Experience in the Netherlands

In the Netherlands there has been more than ten years of experience of operating larger and heavier vehicles alongside regular traffic, with increasing numbers on the roads.

Vehicles are allowed only on approved routes but have increased tolerance in turning circle restrictions as compared to conventional vehicles.

During operation, safety has been under continuous scrutiny. A report by the Netherlands Ministry of Infrastructure and the Environment (MIE, 2011b) found that:

> *"Between 2007 and mid-2010 the police registered 19 accidents involving an LHV. In only one case a person was slightly injured. The other accidents involved material damage only (MDO). Companies reported a further 35 accidents; one of which involved a hospital casualty.*
>
> *Both accidents with casualties concerned rear-end collisions whereby specific LHV characteristics (length and swerving behaviour) played no role. None of the accidents involved vulnerable road users". (p75)*

The same report listed the following conclusions:

> *"No direct issues were observed with regard to traffic safety, traffic flows and road design;*
>
> *The type of accidents that involved LHVs are usually typical truck accidents.*

In view of the fact that the number of LHVs is still limited, it cannot be established whether a certain type of accident that typically involves trucks occur more or less frequently during accidents with LHVs." (p75)

6.3 Identification, Assessment and Mitigation of Risks

Appendix G of this document contains a detailed review of literature concerning the HCV risk areas identified in table 6.2:

Risk Area	Description
Field of view	All of the areas the driver can see either directly or indirectly via mirrors or other supporting devices.
Lighting	Equipment designed to ensure that: • the driver is able to see well enough • the vehicle is clearly visible to other road users
Braking & acceleration	• Equipment fitted to allow the vehicle to be stopped within required distances and remain under control • The suitability of the engine, drive train, etc. to provide sufficient acceleration for the vehicle to negotiate hazards as well as to avoid causing them.
Handling characteristics	• Manoeuvrability • Vehicle dynamics
Counterpart protection	• Amelioration of the consequences of any accident (impact severity) • Impact of vehicle design on the risk of an accident.

Table 6.2: Key safety risk areas.

Of the risk areas reviewed in Appendix G, approximately half are viewed as neutral. Those found to have a positive impact are viewed as "slight" or "significant" improvements, whereas those risk areas found to be negative are all believed to represent "slight" or "possibly slight" increases in risk, some of which can be mitigated through use of technology and driver training.

Table 6.3 lists the key technologies identified in the literature that are available to mitigate safety risks associated with HCV use.

Risk Area	Description
Field of view	Use of additional mirrors and CCTV equipment to cover areas with restricted / obscured view (configured to display when relevant only to prevent driver distraction).
Lighting	Additional side and rear lighting / marking to enable other road traffic to clearly identify an HCV in all operating conditions.
Braking & acceleration	• Electronic Braking Systems (EBS) to counter the delay in communicating braking signals in pneumatic systems over distance. • Anti-lock braking systems (ABS) – mandatory on new large commercial vehicles.
Handling characteristics	• Rear steer axles configured to enable compliance with existing EU turning circle regulations. • Electronic Stability Control / Roll Stability Control Systems to reduce risks associated with vehicle instability.
Counterpart protection	• Collision Mitigation Braking Systems to apply braking when approaching an obstruction at speed.

Table 6.3: Technology Countermeasures.

Listed technology countermeasures are generally mature for use in standard large goods vehicles and in use within the EU, however, they may require further development for use in HCVs. There is a consensus in reviewed reports that such technologies have the capability to reduce risks associated with HCV operation (Knight et al., 2008, De Ceuster et al, 2008, ITF/OECD, 2010, MTPWWM, 2010).

Vehicles used in the Netherlands are further required to have built-in axle weighing systems to enable the weight transmitted through each axle and the gross vehicle weight to be readily measured and hence overloading to be more readily avoided (MTPWWM, 2010).

There is a consensus in reviewed reports that it is critical that only experienced drivers should be allowed to operate HCVs and that it is vital that they receive training to enable them to not only understand the impact of the increased vehicle dimensions and handling characteristics, but also make full use of the new technology available to assist them (Knight et al., 2008, De Ceuster et al, 2008, ITF/OECD, 2010, MTPWWM, 2010). In the Netherlands, LHV drivers must have at least 5 years experience of operation of large commercial vehicles, must complete specialist training and must pass a combined LHV theory and practical test.

Taking in to account appropriate countermeasures and the probable reduction in large commercial vehicle distance travelled as a result of the introduction of HCVs and the associated reduced likelihood of accidents, the overall safety impact is likely to be broadly neutral.

The “B-double” configuration, if fitted with steer axles (see section 7.2), is found to have advantages over other configurations due to improved handling characteristics and visibility when compared to other variants.

6.4 Conclusions on Safety

Based on the evidence reviewed and subject to the following conditions this report finds that the introduction of suitably configured HCVs to UK roads would have no significant impact on safety in terms of road traffic accidents.

Conditions:

1. All vehicles are purpose built to a suitable specification (including “tried & tested” technological support equipment and systems).

2. Drivers are experienced, have received appropriate training (in both driving and use of the technology) and have satisfied an appropriate test.

3. Support technology is regularly maintained and tested.

4. Whilst it is not felt necessary to restrict usage to motorways and trunk routes, the routes chosen should be selected to avoid unnecessary risks (see section 7.3). Any restriction would be less necessary where the vehicle is being used in “split” mode with only a single trailer (e.g. to deliver to urban sites).

Moreover, when all of the above conditions are observed and the special equipment is of sufficient technological specification, there may be a marginal reduction in the risks of accidents occurring provided that overall “goods lifted & carried” remain constant.

7. Practical Considerations

7.1 Road Infrastructure Damage / Road Wear

Concerns have been expressed over the impact of larger vehicles on the road network, particular issues being whether bridge supports could tolerate impact from a larger vehicle, and whether the spans of bridges / flyover sections could support a full load of such vehicles.

As an HCV has the same weight as a conventional vehicle but occupies a longer length of road, a full loading of HCVs across a bridge span would weigh less than a full loading of conventional 44 tonne vehicles. TRL (Knight et al., 2008, p34) state that 'no adverse effect on bridge loads would be expected over and above those already applied to standard 44 tonne vehicles'. The impact damage to the bridge structure associated with collision between an HCV and bridge supports would not be materially different to a collision involving a conventional vehicle of the same weight.

Road wear is related to the weight applied to the road surface transmitted through the axles of a vehicle. A conventional 44 tonne GVW vehicle transmits the total weight through 6 axles, whereas an HCV would be likely to have a minimum of 8 axles to spread the same weight – therefore weight per axle and hence damage are reduced. TRL (Knight et al., 2008) calculate that the wear factors for an 8 axle HCV at 44 tonnes are 55% of those of a conventional articulated vehicle and 68% of the wear caused per 100 tonnes of goods transported.

7.2 Vehicle Manoeuvrability

In general terms, the greater the length of a vehicle, the less manoeuvrable it becomes as the rearward sections of the vehicle deviate from the path of the cab of the vehicle (effects known as 'off-tracking' and 'outswing'). This can cause particular problems with cornering and navigation of roundabouts.

EC Directive 96/53/EC requires that vehicle combinations must be able to turn within a circle having an outer radius of 12.5m and inner radius of 5.3m – the difference representing the "swept path" of the vehicle – a maximum of 7.2m (EC, 1996).

In the Netherlands, domestic regulations allow greater tolerance than 96/53/EC for the turning circle of LHVs – with an outer radius of 14.5m and an inner radius of 6.5m, yielding a maximum swept path of 8m. LHV usage in the Netherlands is limited to specific sections of the road network that can accommodate reduced manoeuvrability (MTPWWM, 2010). The UK road network generally has greater constraints associated with smaller roundabouts and tighter cornering than that of the Netherlands and therefore increased tolerance would not be a viable option.

As section 2.4 notes, the B-double configuration, when fitted with active steer systems, has been proven to comfortably comply with 96/53/EC (BTAC, 2005, Knight et al., 2008, Roebuck et al., 2010) and therefore would have no greater difficulty manoeuvring than conventional vehicles.

HCV configurations A, B, D and E have an additional articulation point over and above the single articulation point found in a standard articulated vehicle or a drawbar combination. This results in additional difficulties when reversing as it is more difficult to control the direction of the rearward section of the vehicle. Additional driver training in reversing operations is required. Roebuck et al. (2010) have proposed that active steering could be developed to mitigate difficulties with this type of manoeuvre, although this is viewed as desirable rather than essential for HCV operation.

7.3 Road Access Restrictions

The section above notes that, when fitted with active steering, the B-double can achieve the same forward manoeuvrability standards as a conventional articulated vehicle. Such a vehicle faces no more difficulty in navigating the UK road network than a conventional 44 tonne vehicle and could therefore in theory be allowed to access the network to a similar extent.

There will, however, be additional points of risk on the road network, resulting from the additional length of an HCV. A longer vehicle takes additional time to clear a traffic junction than a vehicle of conventional length. There are concerns that the additional time to clear a level crossing could be problematic and this would be compounded if there were a shortage of available road length on the far side of the crossing (e.g. because of a further junction in close proximity).

Allowing use of HCVs in residential areas is likely to be resisted by local residents because of perceived safety fears and environmental intrusion.

Use of HCVs on the motorway and major route network should not result in any additional difficulties over those incurred by standard length vehicles. When leaving the core network it is desirable that routes selected for use by HCVs are assessed in advance before usage is authorised to enable risks to be properly assessed (as is the case in the Netherlands).

The modelled results from HCV usage in case study 1 reveal that 94% of all HCV road kilometres in that company's transport operations would be on motorway, dual carriageway or trunk routes (see Appendix E, table E.8). The company concerned is distributing between network locations or to the distribution centres of major retailers, sites that tend to be located in close proximity to the major road network. This indicates that very little additional route approval would be necessary.

Should network restrictions prohibit access to particular sites, the ability to decouple the trailers of the vehicle and for the vehicle to then access the loading point twice with a single trailer on each visit is a potential solution to this problem. Configurations A, B and E have this capability.

7.4 Parking

Previous studies have raised concerns over the availability of parking facilities for longer vehicles as UK infrastructure is not in general configured to accommodate such vehicles. It would be essential that adequate parking facilities are made available to enable drivers to comply with legally required breaks and rest periods.

Analysis of the opportunity for use of HCVs in sections 3, 4 and 5 identifies that the potential maximum use of HCV would equate to approximately 1.05 billion HCV kilometres per annum. At an estimated average use of 150,000 kilometres per annum, this would equate to approximately 7,000 vehicles. It is estimated that take up would be in the range of 40% to 60% of the total opportunity, suggesting a total vehicle park of between 2,800 and 4,200 vehicles.

At this level of operation, it is estimated that no more than 750 to 1,000 spaces would be required, partially offset by the reduced requirement for standard vehicle parking facilities.

Operators of HCVs are likely to include large third party logistics companies as well as smaller hauliers aligned under umbrella network organisations – it is probable that such organisations could use existing network resources to provide parking capacity to supplement public sites. Parking areas at motorway service stations and truck stops would need to be modified to accommodate such vehicles (in some locations requiring minor modifications to road markings only). There is currently a general shortage of large vehicle parking positions in some regions of England, although other regions have surplus capacity (Aecom, 2011). As the area required for each metre of load length for an HCV is not significantly different to that of a standard vehicle, the introduction of HCVs is unlikely to have any significant detrimental effect on parking capacity.

7.5 Congestion

Use of HCVs to carry low density loads currently transported by road would result in a maximum of 1,425 million kilometres of heavy goods vehicle traffic transferring to HCV, resulting in a potential 470 million kilometre reduction in road usage. This would be partially offset by any container traffic migrating from rail to HCV (with an estimated maximum transfer of 153 million conventional vehicle kilometres / 102 million HCV kilometres).

The net impact, assuming 100% take up for identified opportunities, would be a reduction in vehicle distance travelled of circa 370 million kilometres, equating to a 4% reduction in total annual large goods vehicle kilometres.

As previously noted, vehicle take up rates and hence the reduction in distance travelled is more likely to be between 40% and 60% of these totals, however, there would still be a useful contribution to reduction in congestion levels.

7.6 Delivery Point Issues

The issue that some delivery points may not have sufficiently large sites or loading / unloading areas to accommodate a fully configured HCV was raised during discussions with hauliers using longer vehicles in the Netherlands as well as by representatives from case study companies. This was particularly perceived as an issue at smaller manufacturing locations, but not at large retailer / manufacturer distribution locations.

It has not been possible to quantify the extent of this constraint, however, it is noted that use of steer axle technology would mitigate the problem in some circumstances. The ability to decouple the trailers of the vehicle and for the vehicle to then access the loading point with single trailers (see section 2.4) is a viable solution to this issue, but does depend on the availability of suitable decoupling points in close proximity (either on or off site).

An additional point raised by operators was the impact on operations that are dependent on use of stand trailers for loading/ unloading. The capital cost of trailers used by HCVs would be marginally higher than those of a standard vehicle (and in the case of the B-double interlink trailer substantially higher). The incremental investment requirement would need to be considered when deciding whether to use stand trailers on HCV operations.

Configurations A to E with curtain sided trailer bodies can all be accessed from the side for unloading. Many locations prefer or require vehicles to be unloaded from the rear on to loading docks. Trailers of configurations A, D and E can be decoupled to achieve this. With the B-double, the rear trailer can easily be parked at dock and accessed through the rear doors. There is a difficulty with the interlink trailer as the body and hence rear doors are set back from the end of the vehicle with the fifth wheel protruding and preventing the body from being parked directly adjacent to the loading dock. Trailer manufacturers in the Netherlands have designed a number of different solutions to this issue, including: mechanisms to slide the body backwards; use of a telescopic chassis; detachable bogies; demountable bodies; and; drawbridge style vehicle doors. These are all viable solutions but add capital cost and complexity.

7.7 Multi-drop Issues

The use of HCVs for multi-drop trips is feasible, but does come with the added complexity of ensuring that all locations can be accessed by the vehicle and will in many instances require additional decoupling / re-coupling of the vehicle and additional distance travelled if this cannot be achieved on site.

The benefit of consolidating multiple drops on to a single trip is that other trips can be avoided and hence the total distance travelled can be reduced. The cost per kilometre travelled will increase due to the additional costs of operating an HCV compared to standard vehicles. The overall cost effectiveness of this approach is affected by the relationship between the distance between drops and the distance from origin of each location. As a result, HCV usage for multi-drop trips is best focused on drop points where there is a reasonable stem mileage and drop points are in close proximity to each other to enable the benefits to be maximised.

7.8 Back Load Availability

For HCVs to provide an economically viable solution, back loads must be available to the same extent as for conventional loads. It would be better to make two trips with a conventional articulated vehicle, each with a back load, than to run a single trip with an HCV and return empty.

In theory, back loads should be available for HCVs to a greater extent than for standard loads because a lower price can be offered. There is a risk, that if route restrictions and site access issues affect the availability of back loads, that the level of back loading falls below that for standard vehicles.

Hauliers from the Netherlands commented that the approach taken in the Netherlands, that restricts vehicles to specific routes, did affect back load availability, although this could generally be resolved by decoupling the vehicle. It was stated that routes had to be carefully selected to ensure that back loads were available before committing to supply a specific route by HCV.

There is a commercial incentive for hauliers to consider such issues before agreeing to provide transport and therefore hauliers will focus the use of HCVs on routes where vehicles can be filled in both directions.

7.9 Preferred Vehicle Configuration

This study did not set out to identify a preferred HCV configuration for the UK. It is noted, however, that the B-double has unique advantages that other configurations cannot currently offer. It:

- has superior manoeuvring capabilities when fitted with steer axles;
- is better aligned to the requirements of UK road infrastructure; and;
- has improved safety features (visibility and stability).

In addition, the B-double can be readily coupled and de-coupled, with interchangeable trailers transported separately (as can configuration A and E). In common with configurations A and D, a B-double can also accommodate one 40' container and one 20' container (or three 20' containers).

The disadvantages are increased capital cost of this variant and complexity when loading / unloading the interlink trailer. The A and E configurations have the flexibility advantages of the B-double with reduced capital cost and easier loading / unloading capabilities. Manoeuvrability and visibility would need to be enhanced through further technical development.

As noted in section 6, any HCV configuration would need to be equipped with suitable technology countermeasures to mitigate areas of increased safety risk.

8. Discussion and Conclusions

8.1 Discussion

The decision to deny or progress the opportunity of use of HCVs on the UK road network is complex and there are many stakeholders with opposing views as to the best way forward. Proponents argue that, following successful trials in other European countries, the case for enlarged vehicles is proven, whereas others argue that deployment is not acceptable within the UK as such vehicles are incompatible with the road network, would undermine the success of the rail industry and would have adverse impacts on the environment.

In this context, great care has been taken in the preparation of this report to ensure that findings are valid and are supported with appropriate evidence. A range of techniques has been deployed, including literature review, case study investigation, modelling / analysis and discussion with expert users to gain evidence on which the findings have been based. There are, however, some areas where sufficient proof is not available and in these circumstances prudent assumptions have been made and are noted in the text.

This report has identified areas of current road and rail transport where there are flows that could be suitable for the use of HCVs, the key criteria being that goods are moving in sufficient quantity to justify use of an HCV and that goods are lightweight in nature.

The principal opportunities are identified as:

- lightweight goods carried as pallets or roll cages (c23% of all palletised / roll cage traffic carried by articulated vehicles)
- lightweight containers (c20% of container tonne kilometres).
- Other modes of appearance (c5% of non-bulk volumes)

Collectively (after allowing for empty running), a total of 1,425 million kilometres of current road activity has been identified as suitable for transfer to HCV, equating to approximately 15% of current articulated vehicle kilometres. The equivalent of an additional 153 million articulated vehicle kilometres (1,060 million tonne km) of rail container traffic could also transfer to road. After allowing for the larger carrying capacity of HCVs, the total market opportunity would equate to 1,050 million HCV kilometres.

Principal flows identified are flows of palletised goods from plant to manufacturer or retailer distribution centres and container volumes to / from port. Specific lightweight commodity groups have been identified.

The economic and environmental case for use of HCVs has been assessed – making comparisons at vehicle level and exploring the impact within case study companies.

A key variable in this analysis has been the fuel consumption of an HCV as compared to a standard vehicle – this impacts on the reliability of emissions analysis and the cost of operating an HCV. There is limited available data to quantify this, with the most reliable evidence pointing to a fuel consumption increase of approximately one third as compared to standard vehicles. There is, however, evidence emerging from a number of sources that in practice the fuel consumption increase is lower than this differential, although such data has not been compiled under controlled conditions and cannot be fully verified. To ensure that findings on economic and environmental issues are robust, a high estimate for fuel consumption has been used. Drawing on this data it is shown that although, at vehicle level, fuel consumption increases, the fuel consumption per unit of payload, when measured on a volume, container or per pallet basis, decreases. This has a corresponding beneficial impact on emission levels. The cost on a per pallet or container carried basis is found to be significantly lower with HCVs than for standard articulated vehicles.

The use of HCVs has been explored within case study companies. The organisations chosen were drawn from commodities with high potential for use of HCVs and have high volume operations. Results are likely to be better for these organisations than for their commodity groups as a whole. This analysis has been used to demonstrate the level of savings in terms of cost and emissions that are available to organisations that transport large quantities of low density goods.

Between individual case studies, the level of achievable benefit varies considerably. In the scenario where HCV use is restricted to full loads only, this is largely driven by the extent of full load movements in the network and whether such loads were sufficiently lightweight to be transported by HCVs. In the case study with the lowest cost and emission reduction results, a key issue was that inbound loads were weight constrained and therefore not appropriate for HCV usage – a small number of trips were involved but these involved long distance transfers. This constraint also affected some loads on other case studies but to a lesser extent.

With the unrestricted HCV scenario, the density of drops was an issue that affected the incremental level of benefit. Where drop points are geographically dispersed, the reduction in trip distance achieved was outweighed by the additional vehicle cost per kilometre and therefore was not economically worthwhile. The results demonstrate that there are incremental emission reductions and cost saving benefits to usage of HCVs for part loads as well as for full load traffic.

The capital cost of an HCV will be higher than that of a standard articulated vehicle. However, as the increase in capital cost is likely to be of approximately the same magnitude as the increase in vehicle carrying capacity (54%), the capital cost per unit of load carrying capacity will remain largely constant. As operational costs per pallet kilometre for an HCV are significantly lower than for a standard vehicle, an HCV will yield a higher return on investment than standard fleet operating at similar levels of utilisation.

The data analysis shows that in total, substitution of road vehicles with HCVs for the transport of lightweight goods (including containers) to the maximum possible extent has financial benefits to shippers / transport operators of circa £216 million per annum, with emissions reduced by 174 thousand tonnes CO_2 per annum.

The issue that is critical to the overall environmental impact of HCVs is the degree to which transport of ISO shipping containers transfers to HCV transport, specifically the extent to which current rail volumes shift to HCV haulage. A detailed analysis of shipping containers received at Felixstowe port finds that a maximum of 20% of shipping containers are sufficiently low in weight to utilise the weight carrying capacity of an HCV – the limiting factor is the availability of lightweight 20' containers. This in effect places a ceiling on the maximum possible volume transfer. Other commodity groups carried by rail are not at any significant risk of transfer to HCV because of their generally heavy nature.

Rail is reported to be considerably more environmentally friendly than road, with reported CO_2 emissions quoted at an average of 28.5g per tonne km (ORR, 2011), which is a fraction of the equivalent road figure. The actual emissions will be dependent on a number of factors including the type of traction, weight of goods hauled, train length and degree of empty running. The average figure is calculated by establishing total rail freight emissions and dividing this by recorded tonne kilometres. As goods transported by rail are generally heavy (e.g coal, metals and construction materials), the resultant average is skewed towards the emissions associated with transport of heavy materials. The average therefore significantly underestimates the emissions associated with transport of a tonne of lightweight container traffic.

In the absence of transparency of information on rail CO_2 emissions, calculations on the impact of modal shift of container traffic were based on the average rail emissions figure as compared to a robust calculation of the emissions of road transport of lightweight containers. The results of the analysis will therefore over estimate the additional carbon emissions associated with transfer of traffic from rail to road.

The outcome of the analysis is that if all current lightweight container volumes shifted from rail to HCVs, additional CO_2 generated would equate to 79 thousand tonnes per annum. Additional shipping cost reductions estimated at £10 million per annum from this transport stream could also be realised.

Assuming equivalent take up rates of HCV use for lightweight palletised / roll cage goods transport and for lightweight container transport, analysis demonstrates that in all cases there is a net reduction in carbon emissions. At the maximum possible level of HCV usage within both road and rail freight transport, the level of benefit is estimated at 96 thousand tonnes of CO_2 per annum - equating to a reduction of approximately 0.5% in total road freight transport CO_2 emissions (based on heavy goods vehicle greenhouse gas emissions equivalent to 21 million tonnes of CO_2 in 2009 (DfT, 2011d)). There is only a risk of a net increase in emissions if a significantly higher proportion of lightweight rail container transport transfers to HCV than the proportion of lightweight road traffic transferring to HCV.

Most operational constraints to HCV usage would apply equally to transport of general lightweight goods and container transport, however, additional economic and operational barriers apply to the transfer of rail volumes to HCV. Due to the high fixed cost / low variable cost structure of rail, longer distance rail transport will remain cost competitive to road and it is therefore only short to medium distance flows that will be vulnerable to transfer. There will be considerable complexities in scheduling container movements on HCVs that combine two lightweight containers of different sizes moving to similarly located destinations. At port of entry / exit, port operators are likely to continue to prefer use of rail to road as operationally it is simpler. Taken together, these constraints make it highly likely that less lightweight containerised rail traffic will move to HCV than the proportion of general lightweight traffic transferring to HCV and that estimates of parity of transfer rate underestimate the emissions reduction benefits of HCV use.

Operational constraints to the use of HCVs, including issues such as road network access, site access restrictions, loading complexity, the economics of multi-drop loads and backload availability have been explored in general terms in this report. The conclusion is that these issues will reduce the volume of traffic transferring to HCV, though there are solutions to most of these issues that mitigate the problems. Where there are significant volumes and hence significant potential for cost savings, it will continue to be worthwhile to use HCVs even where constraints apply. The most likely applications for HCV use would be for full load, regular single point to single point flows with good availability of corresponding back load traffic.

A literature review has been carried out to assess safety risks associated with HCV use – most existing reports conclude that there is either a neutral or very slightly increased risk associated with HCV use as compared to standard road vehicles when suitably specified vehicles equipped with appropriate risk reduction technologies are used. Where increased risks are noted, it is usually acknowledged that the reduction in travel distances associated with HCVs mitigate the increased risk.

8.2 Conclusions

From the investigation, analysis and discussion in this report it can be concluded that:

- The transport of low density goods on a per tonne basis is more costly and creates higher emissions than the transport of a tonne of higher density goods.

- There are significant flows of low density goods that could be transported more efficiently by HCVs, including the transport of lightweight palletised / roll cage goods, lightweight containers and other niche applications.

- The cost and emissions of an HCV are higher than those for a standard (33 tonne) articulated vehicle by approximate factors of 25% and 32%. However, the increased carrying capacity of an HCV results in reduced costs per pallet kilometre of approximately 19% and reduced emissions of between 11% and 19%.

- There are significant cost and emissions savings to be accessed through the deployment of HCVs within organisations that transport high quantities of lightweight goods. Case studies revealed savings of between 5% and 12% of total transport costs and between 4% and 10% of total emissions (5 to 17% of costs / 4 to 13% of emissions when compared to articulated vehicle costs / emissions only). Benefits were greatest where companies were transporting a high proportion of lightweight full loads. Greater financial and emissions benefits were recorded where organisations were able to use HCVs for multi-drop transport in addition to full loads, however, this was found to be economically viable only where drop points are in reasonably close proximity to each other.

- HCVs are likely to attract a proportion of lightweight containers currently transported by rail. A maximum of 20% of total container traffic is found to be sufficiently lightweight for carriage by HCV. For longer distances rail will continue to have a competitive advantage. The increased emissions of transport by HCV as compared to rail transport for shifted volumes will negate some of the emissions benefits of transfer of other volumes from conventional road to HCV.

- Overall, the economic impact of use of HCVs is positive, with maximum savings of £226 million per annum if identified transport streams were to fully transfer to HCV.

- Overall, total emissions will be highly likely to reduce as a result of use of HCVs. The annual reduction benefit is calculated to be 96 thousand tonnes of CO_2, if 100% of identified transport streams transferred to HCVs. The only circumstance where there is a risk of a net increase in emissions would be if rail volumes transfer to HCV at a significantly higher rate than general road transport shifts to HCV. This is highly unlikely due to additional barriers to the transfer of rail freight.

- The usage of HCVs would contribute to a reduction in total annual vehicle kilometres, with total articulated vehicle distance travelled reducing by 4% in the event of transfer of 100% of identified lightweight loads to HCV. This would make a useful contribution to alleviating congestion.

- Operational constraints such as road access restrictions, site access restrictions and availability of backloads will reduce the take up of HCVs, with likely take up rates of between 40% and 60% of suitable transport flows.

- The use of HCVs would have no significant impact on road safety.

Taken in totality, this report concludes that the introduction of HCVs in the UK would;

- lead to substantial economic benefits to the shippers of low density goods;

- reduce CO_2 emissions of current road freight transport;

- make a useful contribution to a reduction of congestion levels; and;

- would not have an adverse impact on road safety.

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Appendix A: Methodology Table

Section / Objective		Methodology
2	**Background Research**	
2.1	Document current EU / UK regulations on maximum vehicle weights and dimensions	Literature review focusing on major governmental and non-governmental organisation reports, academic journals and reliable industry sources.
2.2	Document current experience of use of longer and / or heavier vehicles in the European Union and elsewhere.	“”
2.3	Document the alternative options for the configuration of longer and / or heavier vehicles.	“”
2.4	Review the relative advantages of LHV configurations.	“”
3.	**Opportunity Assessment**	
3.1	Review the characteristics of HCV’s.	Comparison of the characteristics of an HCV and a standard articulated vehicle.
3.2	Review the issues associated with the transport of low density goods.	Consideration of the cost and carbon emissions of transportation of low density goods as compared to high density goods.
3.3	Identify the scale of the opportunity for HCV usage.	Identify supply movements where there is sufficient volume to justify usage of HCVs.
3.4	Identification of specific commodity groups where there is greatest potential for use of HCVs.	Review of DfT data – identifying commodity groups where a substantial proportion of full loads “cube out” at low weights.
4.	**Environmental Impact Assessment**	
4.1	Document relevant conclusions from key reports on longer and or heavier vehicles.	Literature review focusing on major governmental and non-governmental organisation reports.
4.2	Analyse the fuel consumption and carbon emissions of HCVs as compared to standard vehicles.	Review and analysis of data drawn from literature, past operational trials and a sample Netherlands operation. Presentation of results at vehicle and unit load level.
4.3	Assessment of fuel and CO_2 impact of utilisation of HCVs within case study companies drawn from sectors / commodity groups identified in section 3.4.	Detailed modelling and analysis of the transport operations of four case study companies to quantify CO_2 impact.
4.4	Assessment of modal shift risk.	Review and analysis of current rail freight traffic and identification of sectors / commodities vulnerable to modal shift (using ORR Data). Review of maritime statistics (using DfT data) to assess vulnerability of deep sea containerised traffic to modal shift from rail to road.
4.5	Estimation of net environmental impact.	Calculation of carbon emission changes for HCV opportunities identified in section 3.3, using carbon emissions factors developed in section 4.2, taking in to consideration modal shift risk established in section 4.4. Assessment of CO_2 impact of differing levels of modal shift.

Section / Objective		Methodology
5	**Economic Impact Assessment**	
5.1	Comparison of costs between HCVs and standard articulated vehicles on a cost per km and unit load level.	Review and analysis of data drawn from literature, past operational trials and a sample Netherlands operation. Presentation of results at vehicle and unit load level.
5.2	Assessment of the cost impact of utilisation of HCVs within case study companies as modelled in section 4.3.	Detailed modelling and analysis of the transport operations of four case study companies to quantify cost impact.
5.3	Estimation of net economic impact.	Calculation of cost changes for HCV opportunities identified in section 3.3, using cost factors developed in section 5.1, taking in to consideration modal shift risk considered in section 4.4.
6	**Safety Impact**	
6.1	Document relevant conclusions from key reports on longer and or heavier vehicles.	Literature review focusing on major governmental and non-governmental organisation reports.
6.2	Review of accident experience in Netherlands.	Review of documentation pertaining to accident experience in the Netherlands.
6.3	Identification and assessment of key areas of risk and risk mitigation strategies.	Detailed literature review comparing and analysing literature findings.
6.4	Safety conclusions	Drawing of conclusions based on content of sections 6.1 to 6.3.
7	**Practical Considerations**	
7.1	Review of infrastructure issues.	Literature review focusing on major governmental and non-governmental organisation reports. Review of case study results – including travel distance on minor roads. Use of volume data established in section 3.3. Consideration of comments by hauliers in the Netherlands and representatives from case study companies.
7.2	Consideration of vehicle manoeuvrability issues.	
7.3	Review of the requirement for road access restrictions.	
7.4	Review of parking issues.	
7.5	Consideration of congestion impact.	
7.6	Consideration of delivery point issues.	
7.7	Consideration of multi-drop issues.	
7.8	Consideration of the impact of backload availability.	
7.9	Identification of the HCV variant(s) most suited for use within the UK.	Collation of vehicle configuration specific information identified in previous sections.
8	**Discussion and Conclusions**	Review and discussion of findings of previous sections.

Appendix B: Longer / Heavier Vehicle Configurations

B1. Configuration A

Figure B.1. Configuration A LHV.
Source: Zandbergen Transport (2008).

Configuration A LHVs consist of a standard tractive unit with a standard 13.6 metre semi trailer, towing an additional centre axle trailer connected through a jaw/drawbar coupling.

B2. Configuration B

Figure B.2 Configuration B LHV.
Source: Denby Transport (2012).

Configuration B (also known as a B-double) consists of a standard tractive unit with a fifth wheel attaching to a trailer, usually referred to as the 'A' trailer or interlink trailer. This 'A' trailer then has another fifth wheel coupling which connects to a standard semi trailer.

B3. Configuration C

The configuration C LHV is a longer version of a drawbar LGV. The configuration consists of two components, a rigid towing vehicle with a trailer attached via a jaw/drawbar coupling system. There is a lack of interconnectivity with other LHVs and HGVs and in practice, only very small numbers of operators in the Netherlands have adopted this configuration.

B4. Configuration D

The configuration D LHV consists of a rigid vehicle, attached by a jaw / drawbar coupling to a converter dolly which in turn connects to a standard 13.6m semi trailer.

Figure B.3. Configuration D LHV.
Source: van der Wal transport (no date).

Interconnectivity and minimal investment cost are two of the reasons why this form of LHV is one of the most common configurations within the Netherlands and other European countries.

B5. Configuration E

Figure B.4 Configuration E LHV.
Source: Althoff (2010).

The E configuration consists of a rigid truck pulling two centre axle trailers. All three of the components within this configuration have the ability to carry swap bodies or removable 20' containers. Trailers can readily be swapped or interchanged with regular draw-bar vehicles.

Appendix C: Freight Volume Data Analysis

C1. Opportunity for HCV Usage in Current Road Freight Transport Activity

Section 3.1 of this document noted that the full carrying capacity of an HCV (measured in terms of volume or pallet positions) can only be utilised where product has a relatively low density - equivalent to an average weight per pallet (or pallet stack) of 583kg or less.

The payload weight of a conventional 16.5m articulated vehicle carrying a full load of 26 such low density pallets (or pallet stacks) of 583kg would equate to 15.15 tonnes. If a conventional vehicle is shown to be full in volume terms at a weight of 15 tonnes or less it can therefore be taken as an indication that the load would be suitable for carriage by an HCV.

Analysis of data drawn from the UK DfT 'Continuing Survey of Road Goods Transport' ('CSRGT') identifies that goods carrying vehicles over 3.5 tonne gross vehicle weight travelled approximately 18,846 million kilometres in calendar year 2009. Of this total, loaded articulated vehicles represent circa 35.4% of total distance travelled (6,674 million km). This can be further split by 'Mode of Appearance', principal categories include goods presented in palletised, roll cage, bulk or containerised form – see figure C.1 below.

Total Goods Vehicle km (million) 2009

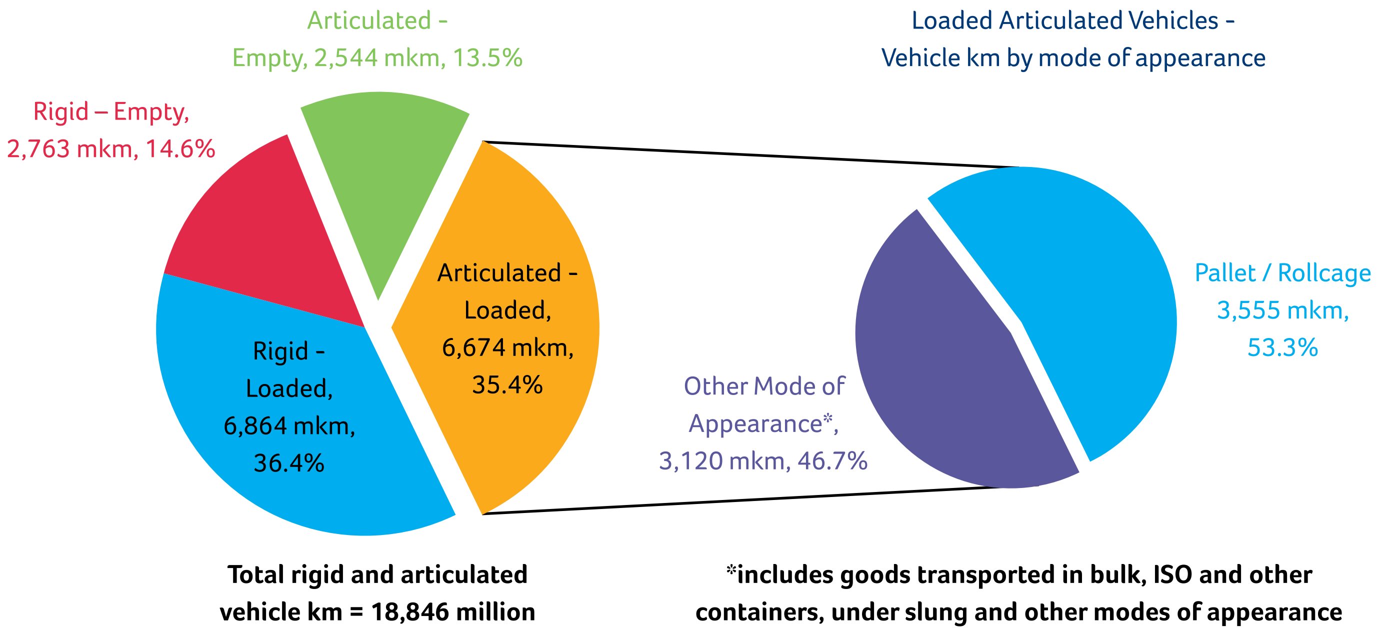


Figure C.1 Chart showing total goods vehicle kilometres split by type of vehicle and MOA.
Source: DfT (2011a).

The data shows that in total in calendar year 2009, UK articulated goods carrying vehicles travelled 3,555 million kilometres carrying goods that were presented in palletised or roll cage form. This can be further analysed into vehicles that are recorded as less than or greater than 90% full in volume terms. The chart below (figure C.2) demonstrates that of this population, 57% of vehicles were recorded as more than 90% full (2,034 million km).

Of those that were more than 90% full, 41% (843 million km) were full at a load weight of less than 15 tonnes.

From this it can be concluded that an estimated 23.7% of articulated vehicle kilometres carrying roll cage or palletised goods "cube out" at a load weight of less than 15 tonnes and are therefore carrying goods that are sufficiently lightweight for carriage by HCV.

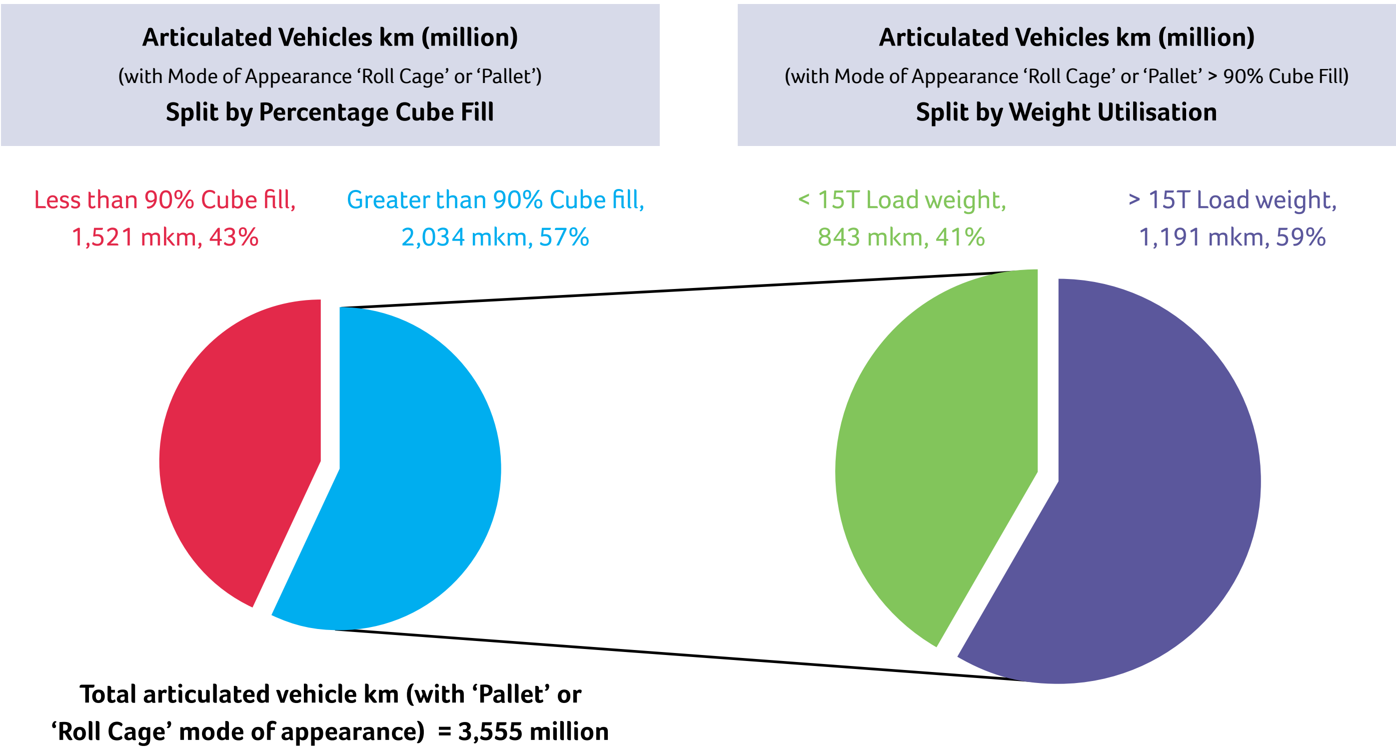


Figure C.2 Loaded Articulated Vehicle Km with Mode of Appearance "Roll Cage" or "Pallet", Split by Cube Utilisation and Weight Utilisation – 2009 Data.
Source: DfT (2011a).

In addition to goods carried in palletised or roll cage form, the CSRGT identifies six other 'modes of appearance' (MOA) that collectively account for 47% of loaded articulated vehicle kilometres. These are:

- Bulk goods (solid & liquid form) ~13%
- Large shipping containers (including ISO containers) ~4%
- Other freight containers (including stillages) ~2%
- No packaging ~2%
- Preslung ~1%
- Other cargo types ~25%

Bulk goods, by their nature, are likely to be too heavy to accommodate within the load carrying capacity of an HCV and therefore there is little or no opportunity within this category.

Analysis of the weights of ISO shipping containers on arrival or departure from UK port indicates that there is some potential for the carriage of these by HCV (see Appendix C section C4). This will be limited by the availability of lightweight 20' containers, with an estimated maximum of 20% of container tonnage (or tonne kilometres) being sufficiently light to be accommodated by an HCV. This would equate to approximately 880 million tonne kilometres or 92 million loaded conventional articulated vehicle kilometres.

Goods in the 'other freight containers', 'no packaging', "preslung" and "other cargo types" categories are diverse in nature and it has not been possible to accurately quantify potential for usage of HCVs for carriage of goods with these modes of appearance and whether there is a tendency to "cube out" at low weights. Overall the potential in these areas is believed to be relatively low, however, there will be niche applications. If it were assumed that between 5% and 10% of loaded articulated vehicle journeys in these categories were suitable for carriage by HCV, this would translate to an annual distance of between 100 million and 200 million articulated vehicle kilometres.

It should be noted that a proportion of “empty” vehicle kilometres will be driven by the above flows and should therefore be considered when calculating estimated total travel distances.

The main opportunities for the use of HCVs are summarised in table C.1 below.

	Million Articulated Vehicle Kilometres		
Opportunity	**Opportunity Scale (2009)**	**Empty Running***	**Total**
Full loads of lightweight goods in palletised or roll cage form	840	320	1,160
Lightweight container traffic	92	35	127
Other MOA full loads (low estimate)	100	38	138
Grand Total	**1,032**	**393**	**1,425**

*In 2009 the CSRGT recorded 27.6% of all articulated vehicle kilometres as empty – this equates to 38% of loaded vehicle kilometres. To account for associated empty running loaded vehicle kilometres are therefore grossed up by a factor of 38%.

Table C.1 Summary of Opportunities for HCV Use.

The above opportunities represent 15% of total articulated vehicle distance travelled in 2009.

In addition there will be low density part loads carried by articulated vehicles and rigid vehicles that, if consolidated through more efficient scheduling, could also potentially be carried by an HCV.

It should be noted that the above volumes exclude any allowance for current rail freight volumes that may transfer to road as a result of the introduction of HCVs.

C2. Identification of Lightweight (Low Density) Commodity Groups

To identify the commodity groupings where there is greatest potential for use of HCVs, data from the CSRGT has been further analysed to identify those commodity groups that have the greatest proportion of articulated vehicle kilometres recorded as greater than 90% full by volume at a payload of less than 15 tonnes (with goods in palletised or roll cage form).

The chart (figure C.3) shows that seven commodity types (out of a total list of 73 commodities) represent 80% of the potential opportunity for use of HCVs for transport of goods in roll cage / palletised form. These commodity groups are:

Packaging; Perishable Foodstuffs; Non-perishable Foodstuffs; Other Manufactured Goods; Parcels; Other Manufactured Articles; and; Paper / Paperboard Manufactures.

Commodity groups Packaging; Perishable Foodstuffs; Non-perishable Foodstuffs; and Other Manufactured Goods alone represent 63% of the opportunity. Companies in these commodity groups are used as case studies to explore the impact that use of HCVs would have on their operations (see Appendix E, and sections 4.3 and 5.2).

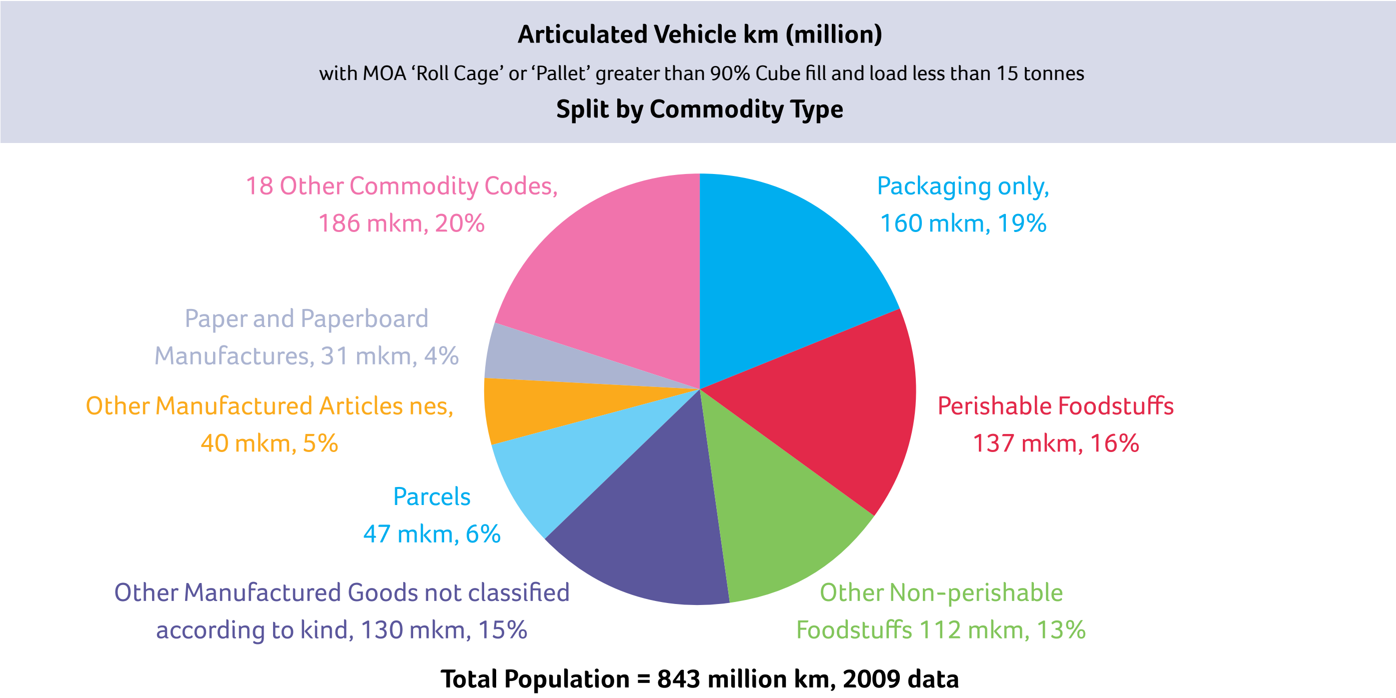


Figure C.3 Commodity Split Chart.
Adapted from CSRGT data (DfT, 2011).

C3. Modal Shift Risk

The chart below (figure C.4) illustrates the commodity split of freight transported by rail.

As TRL (Knight et al., 2008) observe, there is very little risk of transfer of bulk goods transport from rail to HCV – HCVs are designed to carry large quantities of lightweight goods, whereas bulk goods by their nature are generally dense and move in very large quantities. This rules out modal shift related to oil & petroleum, construction, metals and coal. International traffic also faces limited risk of transfer, until such time as HCVs are allowed to operate on an international basis.

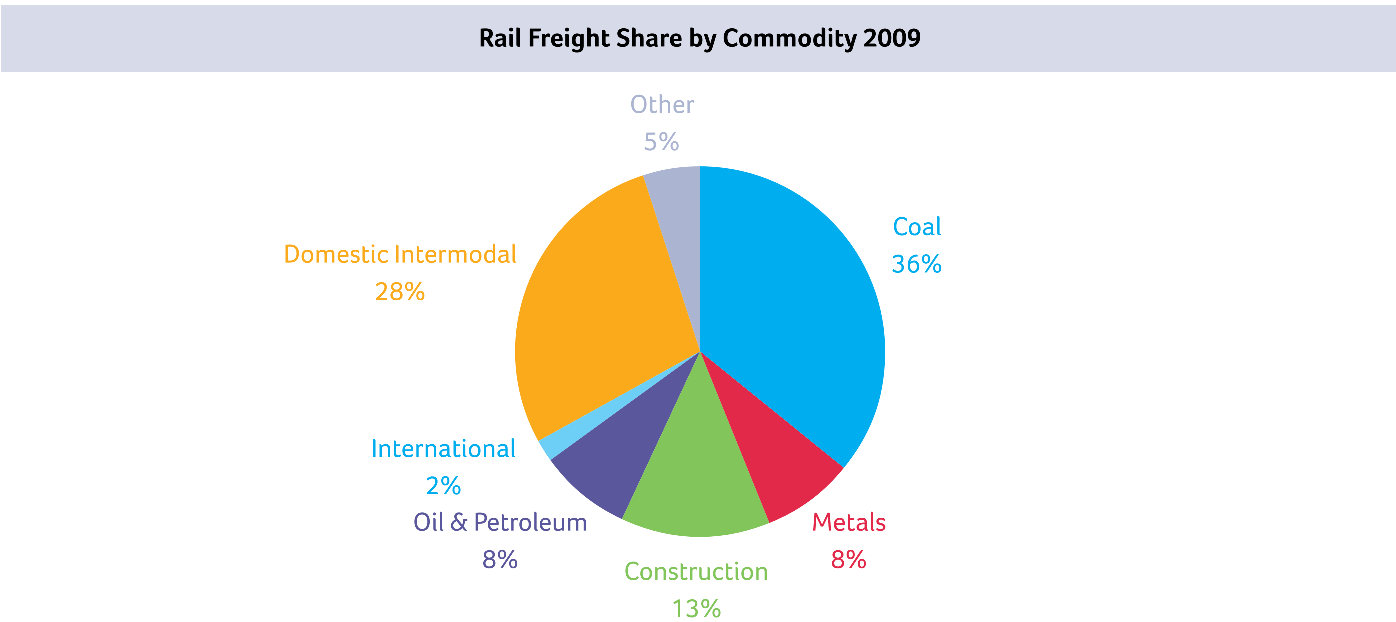


Figure C.4 Rail freight commodity split – tonne km.
(Source: ORR, 2011).

The key area that remains at risk of modal shift is domestic intermodal transport, mainly consisting of transfer of deep sea containers from port to inland terminal (and back to port) plus other internal intermodal moves (mainly long distance north / south movements).

For modal shift from rail to road to arise, the following conditions would need to be met:

- The cost saving would need to be large enough to tempt shippers / forwarding agents to change modes.
- The combined weight of containers transported would need to be below the maximum payload capacity of an HCV.
- Road infrastructure to / from ports would need to be able to accommodate the additional road traffic generated.
- Ports must be able to facilitate such a shift.

An HCV can carry the equivalent of 50% more containerised freight than a standard 16.5m articulated vehicle. Despite higher capital and operating costs per vehicle, the use of an HCV would result in lower transport costs per 20' container (of approximately 17% - see section 5.1) and could potentially attract container traffic to switch from rail to road.

Road and rail are direct competitors for medium and long haul freight transport. Rail has a higher fixed cost structure but lower variable cost per unit of distance than road – as a result for short to medium distances road has a distinct cost advantage and captures most of this market (for example the hinterland of a port). On longer haul, the cost structure of rail becomes more advantageous and it can compete more effectively. The effect of introducing HCVs is a modest increase in the fixed cost of road, but a decrease in the variable cost. This results in an increase in the break even distance where rail can cost effectively compete and means that mid range distances become more vulnerable to transfer to road.

More containerised freight is imported in to the UK than is exported. Inbound containers arriving at port are generally loaded, with a significant proportion of those shipped out being empty and returning to source. The inbound direction impacts on modal choice – it would not be cost effective to return containers using a different mode to the inbound journey due to the specialised nature of container transport equipment.

To make use of the load capacity of an HCV requires one 20' container and one 40' container (or two additional 20' containers) and the combined payload weight of these must be no more than the HCV maximum payload weight of 23.5 tonnes.

Analysis of unpublished shipment data for the port of Felixstowe shows that the average weight of an inbound 20' container in 2009 was 13.99 tonnes, while the average weight of an inbound 40' container was 12.7 tonnes (DfT, 2010c). The number of inbound 20' containers received at Felixstowe is 60% of the number of inbound 40' units. The availability of lightweight 20' containers therefore acts as a limiting factor on the ability to transport container traffic by HCV from Felixstowe (see Appendix C, section C4 for further details of this analysis).

In 2009, there were only 140,000 20' containers received at Felixstowe that weighed less than 12 tonnes, suggesting that only 140,000 HCV loads could practically be constructed. If each 20' container were matched with a 40' container of average or below average weight (of which there is no shortage) to create a full HCV load, the total tonnage of all such loads would equate to approximately 20% of total inbound container tonnage at the port.

Felixstowe handles 40% of all UK container shipments and therefore it can be assumed that the data is reasonably representative of UK container weights and that in general, the limited quantities of lightweight 20' containers in circulation will act to constrain the use of HCVs for container traffic. Unless there is a material change in the weight of 20' containers imported in to the UK, the potential for use of HCVs for container transport is limited to 20% of total container tonnage.

Actual modal shift would be lower than the maximum due to long haul economics (rail would retain a cost advantage for the transport of lightweight containers over longer distances), complexities of scheduling lightweight containers on HCVs and practical constraints at the handling port and point of delivery / origin. The trend to high cube containers is likely to increase container weights still further.

Containerised transport of goods between port and inland destination / origin represents the vast majority of domestic intermodal transport. It is a reasonable assumption that goods carried by rail as part of a purely domestic intermodal shipment would also be limited by the availability of lightweight loads to a similar degree as for port container traffic and that the potential for modal shift for these flows would also be limited.

Assuming rail has a share of total lightweight containers that is proportional to the modal split between road and rail, the data therefore indicates that the availability of lightweight 20' containers would limit mode shift to a maximum of 20% of intermodal movements (c6% of total rail tonne km). The annual quantity of intermodal tonne kilometres moved by rail in calendar year 2009 amounted to 5,300 billion tonne kilometres (ORR, 2011), 20% of this volume would be 1,060 million tonne kilometres (equivalent to 153 million conventional articulated vehicle kilometres).

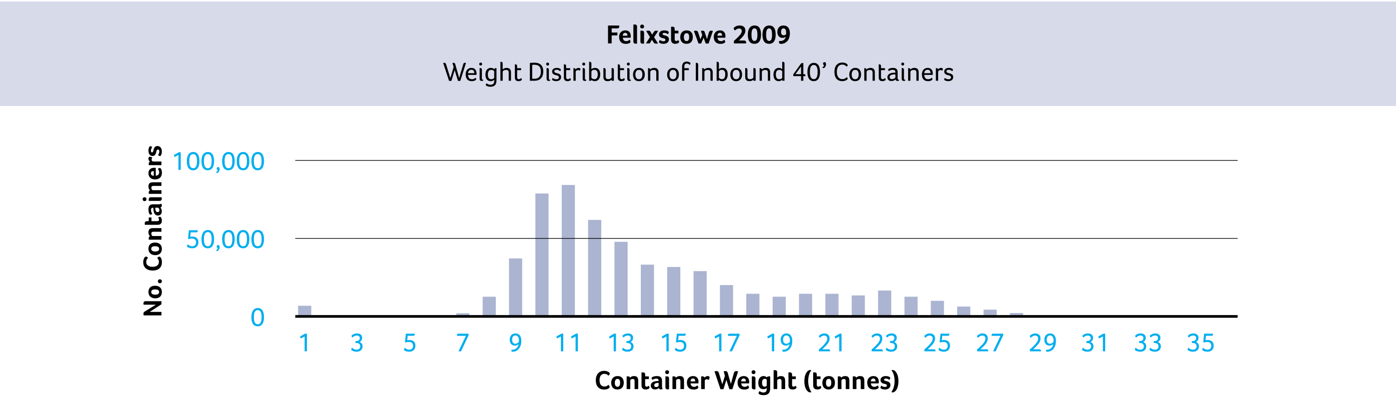
C4. Container Data Analysis

Table C.2 summarises the inbound and outbound container flows through Felixstowe in 2009.

	Total Containers	Loaded Containers	Total Weight (T)	Average (all) Weight (T)	Average Loaded Weight (T)
Inbound 20' Containers	357,093	341,149	4,996,797	13.99	14.65
Inbound 40' Containers	594,997	574,732	7,558,622	12.70	13.15
Outbound 20' Containers	347,336	203,748	3,925,087	11.30	19.26
Outbound 40' Containers	564,625	284,858	5,342,038	9.46	18.75
Total	**1,864,051**	**1,404,487**	**21,822,544**	-	-

Table C.2 Felixstowe port container volumes 2009.
Source: DfT, 2011a.

The charts below (figure C.5) summarise the frequency distribution of inbound container weights for 40' containers and 20' containers arriving at the port of Felixstowe.



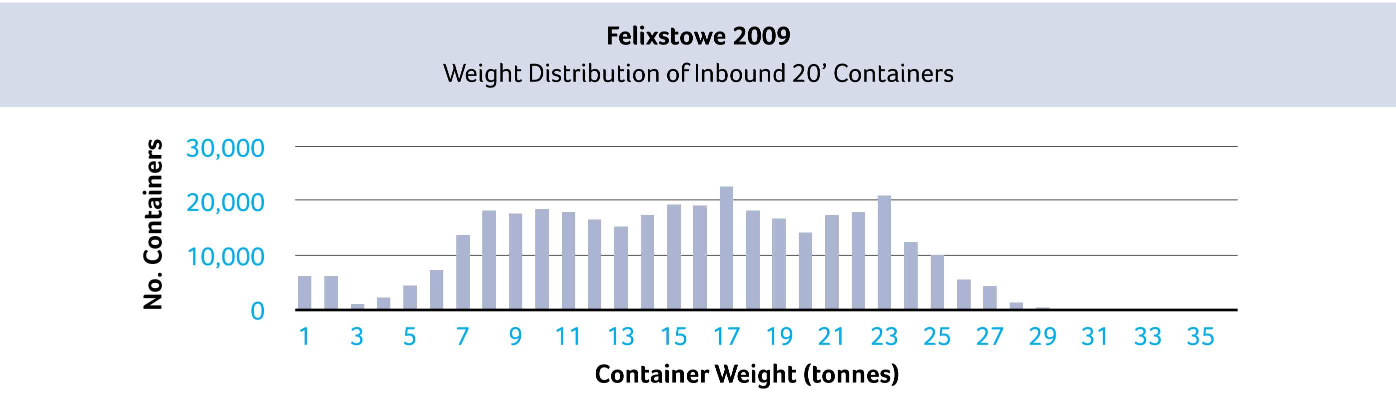


Figure C.5 Charts showing the weight distribution of containers arriving at Felixstowe port.
Source: DfT, 2011c.

The underlying data shows that the average weight of a 20’ container arriving at Felixstowe is 13.99 tonnes as opposed to 12.7 tonnes for a 40’ container (DfT, 2011c). This is because, although a 40’ has twice the volume capacity of a 20’, high density goods cannot utilise the capacity of a 40’ container without “weighing out” and hence they tend to be transported in a 20’ container.

As figure C.5 illustrates, the proportion of 20’ containers with a weight of less than 8 tonnes arriving at Felixstowe is small (less than 72 thousand containers in 2009 - 20% of total 20’ containers, carrying 8% of total weight). If an 8 tonne maximum 20’ container weight applies for the load to be carried by HCV this would mean that only 72 thousand matching 40’ containers of up to 16 tonnes could transfer to HCV, limiting the maximum to transfer to 9% of total tonnes received.

If the maximum weight of a 20’ container were capped at 12 tonnes (of which less than 140,000 were received in 2009), to be paired with a 40’ container such that the maximum 23.5 tonne payload of an HCV is not exceeded, a maximum transfer of 20% of total rail tonne kilometres would be possible (again assuming the Felixstowe profile to be representative).

Appendix D: Fuel Data

Two alternative fuel consumption data sets are presented at different HCV payload weights - one at 23,349kg (full capacity - data source Knight et al. (2008) - adaptation) and the second at 9,450kg (data source MIRA/BTAC trials of Denby Ecolink vehicle (2005)). In each case a fully loaded HCV is compared to a full load of a standard vehicle carrying goods of an equivalent density.

Base fuel consumption and CO_2 emission data is displayed in table D.1. This is then divided by the number of units of freight carried in each instance and the results compared on a per unit of freight basis (table D.2).

	Payload kg	Cubic Capacity	Pallet Capacity	Fuel Consumption Litres / 100km	CO_2 g per km
TRL Data					
Standard 44t artic	15200	100.9	26	32.42	849.3
44t, 25.25m B-double	23349	158.9	40	44.24	1159.1
Change	8149	58	14	11.82	309.72
% Change	54%	57%	54%	36%	36%
Denby Data (BTAC)					
Standard 44t artic	6000	91.4	26	24.1	630.5
44t, 25.25m B-double	9450	143.9	40	31.9	834.5
Change	3450	53	14	7.8	204.02
% Change	58%	57%	54%	32%	32%

Table D.1 Fuel consumption and emissions data.

Note: TRL (Knight et al., 2008) data has been calculated from stated CO_2 emissions for each vehicle type using standard conversion factors and assuming Euro 5 operation. The CO_2 g per km figure has been adjusted for the standard 44 tonne articulated vehicle to allow like for like comparison with goods of equivalent density carried on each vehicle type.

	CO_2 g per			Fuel litres per		
	tonne km	cm km	Pallet km	tonne km	cm km	Pallet km
TRL Data						
Standard 44t artic	55.88	8.42	32.67	0.02133	0.00321	0.01247
44t, 25.25m B-double	49.64	7.29	28.98	0.01895	0.00278	0.01106
Change	-6.24	-1.12	-3.69	-0.0024	-0.0004	-0.0014
% Change	-11%	-13%	-11%	-11%	-13%	-11%
Denby Data (MIRA /BTAC)						
Standard 44t artic	105.09	6.90	24.25	0.04011	0.00263	0.00926
44t, 25.25m B-double	88.31	5.80	20.86	0.03371	0.00221	0.00796
Change	-16.78	-1.10	-3.39	-0.00640	-0.00042	-0.00129
% Change	-16%	-16%	-14%	-16%	-16%	-14%

Table D.2 Fuel consumption and emissions change per unit of freight transport.

Appendix E: Case Study Methodology and Analysis

E1. Case Study Overview

In order to assess the potential economic and environmental impact of the use of HCVs within individual companies in the UK, a detailed analysis has been undertaken of the transportation operations of four case study companies.

Case studies have been selected that focus on the commodities identified in section 3.4 of this document as having greatest potential for usage of HCVs. These include:

- Manufactured Goods;
- Perishable and Non-perishable Foodstuffs; and
- Packaging Materials.

All case study companies are major organisations. Three of the four are well known, large scale manufacturers of branded consumer goods (both food and non-food), supplying product in to leading retail chains. The fourth is a major packaging supplier to manufacturing clients, feeding the production lines of a diverse range of sectors.

E2. Modelling Methodology

For each case study company, transport modelling has been undertaken based on historical delivery data. A detailed routing and scheduling exercise has been actioned for each day of sample data, producing daily route plans designed to comply with operational and regulatory requirements at lowest cost.

Following construction of a distance / time matrix using digitised map data, a two phase algorithm has been used that heuristically builds routes and selects vehicles based on the objective of minimisation of the total cost of operation (using cost per kilometre data for each type of vehicle).

Modelling respects the constraints of vehicle capacity (both weight and pallet capacity), delivery days, operating speeds on different elements of the road network (by type of vehicle) and drivers hours regulations. Fixed times are applied to each individual drop.

For each case study, three scenarios are modelled as follows:

1. **Base Case:** Modelling the resource requirements to economically meet the delivery profile using conventional goods carrying vehicles (both articulated and rigid vehicles). Use of HCVs is excluded from the base case.

2. **HCV Case A (unrestricted use):** Modelling the resource requirements to meet the delivery profile allowing use of HCVs as a substitute for conventional articulated and rigid vehicles for **all consignments** where this produces a more economical solution.

3. **HCV Case B (restricted use):** Modelling the resource requirements to meet the delivery profile allowing use of HCVs as a substitute for conventional articulated vehicles for **full loads only** (defined as 25 or more pallet lifts) where this produces a more economical solution.

In practice this means that in the HCV cases, an HCV will only be selected in preference over other vehicle(s) where it is more cost effective to use such a vehicle to service a destination (or cluster of destinations). The approach of cost minimisation as opposed to distance, fuel or emissions minimisation has been used to reflect the commercial reality of vehicle choice.

Two alternative HCV cases (A & B) are used to quantify the impact of restricting HCV usage to large loads only as opposed to allowing unrestricted HCV use wherever this produces a lower cost solution (ie for small drops on a multi-drop basis as well as for larger loads). This has been undertaken in recognition that there may be constraints that make use of HCVs on a multi-drop basis difficult in practice in some circumstances (see section 7).

Fleet options within the model are restricted to a 17 tonne rigid (14 floor pallet position capacity) and a 33 tonne 16.5m articulated vehicle (26 floor pallet position capacity). For the HCV cases these are supplemented by a 25.25m HCV (44 tonne, 40 floor pallet position capacity). Pallet carrying capacities for each vehicle are adjusted where pallets can be double stacked.

The delivery data used for all scenarios is the same, however, the model has the option of re-profiling full load data for high volume destinations in to full HCV loads where this will produce a lower cost solution. Where there are multiple full loads to the same destination within a one week period, the weekly volume can be re-profiled in multiples of 40 base pallet positions (from 26). This would seem a reasonable assumption as in the data the maximum size of a full load is artificially restricted to the maximum capacity of a conventional vehicle.

Example:
If there were 6 full loads of 26 pallet lifts (156 pallet lifts in total) going from a single origin point, to a single destination within a one week period, these could be re-profiled as 3 full HCV loads of 40 pallet lifts and one part load of 36 pallet lifts if the model finds it more cost effective to do so.

In this example as the part load is greater than the size of a conventional vehicle this would also be available for delivery by an HCV.

Each case study is modelled as a standalone entity with vehicles assumed to return to the origin point to complete the trip. The model considers outbound deliveries and any inter site trunking moves within the case study network. Other collection activity, back loading or use of fleet to service other operations is excluded from each scenario.

For each scenario the model outputs the resources required to fulfil the schedule, identifying the number of trips, kilometres and running time by vehicle type. The model also provides the total mileage run by each vehicle type on each category of road within the UK network.

The resource requirements identified for operation with and without HCVs are used to calculate the fuel consumption, carbon emissions and cost of each case. The results are then compared to determine the net impact of HCV usage against these criteria.

Cost data used within the model reflects the cost per kilometre by type of vehicle established in sections 5.1 and 5.2 (costs adapted from FTA data – see also Appendix F). Fuel consumption of an HCV is based on the analysis contained in sections 4.2 and 4.3. CO_2 emissions are derived from fuel consumption using standard conversion factors. Factors used are illustrated in table E.1.

Vehicle Type	Fuel Consumption per km (litres)	CO_2 per km (kg)	Cost per km (£)
Rigid (17 tonne)	0.24	0.62	0.71
Artic (33 tonne)	0.31	0.82	0.81
HCV (44 tonne)	0.41	1.07	1.01

Table E.1: Table of costs, fuel consumption and emissions per kilometre by vehicle type.

The model results for the first case study have also been used to identify the class of roads that would be used by HCVs as well as the proximity of locations to the main motorway and trunk road network.

E3. Methodology Limitations

It should be noted that the methodology has a number of limitations, the key ones being listed below:

- In each case assumptions are a simplification of operational reality, constraints such as access issues and specific time windows have not been modelled.
- Transport operations have been modelled with the fleet assumed to be operating on a dedicated basis. Each trip is modelled and costed on a round trip basis. In reality transport operations are likely to be operated by a haulier on a shared user basis, carrying goods for multiple customers to reduce empty running.
- Transport overheads have been excluded from the costs of vehicle operation.
- The number of fleet options modelled is limited. In reality companies would have a wider choice of vehicle types.
- Customer collections / returns have not been modelled.

Despite the above limitations, each case / scenario is based on a common set of assumptions and therefore comparison is on a like for like basis.

E4. Case Study Profiles and Modelled Results

The tables following (E.2, E.3, E.4 & E.5) provide a summary profile of each of the case study companies, including an indication of network structure, flows and high level volume information.

It should be noted that some of the participants have requested that their data be anonymised for reasons of commercial sensitivity - for consistency therefore the identity of each case study company has not been disclosed.

The volume data shown is a summary of actual volume data analysed and the associated delivery profile, however, in each case the period to which the data relates has not been disclosed to prevent the identification of the relevant company. Periods range from a week through to more than one year. In some cases the data covers only part of the transport operations of the relevant organisation.

The lower section of the table for each case study company also summarises the modelling results for each of the scenarios. This includes details of the number of trips, miles and running time by vehicle type needed to meet the delivery requirement, together with the associated fuel consumption, carbon dioxide emissions and costs of each scenario.

Case 1: Manufactured Goods

Major manufacturer of branded personal care products (toilet tissue, tissues, diapers, feminine hygiene products etc). UK manufacturing capacity and multiple distribution centre structure. High volume, delivering primarily to major grocery retail and health & beauty retail distribution centres.

Inbound Volume	**Drops**	**Lifts**
Number	18,000	465,000
% Full Load	95%	95%
% < Full Load	5%	4%
Outbound Volume	**Drops**	**Lifts**
Number	42,000	715,000
% Full Load	47%	71%
% < Full Load	53%	29%
Total Volume	**Drops**	**Lifts**
Number	60,000	1,180,000
% Full Load	61%	81%
% < Full Load	39%	19%
No. Origins	**8**	
No. Destinations	**440**	
Average lift weight	**350kg**	

Network Structure:
UK network consists of multiple manufacturing plants, distribution centres and third party co-packing suppliers.

Flows:
Modelled inbound flows include manufacturing plant to DC transport and movements to and from co-pack operations. Outbound flows comprise movements from distribution centres to customer delivery points.

Note:
2,100 inbound and 340 outbound drops consist of material too heavy to be transported as a full HCV load.

Case 1: Model Results

Manufactured Goods	Base Case No HCV Usage	HCV Case A Unrestricted HCV Usage	HCV Case B Restricted to Full Loads	Variance HCV A vs Base Case	Variance HCV B vs Base Case
Rigid Vehicles					
No. Trips	3,421	3,538	3,421	117	0
No. Kilometres	1,869,621	2,088,062	1,869,621	218,441	0
Running Time	33,280	36,601	33,280	3,320	0
Artic Vehicles					
No. Trips	45,739	6,482	13,606	(39,257)	(32,133)
No. Kilometres	18,567,379	3,297,573	6,338,745	(15,269,807)	(12,228,635)
Running Time	368,966	63,788	142,201	(305,178)	(226,765)
HCVs					
No. Trips	0	25,563	21,248	25,563	21,248
No. Kilometres	0	10,356,821	8,332,263	10,356,821	8,332,263
Running Time	0	223,961	158,985	223,961	158,985
Total Fleet					
No. Trips	49,160	35,583	38,275	(13,577)	(10,885)
No. Kilometres	20,437,000	15,742,455	16,540,628	(4,694,545)	(3,896,372)
Running Time	402,246	324,350	334,466	(77,897)	(67,780)
Fuel consumed (ltr)	6,267,687	5,772,799	5,845,817	(494,888)	(421,870)
CO_2 Emissions kgs	16,421,340	15,124,734	15,316,041	(1,296,606)	(1,105,299)
Total Cost £	16,457,204	14,629,819	14,908,089	(1,827,385)	(1,549,115)

Table E.2: Company distribution overview and model results for case study 1.

Case 2: Food manufacturer (A)

Manufacturer of branded lightweight food / snack products. UK manufacturing capacity and single (core) distribution centre structure. High volume, delivering to major grocery retail distribution centres, wholesalers and buying groups.

Inbound Volume	**Drops**	**Lifts**
Number	N/A	N/A
% Full Load		
% < Full Load		
Outbound Volume	**Drops**	**Lifts**
Number	41,000	540,000
% Full Load	36%	70%
% < Full Load	64%	30%
Total Volume	**Drops**	**Lifts**
Number	N/A	N/A
% Full Load		
% < Full Load		
No. Origins	**1**	
No. Destinations	**460**	
Average lift weight	**400kg**	

Network Structure:
UK network consists of multiple manufacturing plants, but a single core distribution location serving the national customer base.

Flows:
Modelled flows cover outbound activity only (DC to customer distribution centre).

Internal flows from manufacturing plant to DC offer further potential for use of HCVs (not modelled), although the distances from plant to DC are relatively short.

Case 2: Model Results

Manufactured Goods	Base Case No HCV Usage	HCV Case A Unrestricted HCV Usage	HCV Case B Restricted to Full Loads	Variance HCV A vs Base Case	Variance HCV B vs Base Case
Rigid Vehicles					
No. Trips	9,729	9,931	9,729	202	0
No. Kilometres	5,012,571	5,165,799	5,012,571	153,228	0
Running Time	88,378	90,614	88,378	2,236	0
Artic Vehicles					
No. Trips	19,310	2,874	6,780	(16,436)	(12,530)
No. Kilometres	8,742,746	1,402,892	2,880,267	(7,339,854)	(5,862,479)
Running Time	174,057	26,748	71,756	(147,309)	(102,301)
HCVs					
No. Trips	0	10,772	8,618	10,772	8,618
No. Kilometres	0	4,803,255	4,026,312	4,803,255	4,026,312
Running Time	0	107,435	71,714	107,435	71,714
Total Fleet					
No. Trips	29,039	23,577	25,127	(5,462)	(3,912)
No. Kilometres	13,755,317	11,371,946	11,919,150	(2,383,371)	(1,836,167)
Running Time	262,435	224,797	231,848	(37,638)	(30,587)
Fuel consumed (ltr)	3,846,344	3,592,899	3,693,517	(253,445)	(152,827)
CO_2 Emissions kgs	10,077,421	9,413,395	9,677,013	(664,026)	(400,408)
Total Cost £	10,682,675	9,661,743	9,972,114	(1,020,933)	(710,561)

Table E.3: Company distribution overview and model results for case study 2.

Case 3: Food manufacturer (B)

Manufacturer of branded lightweight food products. UK manufacturing capacity and multiple distribution centre structure. High volume, delivering to major grocery retail distribution centres, wholesalers and buying groups.

Inbound Volume	**Drops**	**Lifts**
Number	12,500	320,000
% Full Load	100%	100%
% < Full Load	0	0
Outbound Volume	**Drops**	**Lifts**
Number	32,000	355,000
% Full Load	32%	67%
% < Full Load	68%	33%
Total Volume	**Drops**	**Lifts**
Number	44,500	675,000
% Full Load	51%	83%
% < Full Load	49%	17%
No. Origins	**8**	
No. Destinations	**1035**	
Average lift weight	**175kg**	

Network Structure:
UK network consists of multiple manufacturing plants and multiple distribution centres. Manufacturing plants produce different product lines that are shipped to each DC. Each distribution centre serves a specific geographical region.

Flows:
Modelled flows include plant to DC and DC to customer. Collections from raw material suppliers have been excluded from the analysis.

Case 3: Model Results

Manufactured Goods	Base Case No HCV Usage	HCV Case A Unrestricted HCV Usage	HCV Case B Restricted to Full Loads	Variance HCV A vs Base Case	Variance HCV B vs Base Case
Rigid Vehicles					
No. Trips	9,831	9,333	9,831	(498)	0
No. Kilometres	4,481,053	4,313,377	4,481,053	(167,676)	0
Running Time	91,661	88,124	91,661	(3,537)	0
Artic Vehicles					
No. Trips	24,564	2,244	3,251	(22,320)	(21,313)
No. Kilometres	7,772,544	749,806	1,005,011	(7,022,738)	(6,767,533)
Running Time	163,673	19,422	27,060	(144,251)	(136,613)
HCVs					
No. Trips	0	14,677	13,825	14,677	13,825
No. Kilometres	0	4,622,339	4,382,250	4,622,339	4,382,250
Running Time	0	98,872	90,027	98,872	90,027
Total Fleet					
No. Trips	34,395	26,254	26,907	(8,141)	(7,488)
No. Kilometres	12,253,596	9,685,521	9,868,313	(2,568,075)	(2,385,283)
Running Time	255,333	206,418	208,748	(48,916)	(46,585)
Fuel consumed (ltr)	3,425,214	3,121,110	3,139,878	(304,104)	(285,336)
CO_2 Emissions kgs	8,974,062	8,177,309	8,226,481	(796,753)	(747,581)
Total Cost £	9,514,756	8,341,691	8,426,195	(1,173,065)	(1,088,562)

Table E.4: Company distribution overview and model results for case study 3.

Case 4: Packaging Supplier

Manufacturer of packaging materials, supplying the production lines of other manufacturers / re-packagers. The modelled operation supplies cardboard packaging.

Inbound Volume	Drops	Lifts
Number	17	442
% Full Load	100%	100%
% < Full Load	0	0
Outbound Volume	**Drops**	**Lifts**
Number	318	3,250
% Full Load	7%	17%
% < Full Load	93%	83%
Total Volume	**Drops**	**Lifts**
Number	335	3,692
% Full Load	11%	27%
% < Full Load	89%	93%
No. Origins	**2**	
No. Destinations	**87**	
Average lift weight	**400kg**	

Network Structure:
Modelled operation represents one plant / DC from a complex network comprising multiple manufacturing facilities and distribution centres.

Flows:
Outbound flows from DC to regional customer base. Collection of inbound material from one other factory location. Transfer of waste material to another factory location.

Note: Inbound / waste transfer loads consist of high density material that would be too heavy to utilise the additional volume capacity of an HCV.

Case 4: Model Results

Manufactured Goods	Base Case No HCV Usage	HCV Case A Unrestricted HCV Usage	HCV Case B Restricted to Full Loads	Variance HCV A vs Base Case	Variance HCV B vs Base Case
Rigid Vehicles					
No. Trips	12	11	12	(1)	0
No. Kilometres	912	856	912	(56)	0
Running Time	84	75	84	(9)	0
Artic Vehicles					
No. Trips	148	73	83	(75)	(65)
No. Kilometres	40,553	27,976	30,719	(12,577)	(9,834)
Running Time	1,302	787	877	(515)	(425)
HCVs					
No. Trips	0	51	44	51	44
No. Kilometres	0	8,384	6,403	8,384	6,403
Running Time	0	356	286	356	286
Total Fleet					
No. Trips	160	135	139	(25)	(21)
No. Kilometres	41,465	37,216	38,034	(4,249)	(3,431)
Running Time	1,386	1,218	1,247	(168)	(139)
Fuel consumed (ltr)	12,943	12,420	12,481	(523)	(461)
CO_2 Emissions kgs	33,910	32,539	32,701	(1,371)	(1,209)
Total Cost £	33,693	31,872	32,146	(1,820)	(1,546)

Table E.5: Company distribution overview and model results for case study 4.

E5. Summary Results

Tables E.6 and E.7 compare the results for the base case and HCV cases, identifying the percentage change in distance travelled, fuel consumption, carbon emissions and total cost.

HCV (A): Unrestricted use				
Case Ref:	**1**	**2**	**3**	**4**
% Change	**Manufactured Goods**	**Food Manufacturer A**	**Food Manufacturer B**	**Packaging Supplier**
No. Kilometres	-23.0%	-17.3%	-21.0%	-10.2%
Fuel consumed	-7.9%	-7.6%	-10.0%	-4.0%
CO_2 Emissions	-7.9%	-7.6%	-10.0%	-4.0%
Total Cost	-11.1%	-9.6%	-12.3%	-5.4%

Table E.6: Summary results from case study analysis – HCV (A) Unrestricted use.

HCV (B): Full load only use				
Case Ref:	**1**	**2**	**3**	**4**
% Change	**Manufactured Goods**	**Food Manufacturer A**	**Food Manufacturer B**	**Packaging Supplier**
No. Kilometres	-19.1%	-13.3%	-19.5%	-8.3%
Fuel consumed	-6.7%	-4.8%	-9.4%	-3.6%
CO_2 Emissions	-6.7%	-4.8%	-9.4%	-3.6%
Total Cost	-9.4%	-6.7%	-11.4%	-4.6%

Table E.7: Summary results from case study analysis – HCV (B) Restricted use.

E6. Road Network Usage

Table E.8 provides a breakdown of the modelled usage of the road network by class of road in Case study 1 (Manufactured Goods) for the HCV (A) scenario - unrestricted HCV usage.

HCV (A) Road Network Usage						
Class	**1**	**2**	**3**	**4**	**5**	**6**
Kilometres	8,995,735	773,006	208,871	212,030	137,193	29,986
%	86.9%	7.5%	2.0%	2.0%	1.3%	0.3%

Table E.8: HCV road usage by class of road – Case study 1 (Unrestricted HCV use).

Road class 1 and 2 roads equate to motorways and trunk roads, with roads increasingly lower speed / minor as the class number increases. A description of each road type is summarised in table E.9.

Road Class	Description
Class 1	Roads allow for high volume, maximum speed traffic movement between and through major metropolitan areas. Functional Class = 1 is applied to roads with very few, if any, speed changes. Access to the road is usually controlled.
Class 2	Roads are used to channel traffic to Functional Class = 1 roads for travel between and through cities in the shortest amount of time. Functional Class = 2 is applied to roads with very few, if any speed changes that allow for high volume, high speed traffic movement.
Class 3	Applied to roads which interconnect Functional Class = 2 roads and provide a high volume of traffic movement at a lower level of mobility than Functional Class = 2 roads.
Class 4	Applied to roads which provide for a high volume of traffic movement at moderate speeds between neighbourhoods. These roads connect with higher functional class roads to collect and distribute traffic between neighbourhoods.
Class 5	Applied to roads whose volume and traffic movement are below the level of any functional class. In addition, walkways, truck only roads, bus only roads, and emergency vehicle only roads receive Functional Class = 5.
Class 6	Other minor road.

Table E.9: Road network classification.

Functional Class = 1, 2, 3, and 4 roads are connected to form a comprehensive road network for navigation of long distance, mid-range and short routes in any given coverage area. For example, long distance routes are often calculated by searching the road network through progressively higher Functional Classes to get to a Level 1 road. The route continues exclusively on Level 1 roads until travel is required through progressively lower Functional Classes in order to reach the destination.

Appendix F: Vehicle Cost Data

Table F.1 contains a breakdown of the estimated cost of operating an HCV. A low and high estimate are made and the average cost then used for modelling purposes.

	44T	44T HCV		44T HCV	
Base Data	**Standard Artic Benchmark**	**Low Estimate**	**High Estimate**	**Low Estimate**	**High Estimate**
Annual kilometres	136,800	136,800	136,800		
Life (years) -tractor	5	5	5		
Life (years) -interlink trailer	5	10	10		
Life (years) - trailer	11	11	11		
Life (km) - tractor	683,970	683,970	683,970		
Replacement cost - tractor	76,937	76,937	76,937		
Replacement cost - interlink trailer		40,000	60,000		
Replacement cost - trailer	22,488	22,488	22,488		
Fuel consumption km / litre	2.90	2.44	2.44		
Fuel price ppl	113.49	113.49	113.49		
Tyre life (km) - tractor	136,800	136,800	136,800		
Tyre life (km) - interlink trailer	112,650	112,650	112,650		
Tyre life (km) - trailer	112,650	112,650	112,650		
Standing Costs	**£ Per Annum**	**£ Per Annum**	**£ Per Annum**	**Pence Per km**	**Pence Per km**
VED	1,200	1,200	1,200	0.88	0.88
Insurance	2,734	3,418	3,636	2.50	2.66
Depreciation - tractor	12,618	12,618	12,618	9.22	9.22
Depreciation - interlink		4,000	6,000	2.92	4.39
Depreciation - trailer	2,044	2,044	2,044	1.49	1.49
Subtotal	18,596	23,280	25,498	17.02	18.64
Running Costs					
Fuel	53,482	63,654	63,654	46.53	46.53
Tyres -tractor	1,257	1,257	1,257	0.92	0.92
Tyres - interlink		1,291	1,291	0.94	0.94
Tyres - trailer	1,291	1,291	1,291	0.94	0.94
Maintenance - tractor	6,248	6,248	6,248	4.57	4.57
Maintenance - interlink		4,005	4,505	2.93	3.29
Maintenance - trailer	3,505	3,505	3,505	2.56	2.56
Subtotal	65,783	81,251	81,751	59.39	59.76
Total Vehicle Cost	84,379	104,531	107,249	76.41	78.40
Employment cost of Driver	31,699	31,699	33,699	0.23	0.25
Cost of Vehicle and Driver	116,078	136,230	104,949	99.58	103.03
	Premium	17%	21%	**Average**	101.31

Table F.1: Vehicle cost data.

The benchmark figure is based on the "average" cost of operating a 16.5m articulated vehicle as published by the FTA (2011).

The cost table is based on the following assumptions:

1. The base cost is derived from the cost of operating a 44 tonne standard 16.5m articulated vehicle. This is then adjusted to take account of cost changes resultant from operating an HCV, using a high and low estimate of cost changes.
2. The costing assumes that the HCV variant will be a B-double.
3. The incremental cost of a B-double versus a standard vehicle is estimated as between £40,000 (low estimate) and £60,000 (high estimate) for purchase of an interlink trailer (with steer axles) and associated technical upgrade to the tractive unit and second trailer. The actual cost will be dependent on the level of technology employed and whether features such as a telescopic interlink chassis, sliding box or divisible bogie are incorporated in to the design.
4. The additional capital employed on the B-double trailer is assumed to have a life of 10 years (constant for high and low estimates).
5. The fuel consumption of the HCV is based on the average fuel consumption of a 33 tonne articulated vehicle, uplifted by 32% (see section 4.3). This is a constant assumption across both high and low estimates.
6. VED is assumed to be unchanged for an HCV as compared to a standard 44 tonne vehicle.
7. Insurance costs are assumed to increase by between 25% (low estimate) and 33% (high estimate).
8. Tyre costs for the interlink trailer are assumed to be the same as for the standard trailer (this may be an overestimate as the weight through each axle will decrease and tyre scrub would also reduce).
9. Maintenance costs for the interlink trailer are assumed to be the same as for a standard trailer, uplifted by £500 (low estimate) and £1,000 (high estimate).
10. Driver costs are predicted to be the same as for a 44 tonne standard vehicle in the low estimate, with a total increased cost of £2,000 per annum for the high estimate. Anecdotal evidence from the Netherlands found 2 out of 3 hauliers paying no premium to LHV drivers, with the third paying a premium of 1 euro per hour.

The average cost per km (of £1.01) is used in the modelling and analysis of company case studies.

Appendix G: Safety Aspects

G1. Introduction

This section outlines the projected safety impact of operating High Capacity Vehicles (HCV) in the UK. It is based on existing published literature, reports and tests to date.

G2. Definition

Road safety is concerned with the protection of people (road users and others), the environment, property and other assets from the impact of vehicles and road users. More specifically it is concerned with the prevention of road traffic accidents (RTAs) and the amelioration of their impact when they occur.

Road accidents cause both tangible and intangible costs to the economy. Some of the tangible costs include:

- Damage to the vehicle (replacement and repair costs)
- Damage (other vehicles, infrastructure, etc.)
- Increased delays & congestion
- Administration costs
- Medical treatment
- Reduction in output due to injury and death
- Insurance costs.

Intangible costs include:

- Pain, grief and suffering.
- Fear of being involved in a future accident.
- Other psychological or trauma related issues

List adapted from "Impact Of Road Accidents", (RTSA, 2008).

It is clearly important that any proposed change in vehicle regulations should not have an adverse impact on the above. Indeed, ideally, such proposals should reduce the risk of accidents. There have been a number of reports on this subject commissioned by various UK, European, North American or Australasian governments and / or police agencies. In many cases these look at the impact of longer, heavier vehicles (LHVs) rather than simply longer ones that are the concern of this study. The effect of increasing the overall vehicle weight "means greater kinetic energy and thus higher destructive force in the case of accidents compared to standard 40 tonne LGVs" (Leduc, 2009). Despite this the general conclusion of the reports is that the impact of LHVs on road safety is positive or, in the worst case, neutral.

G3. Approach

As stated above, this section is based on existing work, but it is important to understand the outline method used in those studies, so that their relevance either "as a whole" or "in part" can be determined. The general methodology is as follows:

- Identify all variables relevant to road safety
- Assessment of the effects of each type of proposed LHV on road safety
- Evaluation / extrapolation of these to create a valid indication of the possible impact on road safety.

For this report, the above will be "filtered" as far as possible to identify the impacts due to HCVs only; as opposed to LHVs.

G4. Key Variables

There is no definitive list of key variables identified that is common to all of the reports. The following six headings cover the ones most frequently considered:

Field of view	All of the areas the driver can see either directly or indirectly via mirrors or other supporting devices.
Lighting	This covers equipment designed to ensure that: • the driver is able to see well enough • the vehicle is clearly visible to other road users
Braking & acceleration	• Equipment fitted to allow the vehicle to be stopped within required distances and remain under control • The suitability of the engine, drive train, etc. to provide sufficient acceleration for the vehicle to negotiate hazards as well as to avoid causing them
Handling characteristics	• Manoeuvrability • Vehicle dynamics
Counterpart protection	• Amelioration of the consequences of any accident (impact severity) • Impact of vehicle design on the risk of an accident
Other factors	• Technology • Other relevant factors / comments

G5. Assessment of the Impact of HCVs on the Key Variables

The findings of various reports referred to in section G2 have been summarised using the classification from section G4. Refer to section G7 for the report source key.

G5.1 Field of view (FoV)

All of the areas the driver can see either directly through glazed areas or indirectly via mirrors or other supporting devices.

Report	Issue	Risk Impact
PPR285	When cornering the rigid vehicle or front trailer would prevent vision of area in front of the rear trailer. A B-double with fixed axles on the interlink trailer may be the safest option as it does not have exposed dolly wheels that cannot be seen by the driver.	**Slightly increased***
	Straight ahead travel or lane changing – field of view (& therefore safety) is unaffected.	**Neutral**
	*Risks should be minimized by fitting mirrors to Directive 2003/97 and may be reduced further by the use of camera technology to allow drivers to see "blind spots" – this would require additional driver training.	
TREN/G3	Introducing LHVs would not lead to a worse field of direct view for drivers. Specifically the B-double is slightly safer compared to "Std. LGVs" as no exposed wheels are out of the drivers view.	**Slightly Improved**
	FoV of other road users would be reduced – not quantified.	**Not Known**
Comment: HCVs configured to the B-double format would appear to be neutral provided that appropriate technological support is installed and suitable training provided.		

G5.2. Lighting

Report	Issue	Risk Impact
PPR285	No comments made.	**Neutral**
TREN/G3	No comments made.	**Neutral**
AL&HM	No direct statement, but this report comments on the risks of collisions during times of twilight or darkness. The risk of a "rear end" collision is similar, but that of a side collision at a cross road "seems" greater for a longer vehicle. It is therefore important that clear side and rear length markings are always used.	**Possibly Slightly Increased**

Comment:
The impact of HCVs on lighting safety would appear to be largely neutral although there is a possible small increase in the probability of a side collision.

G5.3. Braking & Acceleration

Report	Issue	Risk Impact
PPR285	For B-double vehicles with pneumatic braking systems, stopping distance could be increased by up to 20%. For vehicles with EBS (electronically controlled braking systems), brake reaction / stopping distance would not be substantially different from standard LGVs fitted with the same system and would be improved compared to pneumatic braking.	**Increased** **Neutral or slightly improved**
TREN/G3	Combinations that do not exceed the current GVW would not cause additional poor acceleration risks Longer semi-trailers produce no change in braking performance. NB An increased number of axles may improve the control algorithm of ABS systems.	**Neutral** **Slightly improved**

Comment:
The impact of HCVs on braking & acceleration would appear to be largely neutral with the potential for possible improvement. The use of appropriate modern technology should prevent any adverse effects, but this will need to be tested empirically.

G5.4. Handling Characteristics: Manoeuvrability & Vehicle Dynamics

Report	Issue	Risk Impact
PPR285	Low speed off-tracking – road space required for turns may be increased. Out-swing or tail swing – depends on the overhang and wheelbase. B-double 44 or 60 tonnes comply with the EU 7.2m wide swept path if fitted with steered axles. Most vehicles would comply with EU Directive 97/27/EC.	 **Neutral** **Neutral**
TREN/G3	The B-double has almost the same characteristics compared to a standard combination. Steady state circular test, sinusoidal steering and yaw damping are improved, whilst only lane change manoeuvre space is increased slightly.	**Neutral** **Neutral or slightly increased**

Comment:
The impact of HCVs on manoeuvrability safety would appear to be minimal provided that steer axles are fitted.

G5.5 "Counterpart protection"

G5.5.1 Impact Severity

Report	Issue	Risk Impact
PPR285	Impact severity is a function of various factors such as closing speed, the impact configuration (e.g. LGV to car, LGV to LGV) and mass. None of these are adversely affected by longer vehicles where the permitted weight is not increased.	**Neutral**
TREN/G3	Introducing LHVs would not perceptibly increase impact severity.	**Neutral**

Comment:
As the weight limit will be retained, the impact of HCVs on impact severity will be neutral.

G5.5.2 Junctions, Railway Crossings and Overtaking

Report	Issue	Risk Impact
PPR285	No impact on safety on motorways safety has been predicted but on junctions, railway crossings and especially single carriageway rural roads negative effects may occur. Examples include the greater time required to clear junctions at traffic light controlled intersections – NB increasing "inter-green" time would reduce the capacity of a junction.	**Slightly increased**
	Another predicted risk is the time required to overtake longer vehicles, which could lead to an increase in accidents, but no research has been able to prove any statistically conclusive results.	**Possibly slightly increased**
LPR/DSA	A 50% increase in the length of an articulated vehicle will result in an increased overtaking time of 17-18%, which is felt to be acceptable.	**Possibly slightly increased**

Comment:
Since the proposed usage (with the complete vehicle) is predominantly based on major roads, there would be little problem in restricting longer vehicles to motorways & major routes. If this were the case, then any increase in risk associated with vehicle length could be regarded as minimal.

G5.5.3 Accident Risk

Report	Issue	Risk Impact
ITF/ OECD	Reduced aggregate vehicle kilometres will lead to proportionate safety benefits. This implies that the fewer vehicles are on the road to carry the same quantity of freight, the fewer accidents will occur. If we make the assumption that the number of vehicles on the road at any one time will be reduced due to the increased carrying capacity of the individual vehicles, there could be a very significant improvement in safety.	**Significantly Improved**
PPR285	Accidents on LHVs are very scarce. UK data extrapolation shows no clear trend linking increased weight with increased casualty rates. Literature reviews show that although severe accidents do happen with LHVs, they are generally comparable with conventional LGVs. One study (Fancher, 1989) suggested that the involvement rate of double trailer combinations was 5-10% greater than for singles, allowing for differing road use. A Dutch trial showed no change in accident rate, but it was too small to draw significant conclusions.	**Neutral or slightly increased**
TREN/G3	A Swedish study (1976) stated that there is no statistical interrelation between an increased accident rate and vehicles of excess length (Backman & Ralf, 2002). An increase in accident frequency relates to extended dimensions but an increase in accident severity relates to increased weights. Therefore, increasing both factors may lead to higher risks, increasing the weight up to 44/48 tonnes or increasing the length to 25.25m would only lead to slight additional risks.	 **Neutral or slightly increased**
AL&HM	A 1997 project concluded that the risks associated with an LHV are similar to those of a regular truck combination as long as they meet a number of pre-conditions. (NB These involve braking systems, stability and field of vision). The use of LHVs will lead to an overall decrease in the number of vehicle kilometres, which has a positive effect on traffic safety. Accident analysis does not give any indication that an LHV creates an higher risk than a regular truck combination. Tests at Lelystad (The Netherlands) have shown that the negative effect on two wheelers is no different from that of regular truck combinations. Also there is no additional danger for mopeds on straight roads and intersections.	**Neutral** **Improved** **Neutral** **Neutral**

Comment:
On balance, the impact of HCVs on the probability on an accident occurring will be neutral and may even be reduced if goods volumes remain the same (& therefore, truck numbers reduce). Once again this requires the application of modern technological equipment and the provision of good driver training.

G5.6 “Other factors / comments”

Safety technologies

Report	Issue	Risk Impact
TREN/G3	Various systems provide “counter measure” to enhance safety. Some are “well introduced”, others are “mature” but some are still in development. Of the developed ones, some are optional rather than mandatory (e.g. ESP equipment ratio is some 10%). Some measures apply to tractors, others to trailers, few if any apply to both although they can be mixed. The effectiveness may depend on road types; therefore their suitability may vary by country depending on the prevailing terrain.	**Neutral or potentially improved**
JRC 52392	This report does not assess / review impact of LHVs on the number of accidents It lists a number of technologies that may enhance safety if fitted, including: • Electronic stability control (ESC) • The lane departure warning system (LDWS) • Advanced emergency braking system (AEBS) • Roll stability control systems (RSC) • Improved visibility (cameras, etc.). Whilst these improve safety, the author does not identify specific benefits for longer vehicles up to 44t.	**Neutral**
AL&HM	It is important that LHVs comply with specific pre-conditions (e.g. braking systems, vehicle stability and the driver’s field of vision). Complying with these conditions should be “automatic” on new vehicles, but some form of enforcement may be required where older vehicles are adapted for longer vehicle configurations.	**Neutral** **Neutral**
ITF/ OECD	Harmonisation – this report (along with others) concludes that “Truck traffic, configurations, access limitations, road design, junction geometry . . . should be considered as a system designed to produce the optimum economic, safety and environmental outcome”.	**Potentially improved**
ALL	Experience / Training – all reports state that it is vital that only experienced operators should be allowed to drive HCVs and that it is vital that they receive training to enable them to not only understand the impact of the increased vehicle dimensions and handling characteristics, but also make full use of the new technology available to assist them.	**Neutral or potentially improved**

Comment:
Here the impact of HCVs on the safety is again shown to be neutral or positive, provided once again that appropriate modern technological equipment is installed and training given. It is worth noting that this should not be a problem with “new-build” vehicles, but that any adaptation of older models would have to be subject to thorough scrutiny.

G6. Evaluation of the Key Variable Impact on Safety

The above summary shows clearly that there are many aspects to take into account when assessing the impact of HCVs on safety. It suggests that whilst some factors may benefit road safety, others may be detrimental to it. In addition, it shows that there is a degree of interdependence between them and that any assumption made about one factor will influence others. Further, because of this interdependence, it is difficult to give a “weighting” to the components. Nevertheless, it is important to draw all of the factors together in order to make a reasoned judgement of the overall impact.

G6.1 Discussion

The main commercial incentive to move to HCVs is the fact that the same quantity of goods can be carried using fewer vehicles. By implication then, it can be assumed that (for a given volume of goods carried) the introduction of HCVs would lead to a reduction in the number of vehicles on the road at any one time with a commensurate reduction in congestion, pollution and accidents. This phenomenon, sometimes known as the “Bumper Effect”, is a key factor as it tends to suggest that the overall impact would be one of reducing the probability of accidents occurring.

It would however, be naïve to draw any firm conclusions based on this fact, without taking into account the negative factors. Considering the above summary, in simple numeric terms the majority (about 50%) of comments are neutral, which suggests a minimal impact on safety so these can largely be discounted. More importantly almost all of the “adverse factors” that might increase risks fall into the “slightly increased” or “possibly slightly increased” categories, whereas the positive factors include the only statement flagged clearly as “significant” (improvement). Further, looking more closely at the adverse side, it can be noticed that many of them can be mitigated by the use of technology (e.g. using mirrors and / or cameras to minimize the potential field of view problem when cornering).

The importance of the use of appropriate technology cannot be understated. It is vital that HCVs are fitted with appropriate technology and that the operatives are suitably qualified in its use. This implies that they should be chosen from the most experienced available, given comprehensive training and subjected to rigorous testing before being allowed to drive HCVs.

There are, of course some “fixed” factors (such as the increased vehicle length) that cannot be ignored. Generally speaking the associated risks here (e.g. side on collisions at junctions) are fairly small, but cannot be reduced by technology. Further, since such incidents are likely to be triggered by other road users, driver training will have only limited impact on their reduction. Here the strategy for minimising the risk lies in route selection; for example, by avoiding the use of the full-length vehicle on minor roads or those subject to significant traffic light control.

G6.2 Conclusion

Based on the evidence reviewed and subject to the following conditions this report finds that the introduction of High Capacity Vehicles (HCVs) in the “B-double” configuration to UK roads would have no significant impact on safety in terms of road traffic accidents.

Conditions:

- All vehicles are purpose built to a suitable specification (including “tried & tested” technological support equipment and systems).
- Drivers are experienced, have received appropriate training (in both driving and use of the technology) and have satisfied an appropriate test.
- Support technology is regularly maintained and tested.
- Whilst it is not felt necessary to restrict usage to motorways and trunk routes, the routes chosen should be selected to avoid unnecessary risks at junctions. Any restriction would be less necessary where the vehicle is being used in “split” mode with only a single trailer – e.g. to deliver to urban sites.

Moreover, when all of the above conditions are observed and the special equipment is of sufficient technological specification, there may be a marginal reduction in the risks of accidents occurring provided that overall “goods lifted & carried” remain constant.

Notes:

- The use of non-purpose built vehicles would be possible provided that they are of good quality, well maintained and capable of being upgraded to a suitable technical specification.
- “Tried & tested” technology means that whilst “state of the art” equipment can and should be used, its use on these vehicles must have been tested and demonstrated in practice (as well as theory). Also, that appropriate inspection and maintenance regimes must have been developed to prevent “in field failures”

G7. Source Key

PPR285 Longer and/or Longer & Heavier Goods Vehicles – a study of the Likely Effects if Permitted in the UK: Final Report, Knight et al., TRL Ltd., 2008

TREN/G3 Final Report. Effects of adapting the rules on weights and dimensions of heavy commercial vehicles as established within Directive 96/53/EC, De Ceuster et al., TREN/G3/318/2007, 2008

JRC 52392 Longer and Heavier Vehicles: An overview of technical aspects, Leduc G., 2009

AL&HM Longer and Heavier Vehicles in the Netherlands: Facts, figures and experiences in the period 1995-2010, Aarts, L., & Honer, M., Ministry of Transport, Public Works & Water Management, 2010

LPR/DSA Lincoln Police Report/ Driving Standards Association (Notts). Personal communication (D Denby Esq.)

ITF/OECD Moving freight with better trucks: Final report. ITF/OECD/JTRC(2009)REV1, Joint Transport Research Centre, March 2010

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