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High capacity vehicles: an assessment of their potential environmental, economic and practical impact if introduced to UK roads

HIGH CAPACITY VEHICLES: AN ASSESSMENT OF THEIR POTENTIAL ENVIRONMENTAL, ECONOMIC AND PRACTICAL IMPACT IF INTRODUCED TO UK ROADS

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Purpose

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, although the impact of extending the length of an articulated vehicle to a new upper limit of 18.55m is currently being evaluated through operational trials. This paper assesses the environmental, economic, 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. For the purpose of the study, such vehicles will be known as 'High Capacity Vehicles' (HCVs). The term should not be confused with 'LHVs' (Longer Heavier Vehicles), which has been used to describe vehicles that exceed the maximum vehicle lengths set out in Directive 96/53/EC, or that exceed the gross vehicle weight that Member States must allow to freely circulate (40 tonnes). The scope is limited to the consideration of 25.25m vehicle variants that are currently in use in the Netherlands and covers the following aspects:

- background research into the regulatory environment
- identification of the potential for use of HCVS in the UK
- assessment of the potential environmental and economic impact
- review of the associated practical considerations and safety risks

Research approach/methodology

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

- A 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- Analysis of published and unpublished transport data drawn from government statistics (primarily DfT and Office of Rail Regulation (ORR) transport statistics) and industry sources.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.
- Interviews with stakeholders and other interested parties, which included a 'round table' discussion with hauliers and users of LHVs in the Netherlands.

A key element of the research was the inclusion of case study material based on the logistics requirements of a number of leading manufacturers. The research included exercises in routeing and scheduling of current transport needs, which gives the study a degree of realism, originality and an indication of applicability that helps to validate the findings.

The findings from the various research components have been combined to draw triangulated conclusions on the impact of the use of such vehicles on the UK's roads.

Findings

Use, configuration & regulatory framework in the EU

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). EU Member States may allow domestic deviations from these maxima provided that it does not significantly affect international transport competition. 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).

Longer and/or heavier vehicles have been trialled or are in use in a number of EU member states including: The Netherlands, Sweden, Finland, Denmark and Germany (Vierth et al. (2008), MTPWWM (2010), ITF/OECD/JTRC (2010), IFW (2011)). In addition they are used in non-EU countries such as: Norway, Australia, Canada, South Africa, Namibia and the USA (ITF/OECD/JTRC (2010)).

There are many possible configurations of LHVs and HCVs; a report by the Transport Research Laboratory (Knight et al., 2010) identified a non exhaustive list of 36 different permutations. This paper is focused on increased vehicle length only, limiting its scope to vehicles of 25.25m length as currently permitted for use within the Netherlands as illustrated by Table 1.

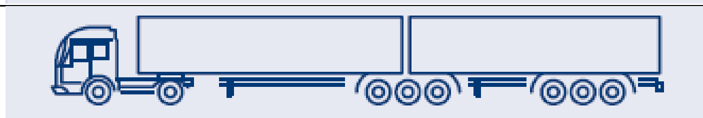
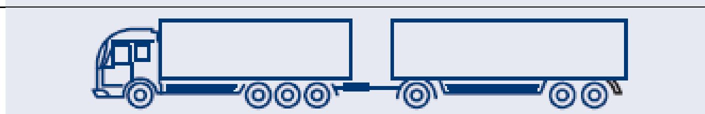
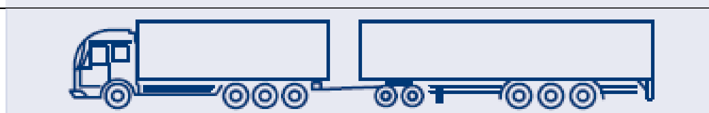
Type	Illustration	Description
A		Tractive unit + semi-trailer + centre axle trailer
B		Tractive unit + semi-trailer (inter-link) + semi-trailer. Also known as the B-double configuration
C		Truck (rigid) + trailer
D		Truck (rigid)+ dolly + semi-trailer
E		Truck (rigid) + two centre axle trailers

Table 1: LHV configurations permitted in the Netherlands (adapted from MIE, 2011b)

There are advantages and disadvantages to each configuration relating to: capital cost, container transport, manoeuvrability, safety and vehicle flexibility. The B-double has been used as the basis of this research.

Opportunity assessment

The potential change in vehicle capacity through using HCVs is illustrated by Table 2 which shows the key weights, dimensions and payload carrying capacity of an HCV (B-double configuration) as compared with a conventional UK specification 16.5m articulated vehicle. It demonstrates that the increased length of an HCV results in an increase in the volume of the vehicle (by 57.5%), and in 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 by 19.8% as a result of the increased unladen weight of the longer vehicle.

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 2: Weight & capacity of an HCV – Adapted from Knight et al. (2008), based on single deck vehicles, 4m high

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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 580kg. The cubic capacity of an HCV can therefore only be fully utilised when carrying relatively low density product, otherwise it will 'weigh out' before it 'cubes out'. This restricts the type of product that can be carried to low density goods.

Low density goods when measured on a weight basis (either in terms of tonnes lifted or tonne kilometres) incur high transport costs, are fuel intensive to transport and generate high emission levels when compared to high density goods. One effect of this is that 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. It is essential to use great care when identifying loads suitable for carriage by HCVs and when assessing the level of benefit.

Data drawn from the DfT (2011a, b & c) has been used to identify road transport flows where goods are lightweight and are transported in sufficiently large quantities to be suitable for carriage by HCV. Such flows are summarized by Table 3. These are approximately equivalent to15% of total articulated vehicle distance travelled in 2009 but only 9% of articulated vehicle tonne kilometres undertaken in that year. The table excludes any allowance for current rail freight volumes that may transfer to road as a result of the introduction of HCVs.

Opportunity	Opportunity Scale (2009) Million Articulated Vehicle Kilometres
Full loads of lightweight goods in palletised or roll cage form	1,160
Lightweight container traffic	124
Full loads carried in 'Other' modes of appearance (low estimate)	138
Grand Total	**1,422**
Notes: Distances travelled include an allowance for empty running. Based on 2009 volumes (developed from DfT (2011a,b,c))	

Table 3: Summary of HCV opportunities

It is important to note that not all commodities are suitable for HCV transportation. 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. These are: 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 were used as case studies to explore the impact that use of HCVs would have on their operations.

Environmental Impact

Numerous studies, commissioned by governmental and non-governmental bodies, have examined the effects of increasing the maximum allowable weight and/or dimensions of goods carrying vehicles. The general consensus is that, for 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 including: Carbon Dioxide (CO_2), Oxides of Nitrogen (NO_x) and Particulate Matter (PM) as well as noise, accidents, congestion and non-renewable fuel consumption.

The fuel consumption of a fully laden 44 tonne HCV will be higher than that 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 caused by increased surface area and additional points of discontinuity together with increased rolling resistance caused by the increased number of axles.

Table 4 summarises three alternative sets of available data that assess the fuel consumption and emissions of HCVs compared with a conventional vehicle, fully loaded with goods of equivalent density.

	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: Overview of fuel consumption data (NB TRL figures have been derived from published CO_2 data)

As each data set has been derived under different conditions (of payload weight, empty running, traffic conditions, speed, driver style, etc.), the recorded fuel consumption for each type of vehicle varies. 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 a 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%.

To investigate the probable 'real life' impact of this, 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 networks. The models demonstrated a reduction in total fuel consumption/CO_2 emissions of case study companies of between 4.0% and 10.0%, but this was restricted to between 3.6% and 9.4% when used 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). Although the greatest level of benefit in terms of distance reduction is achieved for companies with the highest proportion of full loads of a weight suitable for transport by HCV, the unrestricted results indicate that there is additional environmental benefit in using HCVs for part loads as well as for full load movements.

There is a theoretical possibility that some negative environmental impact could result from a 'modal shift' of goods from rail to road transport. In the Netherlands "*No reverse modal shifts have occurred following the introduction of LHVs. According to expectations these effects will not occur in the near or distant future either*" (MIE, 2011a, p7). Analysis of 2009 UK rail freight concludes that the only significant category of rail freight at risk of transfer to HCV is the 'domestic intermodal category' - comprising 28% of rail tonne kilometres in 2009 (ORR, 2011). A review of the weight profile of container traffic indicates that less than 20% of domestic intermodal rail freight would be sufficiently lightweight to transfer (DfT, 2011c). This finding equates to a maximum transfer volume of less than 6% of all rail volumes, which amounts to approximately 1,060 million tonne kilometres per annum (equivalent to 153 million conventional articulated vehicle kilometres or 102 million HCV kilometres at typical lading rates). In practice the rate of transfer would be considerably lower as rail would continue to retain an economic advantage over long distances and practical considerations would limit the transfer rate.

To summarize the predicted net impact on carbon emissions, Table 5 demonstrates the combined impact of differing levels of HCV substitution for lightweight road and rail flows; it shows 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.

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')					
% Transfer of rail lightweight container volumes to HCV.		0%	20%	40%	60%	80%	100%
	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 5: Net carbon impact of HCV implementation at different take up rates

Economic Impact

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)).

To fairly assess the cost impact of using HCVs, the costs of an HCV should be compared with those of a conventional vehicle that has been fully loaded with goods of equivalent density. Table 6 compares the cost per kilometre, per pallet kilometre and per 20' container kilometre and shows that, whilst the cost per km of an HCV is 25% higher than that of a 33 tonne articulated vehicle, the cost per pallet km is 19% lower and the cost per 20' container km is 17% lower. This was supported by a case study analysis of the transport operations of large manufacturing organisations carrying lightweight goods within their respective distribution networks where savings of 4.6% and 12.3% of total transport costs were identified.

	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 6: Cost comparison – HCV vs. 33 tonne 16.5m articulated vehicle (based on Diesel price £1.13/litre)

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 freight transport services purchaser. Summarising the transport streams that could potentially be carried by HCVs and the associated economic impact of 100% of each stream migrating to carriage by HCV, gives an estimated total benefit of £226 million per annum. This is likely to be an over estimate of the economic benefit; a better estimate of transfer levels of between 40% and 60% indicates an annual net economic benefit of between £90 million and £135 million (excluding any investment in infrastructure or regulatory costs).

Practical considerations

Concerns have been expressed over the practicality of using HCVs on UK roads. This has been examined using the following criteria: road infrastructure damage/road wear, vehicle manoeuvrability, road access restrictions, parking, congestion, delivery point issues, possible multi-drop problems and back load availability. There are a number of issues to be addressed, but they can largely be overcome through intelligent vehicle design and restrictions on usage.

Practical considerations suggest that the B-double has a mix of advantages that other configurations cannot currently offer as it has superior manoeuvring capabilities when fitted with steer axles as compared to other variants, is better aligned to the requirements of UK road infrastructure and has improved safety features (visibility, stability & manoeuvrability). Also, it can be readily coupled and decoupled, with trailers transported separately to overcome access constraints and it can accommodate one 40' and one 20' container. The disadvantages are increased capital cost of this variant and complexity when loading/unloading the interlink trailer.

All HCV configurations would need to be equipped with suitable technology countermeasures to mitigate areas of increased safety risk.

Safety considerations

The safety impact has been examined using literature review, accident experience in the Netherlands, identification and assessment of risks. Based on the evidence reviewed and subject to certain conditions it is found that the introduction of suitably configured HCVs to UK roads would have no significant impact on safety in terms of road traffic accidents.

Conditions include: vehicles to be purpose built to a suitable specification (including regularly maintained technological support equipment and systems), drivers trained in both driving and use of the technology, and the use of routes chosen to avoid unnecessary risks. Further, if these conditions are observed there may be a marginal reduction in the risks of accidents for a given volume of "goods lifted & carried".

Discussion of findings

The decision to use HCVs on the UK road network is complex and there are many stakeholders with opposing views. Proponents argue that, following successful trials in other European countries, the case for enlarged vehicles is proven; 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. Therefore, the findings of this paper have been based on a range of techniques to increase the integrity of findings, but there are some areas where sufficient proof is not available and in these circumstances prudent assumptions have been made.

The paper has identified areas of current road and rail transport where there are flows suitable for the use of HCVs, the key criteria being that goods are lightweight in nature and moved in sufficient quantities. A total of 1,422 million kilometres of current road activity (15% of current articulated vehicle kilometres) has been identified as suitable for transfer to HCV. The equivalent of an additional 153 million articulated vehicle kilometres of rail container traffic could also transfer to road.

Principal flows identified are those of palletised goods from plant to manufacturer or retailer distribution centres and container volumes to / from port. Specific lightweight commodity groups have been identified and the economic and environmental case for use of HCVs has been assessed at vehicle level, in the transport operations of case study companies and at macro level.

A key variable in this analysis has been the fuel consumption of an HCV as compared to a standard vehicle – this affects 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. 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 low density 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 with a high potential for their use and high volumes 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. The level of benefit achievable varies considerably between individual case studies. 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 in HCVs. Where no 'full load' restriction is applied, the density of drops affected the incremental level of benefit. 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.

This study found that a maximum of 20% of rail intermodal/deep sea container traffic would be at risk of modal shift to road, which would partially offset the emission savings from the use of HCVs; but, on balance, there would be a significant reduction in carbon emissions. 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 (96,000 tonnes in the event of 100% use in both streams).

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. 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 during the research. The conclusion was that these issues will reduce the volume of traffic transferring to HCV, although there are solutions to most of these issues that mitigate the problems. Where there are significant volumes and hence considerable 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.

Research Impact

The research impact is twofold: firstly it brings together data from disparate sources to draw its conclusions thus providing consolidated base data for subsequent work. Secondly, the conclusions give a reasoned view on all major aspects of the potential use of these vehicles that has been designed to both satisfy academic requirements and inform potential legislators.

Practical Impact

This study finds that permitting the use of HCVs in the UK under controlled conditions will 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.

Keywords: High capacity vehicles, Environment, Economic

References

- Arcadis (2006), Monitoring Research LHVs in the Second Pilot, results of second pilot with LHVs on Dutch roads [Monitoringsonderzoek vervolgproef LZVs, Resultaten van de vervolgproef met langere of langere en zwaardere voertuigcombinaties op de Nederlandse wegen]
- DfT (2011a). Unpublished data sourced from Department for Transport 'Continuing Survey of Roads Good Transport' for 2009, accessed 2011.
- DfT (2010b) 'Maritime Statistics' for 2009, Department for Transport, 2010.
- DfT (2011c). Unpublished data sourced from Department for Transport 'Maritime Statistics' for 2009
- EC (1996): Council Directive 1996/53/EC of 25 July 1996 laying down for certain road vehicles circulating within the Community the maximum authorized dimensions in national and international traffic and the maximum authorized weights in international traffic. The Council of the European Union, Brussels.
- IFW (2011), Gigaliner Trials stalled, IFW [onlline]. Available at: http://www.ifw-net.com/freightpubs/ifw/searcharticle.htm?artid=20017905306&highlight=true&keywords=germany+LHV&phrase=. Accessed 23/9/2011.
- ITF/OECD/JTRC (2010); Moving Freight with Better Trucks, Final Report, International Transport Forum
- Knight, I., Newton, W., Barlow, T., McCrae, I., Dodd, M., Couper, G., Davies, H., Daly, A., McMahon, B., Cook, B., Ramdas, V., Taylor N., McKinnon, A., Palmer, A., (2008), "Longer and/or Longer and Heavier Goods Vehicles (LHVs) – a Study of the Likely Effects if Permitted in the UK", Published Project Report PPR285, TRL. UK.
- Knight, I., Burgess, A., Maurer, H., Jacob, B., Irzik, M., Aarts, L., Vierth, I., (2010), Assessing the likely impacts of potential changes to European heavy vehicle weights and dimensions regulations. Published Project Report PPR505, TRL. UK.
- MIE (2011a), Monitoring Modal Shift – Longer and heavier vehicles, The follow-up measurement, Ministry of Infrastructure and the Environment (Rijkwaterstaat).
- MIE (2011b), Monitoring Traffic Safety– Longer and heavier vehicles, Ministry of Infrastructure and the Environment (Rijkwaterstaat).
- MTPWWM (2010), Longer and Heavier Vehicles in the Netherlands, Ministry of Transport, Public Works and Water Management (Rijkwaterstaat).
- ORR, (2011), National Rail Trends Yearbook 2011, Office of Rail Regulation.
- TIM Consult (2006): Wettbewerbswirkungen der Einführung des Gigaliners auf den kombinierten Verkehr. TIM Consult, Frankfurt, Kombiverkehr, Frankfurt, UIRR, Brussels.
- Vierth, I, Berell, H, McDaniel, J., Haraldsson, M., Hammarström, U., Reza-Yahya, M., Lindberg, G. Carlsson, A., Ögren, M. and Björketun, U. (2008) The effects of long and heavy trucks on the transport system. Report on a government assignment. VTI rapport 605A, VTI, Sweden.