Department for Transport

LHV Trial Feasibility Study

Final Report

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Executive summary

This report is intended to provide a summary of findings related to the possibility of running a Longer Heavier Vehicle (LHV) trial in Great Britain (GB) and is supported by; an extensive Literature Review Report incorporating insights from around 50 published and unpublished documents relating to worldwide LHV trials, with a gap analysis used as the basis for a stakeholder engagement session; and a Stakeholder Report, detailing the outputs from those sessions; and an industry survey assessing potential demand.

LHVs are now used in many countries both within and outside Europe. All countries using them report substantial gains in efficiency, with reductions in traffic, emissions, casualties and costs. We have identified risks associated with their use but also a range of methods used in different places to mitigate those risks. From this, a framework has been developed, within which DfT can explore a range of approaches that could be taken to such a trial, based on different mechanisms to managing the primary sources of risk to Infrastructure (especially bridges and vehicle restraint systems), other road users and mode shift.

Five potential policy options have been defined to highlight the various approaches to a trial. DfT can select one of these options or could tailor one of the options to their own specification. Options 1 to 4 all assume that LHVs would not be permitted on all roads and that approved routes would be defined by demand (operator) led route by route application.

- Option 0: Do nothing
- Option 1: Route Based Risk Control
- Option 2: Vehicle Based Risk Control
- Option 3: Rules Based Risk Control
- Option 4: Hybrid of Option 2 and Option 3

The report concludes that, if a ‘do something’ option is selected, a preparation and testing stage should commence immediately to maintain momentum with existing stakeholders, identify additional stakeholders to develop specific use cases (vehicle combinations and routes) and to complete essential work items, before moving to a commercial trial stage or concluding that an LHV trial is not feasible and the ‘do nothing’ option should be selected.

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1 Introduction

1.1 Brief

In many parts of the world, using goods vehicles of higher capacity has been highlighted as a way to significantly improve the efficiency of road freight transport. The basic premise is that two vehicles of 25.25m length and 60 tonnes weight can replace 3 existing 44 tonne HGVs, thus significantly reducing cost and emissions per unit of goods moved. Experience in other countries has suggested that this translates to substantial economic, environmental and safety benefits. As part of the Government's commitment to decarbonise road transport and improve air quality, the Department for Transport (DfT) has commissioned a study to determine the **technical feasibility** of trialling Longer/Heavier Vehicles (LHVs) on GB roads. The aim of the trial would be to assess whether those claimed benefits seen in other countries, could be reproduced in the UK freight market. A condition of running a trial would be that it must be able to maintain existing GB standards of road safety, operations and infrastructure protection. **DfT have made no decision yet on whether such a trial should take place.**

1.2 Approach

In development of the study, the approach taken was to undertake:

1. An international literature review, starting with results from the last major DfT LHV study (Knight, et al., 2008. Available from https://www.trl.co.uk/publications/ppr285), assessing whether they still apply, or need updating, given new evidence from subsequent international studies, trials, or operational implementations.
2. A substantial risk identification exercise, creating a summary 'gap statement' where a topic has been explored in the literature review.
3. An initial survey of operators to provide a first indication of whether or not there was sufficient industry demand for LHVs to justify a trial and, if so, what sort of vehicles and uses there was interest in. It was not intended to produce an accurate and representative estimate of UK uptake under trial or legalised conditions.
4. Engagement with three groups of stakeholders was undertaken to identify possible problems and their solutions associated with the use of LHVs and the technical feasibility of a trial; Regulatory and Compliance Bodies; Industry (trade associations etc); and Roads Authorities (National Highways, Transport Scotland, and Local Authorities).
5. The development of a manageable set of potential policy options, with possible approaches to trial design, for further review with stakeholder groups.

1.3 Vehicles under investigation

The scope of this study, as defined by the DfT in the terms of reference, was vehicles up to a maximum of 25.25m in length and 60 tonnes in weight. When considering only vehicles of 25.25m length, the main 'core configurations' can be described by the 5 defined in the early trials in the Netherlands and used as a reference set by a number of other European LHV studies and trials. These are the two main configurations described under the European Modular System (EMS as defined by Directive 96/53/EC) plus the B-Double, a standard rigid/drawbar combination, with max length vehicle and trailer, and a rigid truck towing two shorter drawbar trailers. Within Europe, the main vehicle configurations associated with these maximum weights and dimensions are those permitted in the early trials in the Netherlands (Aarts, et al., 2010). These are illustrated in Figure 1, below.

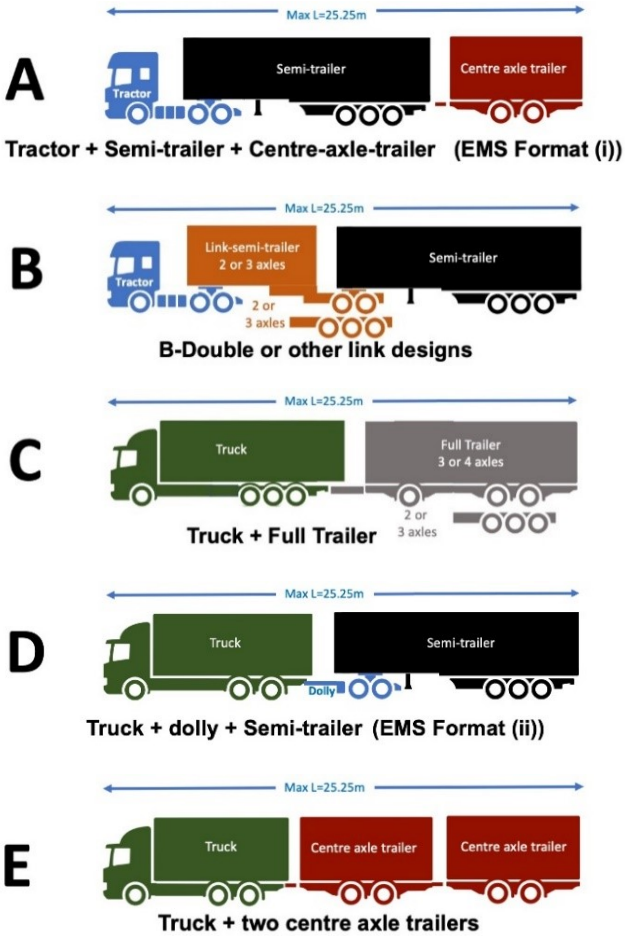

Figure 1: Core LHV configurations at 25.25m & 60 tonnes. Source: Adapted from (Aarts, et al., 2010)

This study focussed mainly on the above core vehicle combinations at the maximum weights and on the assumption of a total of 7 or 8 axles for each, with no increase in the maximum axle weight.

The inclusion of the “up to” the maximum weight and length in the scope definition does highlight the possibility of a range of vehicles that might be less than the length limit, mass limit, or both, which introduces the following possibilities:

- **Minor variations** - ((de Saxe, et al., 2019) highlighted that combinations that look very similar to A-E above could have a range of differences when optimised for different load units. For example, they identified a B-Double carrying a 20 foot and a 45 foot container at 23.9m length, a rigid towing a semi-trailer with the same load units at 25.0m length and a B-double with three 7.825m swap bodies at 27.7m length (which would fall outside of the scope of this work, despite being similar). These could also vary in terms of axle positions, wheelbase, overhang and hitch geometries.
- **Vehicles for very low-density goods** – these might maximise volume but at significantly less than the maximum 60 tonnes (50 tonnes or even less) and could have fewer axles, while respecting the existing maximum axle weights.
- **Vehicles for very high-density goods** – These may currently be carried on vehicles that are shorter and/or lower than the maximum permitted and could, within scope, consider vehicles that are 16.5m or 18.75m in length (I.e., standard articulated, Longer Semi-Trailer (LST) or standard drawbar configuration) but weigh up to 60 tonnes, provided sufficient axles could be included to avoid exceeding maximum axle weights.
- **Additional length for aerodynamic aids**: existing vehicles are permitted to use aerodynamic aids outside of length limits.
- **Additional mass for low or zero emission vehicles**: some existing vehicles are permitted an additional 1 or 2 tonnes gross vehicle weight (GVW) to compensate for the additional mass of the low emission technology.
- **Possible limitations in height to the 4m** more normal in other EU countries, where LHVs have been operated.

These variations have been considered in parallel to the main configurations, where it has been highlighted as particularly relevant. The main options A-E have been referred to as the ‘core configurations’ and the sub-options as ‘variants’.

Double deck vehicles at heights of up to 4.9m also need consideration and there is little international experience to draw on for this variant. The general EU height limit is 4m and although some member states may permit more, for example, 4.2m or 4.6m, the UK is very unusual in leaving height unrestricted, with the 4.9m de facto limit coming from the minimum clearance of bridges over the GB SRN.

1.4 Deliverables

This report describes the main outcomes of the work, the draft policy options, and summarises the considerations and rationale that led to the definition of those options as well as identifying the potential design of a trial if DfT were to choose a 'do something' option and the additional work and evidence that may be required before the trial could commence. Detailed reporting of the evidence base is available from the separate literature review (Knight, et al., 2022) and stakeholder reports (Brand & Smallwood, 2022).

2 Summary of experience with LHVs

Australia and Canada are seen as the pioneers of the use of LHVs but a large number of countries around the world are now following a similar concept. This includes ten EU countries that have either legalised the use of LHVs or are engaged in some form of trial of their use. Here in the UK, we have also had around ten years of experience with the longer semi-trailer trial, which is also a form of higher capacity transport.

When considered in the worldwide context, there is considerable diversity in “standard” HGVs in terms of the exact dimensions of rigid vehicles, trailers, semi-trailers and tractor units used. This diversity is then expanded when they are assembled into longer combinations. No countries have been identified where the authorities presumed no difference in risk compared to their existing ‘standard’ HGVs. All saw some level of different or increased risk associated with LHV use, so all impose some form of additional restrictions designed to control those risks. However, the ways in which those risks have been managed have also been quite diverse.

Australia exemplifies an innovative and flexible approach that is adaptable to new, and perhaps, as yet, unknown vehicle variants. The view is taken that the main reason for imposing limits of weights and dimensions is to control safety and infrastructure risks. However, it is considered that length and overall weight are relatively poor and inflexible proxies for safety and infrastructure risk. So, for vehicles that exceed their standard legal length and weight limits, there is no limit at all to the total mass or length that can be considered, provided they meet the limits defined in a comprehensive set of **Performance Based Standards** (PBS), that are intended to measure safety and infrastructure performance more directly, for example, low speed manoeuvrability, traction and acceleration performance, roll and directional stability, vertical and horizontal loading on pavement etc. This scheme categorises vehicles into one of four performance categories and the road network is similarly divided into 4 categories of safety and robustness. Vehicles that perform to the highest level are granted access to the widest network of roads, whilst vehicles with high productivity but lower PBS levels, can still gain access to a smaller network of roads considered sufficiently safe to allow them.

The rules can become relatively complex in this arrangement and there were strong concerns as to how compliant with the rules operators would be. This also led to the development of the ‘**Intelligent Access**’ (IA) concept, where road authorities made it a condition of permits granting access to their roads that some vehicles registered on the intelligent access programme. The scheme is intended to use the high-capacity vehicle permit scheme as a positive incentive to operators to comply with the rules, and to share useful data with the authorities. Many of the principles on which it is based are shared with the Earned Recognition Scheme applied by DVSA in the UK, although earned recognition applies only to roadworthiness and driver’s hours offences, so that the technical solutions are different. In the Australian concept, vehicle location is a key measure, so operators must fit a telematics device in their vehicle that can report any non-compliance with permit restrictions to the road authorities. It is administered by an independent 3rd party monitoring body and can result in much greater voluntary data sharing between operators and authorities, to demonstrate good compliance, where this results in a win/win situation for all involved. Incidentally, this IA data, in suitably redacted and anonymised forms, is made available for a variety of purposes, including asset management for road owners, research and data analysis.

The situation in most of Europe is more prescriptive, with details of maximum length, wheelbase, loading length, axle spacing, total masses, and axle masses all specified to some degree for motor vehicles, trailers and vehicle combinations under the control of Directive 96/53/EC. Vehicles complying with these limits are guaranteed free circulation in every member state. This results in the maxima for vehicle combinations of 4m height, 40 tonnes in weight and 16.5m length for an articulated vehicle (tractor semi-trailer) and 18.75m for a drawbar (rigid and trailer). In certain circumstances, it permits member states to use individual vehicles and combinations that don't meet those standards, provided they also allow any combination of vehicles and trailers that do meet the standards, in a form that allows at least the same loading length to be achieved as the non-standard configuration that is permitted. This has become known as the European Modular System and is the principle underlying the 5 core configurations studied in this report.

The approach is principally justified on an economic basis intended to promote harmonisation in weights and dimensions. Member States cannot use weights and dimensions regulation to favour national haulage companies over those from other countries, because that can also lead to anti-competitive and/or inefficient practices. This was a constraint when considering the length of the GB longer semi-trailers because, if the loading length remained less than permitted for a drawbar (18.75m) then a standard modular configuration (the 18.75m drawbar) could achieve at least the same. If that was exceeded, then it was considered that GB would have been obliged to permit 25.25m LHVs as the next smallest configuration of standard loading modules that could achieve at least the same loading length as an LST. Similarly, permitting only a B-double with steered axles may have been difficult under this regulation. Post Brexit, subject to legal advice, it is likely that these constraints will now only apply on international journeys between the UK and the EU. It should also be noted that the EU are currently reviewing the effectiveness of Directive 96/53/EC (https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13278-Commercial-vehicles-weights-and-dimensions-evaluation-_en) and considering whether a prohibition on cross-border use of LHVs has been effective or appropriate is one consideration in the review. As such, these constraints may or may not change in the coming year or two.

Even within this EU framework, there has been substantial variation in how LHVs have been permitted. Nearly all countries have granted access to only a sub-set of roads in their network considered to be those better able to handle the larger vehicles. Finland has a default permission on all roads, but with local authorities able to impose local restrictions in the same way as happens in all countries with respect to standard HGVs. Most countries have permitted up to 60 tonnes GVW and all 5 configurations of LHVs, but some have been more restrictive, in particular ruling out the rigid with 2 drawbars (Configuration E) on the grounds of its dynamic stability. Most have also relaxed their national requirements on the manoeuvrability (the turning circle tests) which means no requirements for rear or trailer axles to be steered. Within those, most have simply limited routes to those already capable of handling the larger vehicles. In some cases, there is still quite a wide range of roads accessible. In others, the aim was to limit routes to motorways plus the smallest possible non-motorway “tails” to connect to depots/destinations. Some, notably Sweden and Denmark have invested in the road network to expand the routes on which LHVs can travel (for example, by improving port access roads). Germany is relatively unique in having permitted 25.25m LHVs but required that they meet their existing national manoeuvrability standard (needing steered rear or trailer axles in many cases) and limited vehicles to the existing 40 tonne weight limit (in order to protect an ageing bridge stock). Some countries have asked authorities to identify all the roads on which LHVs can travel to create a pre-determined LHV network. Others have taken a demand led approach where shippers or operators apply for a route where they want to operate LHVs (and contribute to the work required to verify the route as suitable), such that the route network grows over time.

The degree to which countries have trialled solutions before implementation also varies. The Netherlands have progressed through a carefully controlled trial process, starting with very small numbers of vehicles and then growing and expanding over time. The first trials began in 2001, spanned 3 phases and resulted in national implementation of a permit scheme from 2013. However, the evolution process has continued and new work commenced around 2020 with single experimental vehicles to trial going even longer and heavier with two semi-trailers at a total length of up to around 32 metres and 72 tonnes.

By contrast, in Spain, a pilot lasting only around one year was undertaken before the longer vehicles were formally legalised, but with quite substantial route assessment requirements, with the analysis work being carried out largely by the haulage operator.

The demand for using LHVs has varied considerably in different countries. In those that have permitted their use for many decades, they take a major proportion of all freight, for example around three-quarters of tonne kms in Sweden. In those without this long culture of use, the demand has been lower. Both the Netherlands and Spain operate a permit system, where the vehicle operator has to get a permit that designates a particular vehicle as being suitable for use in an LHV combination. In the Netherlands around 1.5% of all registered HGVs have a permit authorising them for use as an LHV, after around 20 years experience (including early trials). In Spain the equivalent figure is around 0.4%. The sectors where demand is seen are quite diverse but forestry, automotive, fast moving consumer goods, shipping containers and palletised goods, particularly on longer hauls are all regularly reported.

Countries that have permitted or trialled LHVs have generally reported that the implementation has been an overall success, although details of policies are also often improved over time. For example, Australia’s Performance Based Standards (PBS) approach has been operated as a permit scheme for longer heavier vehicles, open to any operator (not on a trial basis) for more than 20 years. Authorities there (NTC, 2018) have estimated that the scheme has saved between $8billion and $20billion and 5.9 million tonnes of diesel. In general, the findings on performance, operator take up conditions and safety outcomes are broadly consistent with those of the GB longer semi-trailer trial, just with increased gains because of the larger capacities and a wider range of risks and policies needed to control those risks.

Much more detail on what has been done in different countries can be found in the literature review (Knight, et al., 2022).

3 Policy options

3.1 Approach to developing the options

The terms of reference of this study were to investigate the feasibility of a trial **while maintaining existing standards of safety and infrastructure protection**. It was apparent from the literature review (Knight, et al., 2022) that there are risks to both safety and infrastructure that are presented by LHVs and ALL countries that use them do take measures to control those risks to at least some degree. It is also apparent that there is a very large number of different ways of producing a package of policy measures to control the risks of LHVs. In considering how to develop a manageable set of potential policy options for UK decision makers, we identified four potential approaches or methods, each with their own 'pros and cons'.

Ref	Approach	Pro's	Cons'
A	**Adopt the approach of a chosen country** with similar characteristics.	Very easy to define the trial, using the processes and experience of an existing trial.	Unlikely to deliver applicable enough results due to specifics of GB infrastructure, regulation, and policy.
B	**Create a matrix for every option** permutation, creating 1,000's of potential options.	Ensures all elements of the trial are tailored to GB infrastructure, regulation, and policy.	Very time consuming and costly. Difficult to get started and to maintain momentum.
C	**"Peeling the Onion"** approach, considering the highest-level categorisation of options before systematically reviewing sub-options at several levels of detail.	Considers the key questions, based on gap analyses, and creates themes for development with stakeholder groups.	Requires substantial effort from external stakeholders adding cost and stifling momentum.

Ref	Approach	Pro's	Cons'
D	**"Agent provocateur"** approach where the project team identify a small range of realistic options, based on the literature review and stakeholder engagement and test and refine with key stakeholders.	A much faster route to a manageable set of options for consideration and critique alongside stakeholders.	Given the wide range of possible options, there is a risk that a strong permutation is missed.

Figure 2: Table of potential approaches to trial design.

After a review with DfT and key stakeholders, it was decided that approach D was the most pragmatic and appropriate with the risk of missing a strong permutation seen as low and mitigated through ongoing review with the stakeholder group.

When reviewing the gap analysis and stakeholder outputs, we identified 4 major levers, described in section 2, that act as criteria that would differentiate the policy options:

- **Vehicle Configurations** – The range of permitted weights, heights and trailer types and combinations etc.
- **Vehicle Performance** – The range of permitted manoeuvrability, standards, and technologies etc.
- **Network Access** – The type and level of routes and route restrictions etc., that trials could be applied to.
- **Stages of trial/Degree of Monitoring** – The scale and nature of trial conditions and monitoring.

These levers were applied to a simple trial option matrix allowing us to illustrate and compare the various options, highlighting the extremes of each of the 4 criteria in terms of how permissive or restrictive each element was considered (1 being the most permissive and 5 being the most restrictive). See the table below for details:

Criteria	Permissive means	Scale	Scale	Scale	Scale	Scale	Restrictive means
Vehicle Configurations	60t	1	2	3	4	5	44t

Criteria	Permissive means	Scale	Scale	Scale	Scale	Scale	Restrictive means
Vehicle Performance	Any configuration <=25.25m and meeting existing axle load limits	1	2	3	4	5	Only highly manoeuvrable, highly stable vehicles with SOA ADAS
Network Access	Any road subject to operator risk assessment	1	2	3	4	5	Motorway only plus independently approved 'tails' <XX miles
Stages of trial/Degree of Monitoring	Straight to in service trial, Light touch monitoring	1	2	3	4	5	Single vehicle, into service in stages, maximum telematic monitoring

Figure 3: Trial option matrix.

In the options described below, the number indicates broadly where on the scale of permissive or restrictive each option sits against each of the 4 key criteria. We have also qualitatively reviewed (based on the cumulative results from the 2008 study in the UK (Knight, et al., 2008), the findings of the literature review (Knight, et al., 2022) and experience in the LST trial) the outcomes of each option, considering a low, medium, or high rating for:

- Operator take-up – The likely extent of operator interest in taking part in LHV trials.
- Impact on infrastructure risk – The increase in the existing level of risk that LHV trials represent to the GB road infrastructure, focussed predominantly on bridges but also considering roads, roadside restraints, parking and depots.
- Impact on safety risk – The increase in the existing level of risk that LHV trials represent to GB road safety, including manoeuvrability, field of view, braking, sidewind loading, impact severity and roll and directional stability.
- Policy effort (Gov) – The extent to which current legislation and policy would require change to enable the LHV trials to proceed on GB roads.
- Compliance effort (industry) – The level of compliance activity an operator would need to complete and adhere to, to enable the running of vehicles in an LHV trial.
- Trial cost – The relative cost to set up and manage the trial option.

3.2 Options

DfT have consistently made clear from the terms of reference and throughout the project that there would always be a “Do nothing” option, where no trial takes place.

Three “do something” options were developed to illustrate the different ways of controlling risk during a trial and, because they are themed in this way, they can be considered to represent the boundaries of what might be considered realistic based on the literature review, stakeholder input and experience elsewhere. The aim was to make stakeholder groups consulted think through the processes and provide constructive feedback. This feedback would in turn highlight the key considerations for the preparation and delivery of any trial.

A fourth hybrid option combined other options to give a pragmatic approach to the structure of a trial that is intended to allow achievement of two otherwise competing objectives; (a) getting started as soon as possible even if that is with a restrictive set of vehicles and routes, while (b) enabling expansion to gradually move beyond both those constraints. Of course, it does remain possible for DfT to select elements of different options and derive alternative options if they are considered to better suit their objectives.

3.2.1 Option 0: Do nothing

If this option were selected, then the work would be ceased, and no trial would be run.

It is clear that there are risks to implementing LHVs, that it can take considerable effort to make implementation a success, and that effort implies time and cost. The option to do nothing is, therefore, important. Two of the key areas that can undermine the benefits of LHVs are:

- the availability of sufficient bridges that can take the loading to make enough routes economically viable; and
- the risk of a substantial mode shift from lower carbon forms of transport undermining the environmental benefits.

The evidence identified so far (Knight, et al., 2022) has shown that at least some forms of LHVs produce effects in bridges that fall within the envelope produced by a design load model that was current until relatively recently. Confirmation of the same is still needed for the latest version of the load models and for assessment models. If it is confirmed that they fall within those models too, then they can be considered consistent with existing traffic such that there is no increased risk of deck failure due to vertical loading.

Collision loads on structures are also important and require a formal risk assessment.

The evidence on mode shift (Knight, et al., 2022) remains controversial. In the previous UK study (Knight, et al., 2008) it was estimated that 8-18% of rail tonne kms could transfer to road and, at the time, there were studies suggesting higher levels. This estimate this was based on a combination of feedback from industry and a simple econometric analysis of price elasticities. Similar theoretical studies undertaken since that time have been critical of simple econometric models based on price elasticity, noting that they fail to reflect the real world complexity of modal choice and that the elasticity values used are often not empirically derived. In addition to this, more empirical studies have become possible with greater experience with LHVs, particularly through studies of the trial in the Netherlands. There have also been studies showing the advantages of LHVs within an intermodal transport chain. At least one country implemented restrictions intended to actively prevent mode shift in one key market. However, the detail of trial design to replicate this in the UK has not yet been developed in detail.

If option 0 is implemented now, then the potential emissions reduction and other industry benefits will not be achieved but the evidence available to prove that this is justified will be limited in the above respects. Additional evidence gathering and analytical work has been outlined (see sections 4 and 5) that would be expected to answer some of these questions more definitively before a road trial is implemented. As such, the DfT can choose to undertake that additional work before choosing to implement a trial on the basis of any of the “do something” options listed below. The implications of choosing to do nothing once that work is complete risks only the additional investment in the extra research. So, a ‘do something’ option could be selected now, while retaining the ‘do nothing’ option at minimal risk until the extra analyses are complete.

The “do nothing” option does of course minimise the effort and cost from a policy and compliance perspective and maintains the current level of safety and infrastructure risk. However, it also misses the opportunity to test and measure the potentially significant benefits of LHV’s, particularly decarbonisation, both in terms of the reduction in per tonne km and as a potential enabler in the hybridisation of HGV combinations if, for example, the trial were set to encourage the use of electrified dollies or link trailers.

3.2.2 Option 1: Route Based Risk Control

Summary

If Option 1 were selected, it would permit the widest range of vehicle configurations (illustrated by **X** on the table below) but would aim to control the risks primarily through limiting access to only the appropriate roads. To limit the time and cost associated with route assessment and approval, then only routes that the 'worst case' configuration could navigate would be approved, so that each approval needs to be done with only one set of vehicle characteristics. This results simpler approvals processes, but a more limited route network. It would require robust compliance monitoring and a common database of approved routes. Time to trial start would be moderate.

Criteria	Permissive means	Scale	Scale	Scale	Scale	Scale	Restrictive means
Vehicle Configurations	60t	**X**	2	3	4	5	44t

Vehicle Performance	Any configuration <=25.25m and meeting existing axle load limits	**X**	2	3	4	5	Only highly manoeuvrable, highly stable vehicles with SOA ADAS
Network Access	Any road subject to operator risk assessment	1	2	**X**	4	5	Motorway only plus independently approved 'tails' <XX miles
Stages of trial/Degree of Monitoring	Straight to in service trial, Light touch monitoring	1	2	**X**	4	5	Single vehicle, into service in stages, maximum telematic monitoring

Figure 4: Option 1 matrix.

Characteristics

Vehicle Configurations – The range of weights, heights and trailer types and combinations etc. that would be permitted:

- Core configurations A to E (Figure 1) at a maximum mass up to 60t and length up to 25.25m, simultaneously, on a minimum of 8 axles in vehicle configurations.
- Variants identified in section 1.3:
  - Minor variations, e.g., 60 tonne B-double at 23.9m optimised for different load units.
  - Vehicles for low density goods, for example, longer but not maximum weight (e.g., 25.25m at 50t; 19.4m at 44t).
  - Vehicles for high density goods, for example, heavier (60t) but not max length (e.g., 16.5m at 48t or 19m at 60t)
  - Aero Allowance: aerodynamic cab shapes and tail fins are excluded from consideration within the 25.25m length.
  - Mass allowance for vehicles with low or zero tailpipe emissions: the additional 2 tonnes GVW for zero emission vehicles is not permitted
- Special restrictions (load/operation): None.

Vehicle Performance – The range of requirements for manoeuvrability, standards and technologies etc:

- No turning circle requirement – only routes capable of supporting reduced manoeuvrability (worst case) will be approved.
- Braking / stability – mandatory Antilock Braking System (ABS), Electronic Stability Control (ESC), and Advanced Emergency Braking (AEB) (i.e., modern motive power units only).
- No requirement on minimum vehicle power (acceleration).
- Existing axle load limits applied (note actual average loads at max GVW may be slightly higher than at 44t on 6 axles).
- Each operator would require approval via a vehicle special order (VSO) covering all motive units, trailers and dollies that may be used in an LHV combination.

Network Access – The extent to which trial vehicles can access the network and the processes used to determine that access.

Demand (operator) led route by route application with approval based on set criteria covering safety, structures, accessibility, parking and competition with rail, based on the worst-case vehicle configuration such that each route only needs approval once (unless infrastructure conditions change, in which case approval can be revoked). An individual operator may apply for use of a route, via the ESDAL process or similar (ESDAL is a system used to permit the movement of abnormal indivisible loads), but approval by roads authorities would be granted to all operators such that it generates an expanding database of approved routes. Such a database does not currently exist, and an organisation would need to be designated to host and maintain it. In functional terms this would not need to be a particularly complex database and is one that could be maintained at relatively low cost by the research team, at least during early parts of the trial phase. Ultimately a robust, and secure "production standard" version would be required if the numbers increased and the system moved toward business as usual.

Stages of trial/Degree of Monitoring – The scale and nature of regulation and monitoring of regulation.

- A system of monitoring weight and route compliance using data from on-board weighing devices and GPS, recorded by operators using standard in-cab telematics devices already used by most operators, with data access granted to an independent body for verifying compliance. This would be similar to the "intelligent access" concept successfully deployed in Australia for around 14 years.
- Special requirements for measuring mode shift effects where a calculation following principles adapted from the Mode Shift Benefits method employed by DfT shows that a competitor intermodal route would emit less CO_2 than the proposed LHV route for the same quantities of freight.

Expected Outcomes

Outcome	Impact	Rationale
Operator take-up	Medium	Simple and easy to understand for industry, high uptake on permitted routes but network may be limited.
Impact on infrastructure risk	Low	Available network could be very limited by bridge constraints if worst case 16.5m & 60t LHV’s in scope.
Impact on safety risk	Low	The very limited number of routes would control the impact.
Policy effort (Gov)	Low	Very limited number of routes and operators applying for routes.
Compliance effort (industry)	Medium	The operator is required to apply for routes and set up independent monitoring.
Trial cost	Low	The number and size of trials would be very limited.

3.2.3 Option 2: Vehicle Based Risk Control

Summary

Criteria	Permissive means	Scale	Scale	Scale	Scale	Scale	Restrictive means
Vehicle Configurations	60t	1	**X**	3	4	5	44t
Vehicle Performance	Any configuration <=25.25m and meeting existing axle load limits	1	2	3	4	**X**	Only highly manoeuvrable, highly stable vehicles with SOA ADAS
Network Access	Any road subject to operator risk assessment	1	2	**X**	4	5	Motorway only plus independently approved 'tails' <XX miles

Criteria	Permissive means	Scale	Scale	Scale	Scale	Scale	Restrictive means
Stages of trial/Degree of Monitoring	Straight to in service trial, Light touch monitoring	1	2	**X**	4	5	Single vehicle, into service in stages, maximum telematic monitoring

Option 2 permits only the most stable and manoeuvrable vehicle configuration, in combination with multiple additional vehicle or operational restrictions to minimise risks. The process of determining network access is the same as Option 1 but the 'worst case' vehicle is much better performing, so more routes should be available. There would be reduced risk if non-compliance occurs, which allows for slightly less restrictive monitoring of the trial and simplifies the work needed in advance, such that this produces the shortest time to commercial trial.

Figure 5: Option 2 matrix.

Characteristics

Vehicle Configurations – The range of weights, heights and trailer types and combinations etc:

- Core configuration B only (Figure 1) at maximum mass of 60t and a length of 25.25m, simultaneously, on a minimum of 8 axles. (If it is subsequently demonstrated that this does not fall within existing bridge load models this could be reduced to a level that does fall within those limits.)
- Variants:
  - Minor variations: Yes, if proven not to exceed bridge load models
  - Vehicles for low density goods: Yes, provided over full 25.25m length
  - Vehicles for high density goods: No
  - Aero Allowance: No.
  - Mass allowance for Electric Vehicle: No.
  - Special restrictions (load/operation): No Dangerous Loads, no routes approved where the same quantity of freight could be moved between the same origin and destination with lower emissions via another transport mode.

Vehicle Performance – The range of manoeuvrability, standards, and technologies etc:

- Must comply with existing turning circle requirement.

- Braking / Stability – mandatory ABS, ESC, AEB* (i.e., modern motive power units only).
- Include requirement on minimum vehicle power per tonne and proportion of mass on drive axle (accel/traction).
- Existing max axle load requirements apply.
- Set vehicle speed limiter to 80 km/h not 90 km/h. This would mean that the kinetic energy of a 60 tonne LHV at maximum speed (80) was similar to that of a standard 44 tonne HGV at maximum speed (90), which may mitigate some concerns around severity in the event of a collision. Some existing HGV operators already implement similar measures as a voluntary means of reducing fuel consumption because of reduced aerodynamic drag.

Network Access – The extent to which trial vehicles can access the network and the processes used to determine that access.

- Demand (operator) led route by route application with approval based on set criteria covering safety, structures, accessibility, parking and competition with rail. With approval by roads authorities to an individual operator, via ESDAL process or similar and with an expanding database of approved routes.

Stages of trial/Degree of Monitoring – The scale and nature of regulation and monitoring of regulation.

- Self-assessed ‘intelligent access’ telematics-based monitoring of weight and route compliance, with records available to regulatory authorities on request.

<u>Outcomes</u>

Outcome	Impact	Rationale
Operator take-up	Medium	Limited uptake on available routes (e.g., rear loading & other restrictions) but more routes available.
Impact on infrastructure risk	Low	The use of one vehicle combination with the lowest impact would limit risks.
Impact on safety risk	Low	The use of the lowest risk vehicle combination would control the impact.
Policy effort (Gov)	Low	Standards and route assessments need consider only one set of vehicle characteristics.
Compliance effort (industry)	Medium	The operator is required to apply for routes and self-monitor telematics data.
Trial cost	Low	The number and size of trials would be very limited.

3.2.4 Option 3: Rules Based Risk Control

Summary

This option maximises the potential use cases of LHVs by permitting the widest possible range of vehicle configurations and allowing full optimisation of those configurations for both the economics of operation and the safety and infrastructure protection on the routes they need to travel on. Given the extent to which this pushes the current operational envelope, robust compliance monitoring is vital. The rules required to achieve this maximisation and optimisation safely are inevitably more complex to develop meaning that substantial time would be required before a trial could be commenced. Once developed, the rules make it very easy for regulators to accommodate new innovations, but industry must go to increased effort to prove their vehicle complies and route approvals may be more complex. This may slow initial uptake.

Criteria	Permissive means	Scale	Scale	Scale	Scale	Scale	Restrictive means
Vehicle Configurations	60t	**X**	2	3	4	5	44t
Vehicle Performance	Any configuration <=25.25m and meeting existing axle load limits	1	**X**	3	4	5	Only highly manoeuvrable, highly stable vehicles with SOA ADAS
Network Access	Any road subject to operator risk assessment	1	2	**X**	4	5	Motorway only plus independently approved 'tails' <XX miles
Stages of trial/Degree of Monitoring	Straight to in service trial, Light touch monitoring	1	2	3	**X**	5	Single vehicle, into service in stages, maximum telematic monitoring

Figure 6: Option 3 matrix.

Characteristics

Vehicle Configurations – The range of weights, heights and trailer types and combinations etc:

- Core configurations: A-E and any others up to 60t and length up to 25.25m,
- Variants:

- Minor difference for optimisation with load units: Yes
- Vehicles for low density loads: Yes
- Vehicles for high density loads: Yes
- Aerodynamics Allowance: Yes.
- Mass allowance for Electric Vehicle: Yes.
- Special restrictions (load/operation): At discretion of road authority granting access.

Vehicle Performance – The range of manoeuvrability, standards, and technologies etc:

- Vehicles must meet a comprehensive set of performance-based standards (PBS) for safety and infrastructure protection, set at multiple levels designed to match equivalent levels of infrastructure capability.

Network Access – The extent to which trial vehicles can access the network and the processes used to determine that access.

- Demand (operator) led route by route application with approval based on set criteria covering safety, structures, accessibility, parking and competition with rail that categorises routes into multiple levels, showing they are capable of supporting vehicles at different PBS levels.
- Road's authorities can authorise all vehicles at PBS Level x or better, authorise only operators meeting compliance conditions, place special conditions such as time of day, special speed limits, reporting requirements etc., to allow as many high-capacity movements as possible while maintaining safety and protecting infrastructure.

Stages of trial/Degree of Monitoring – The scale and nature of regulation and monitoring of regulation.

- Independently coordinated intelligent access monitoring of actual vs approved route with bespoke additions for special conditions, applied by infrastructure owners.
- Special requirements for measuring mode shift effects where a calculation following principles adapted from the Mode Shift Benefits method employed by DfT shows that a competitor intermodal route would emit less CO_2 than the proposed LHV route for the same quantities of freight.

Outcomes

Outcome	Impact	Rationale
Operator take-up	High	Ultimate flexibility, likely to promote maximum uptake in long term, despite increasing compliance effort for industry.

Outcome	Impact	Rationale
Impact on infrastructure risk	Low	Access will only be given to operators on approval, based on a route risk assessment.
Impact on safety risk	Low	A permit will only be given based on approval of both vehicle combination and operator.
Policy effort (Gov)	High	Processing and evaluation of PBS standards and implementation of an intelligent access monitoring system.
Compliance effort (industry)	High	Significant proof required to prove compliance conditions.
Trial cost	High	Development of an intelligent access monitoring system and testing across all vehicles at PBS level.

3.2.5 Option 4: Hybrid of Option 2 and Option 3

On the assumption that risks in respect of modal shift should be measured, or can be controlled, then the evidence suggests very positive benefits of LHVs, particularly for transport costs and decarbonisation. Where something is strongly beneficial, two obvious objectives become to implement the measure as quickly as possible and to maximise the take up of the option and the ultimate impact. Option 2 sought the fastest route to achieving commercial impact by seeking a path of least resistance and choosing technical variations that minimised the risks in all the areas stakeholders and literature has suggested there are concerns about. This means limiting the choice of vehicle configuration to just one of the 5 main options (a B-double proven to be the most stable combination), adding strict requirements on vehicle manoeuvrability and safety equipment to suit GB conditions, limiting the permitted routes accordingly and implementing the trial in very controlled circumstances.

However, ultimately some of those restrictions may prevent some sectors of the road freight industry from benefitting from the measures (e.g. Interlink trailers cannot easily be unloaded from the rear), will add costs and may not be necessary for all operations. While it is likely to be the best option for minimising the time to reach market, it may fail to work well at maximising the long term benefit.

Option 3 aims to produce an innovative and flexible system of rules based risk control modelled on the performance based standards employed successfully in other parts of the world, notably Australia. This system is designed to encourage innovation in the freight sector so that every operation can maximise its efficiency where the economics justify the investment in configuring non-standard vehicle combinations. This option would be highly likely to maximise the possible long term benefit of introducing LHVs. However, to achieve this requires a radical change in the way the industry thinks about vehicles and a set of performance standards that all stakeholders can be confident are a robust replacement for the more prescriptive design rules applied in option 1 and 2. Developing these rules and gaining the confidence of stakeholders and generating that mental shift in approach takes time. As such what may be the best option for the ultimate long term benefit, might also be the worst option for minimising the time to reach market.

Option 4 is a hybrid of option 2 and option 3 that aims to achieve the best of both. It can be thought of simply as implementing BOTH option 2 and option 3 simultaneously in two parallel but inter-related work streams. At the same time as quickly defining a simple, restrictive standard to rapidly permit high specification B-doubles on selected relatively safe and productive routes, another team begins the longer term work to develop the more complicated but flexible set of performance based standards required for option 3. In reality, it is likely that the option would not prove to be a simple sum of options 2 and 3 because the option 2 vehicles would be on the road and gaining experience before the rules approach for option 3 was fully developed. As such, the development of those rules would benefit from experienced gained with the lowest risk vehicles and may allow a performance based standards scheme that is much more tailored to GB demand and conditions than it would otherwise be when developed under option 3 as more of a desktop exercise.

In fact, it is possible that the more complicated and flexible performance based standards approach implied by the option 3 element may never be embodied in a routine law permitting LHVs after a lengthy trial. It is possible that use of it during the trial may identify a smaller range of GB optimised use cases and it may be that GB operators see less demand for further innovation. If so, those use cases can subsequently embedded in a more traditional prescriptive regulatory approach.

4 Key questions, evidence, rationale, and next step

The key questions considered in this section are those that the literature review (Knight, et al., 2022) or the stakeholder engagement (Brand & Smallwood, 2022) has suggested are the most important. It is not an exhaustive list of considerations. The evidence from experience in other countries, literature review, stakeholder engagement and, in some cases, project team analysis, is briefly summarised and then the reasoning and rationale that led the project team from the evidence to aspects of the illustrative policy options proposed are explained. Finally, in each question, the additional pre-road trial work that would be required if the Government decides to pursue one of the 'do something' options, is outlined. It should be noted that the project team consider that the "do nothing" option can be retained with minimal consequences until such time as industry needs to start investing significant sums in specialist equipment to actively implement a trial route. At that time, industry need confidence that their investment will be worthwhile, with a reasonable chance of generating a positive return.

4.1 Is there sufficient GB demand to justify a trial?

This is a key question because if the shippers of goods and the organisations carrying the goods do not see a benefit, then the rest of the study is irrelevant.

Evidence summary

Experience in other countries shows that where LHVs have been part of the landscape for many decades, usage is high. Unfortunately, the source literature identifying usage does not always use consistent definitions and terminology that complicates comparisons. For example, it was reported that around 74% of tonne kms in Sweden is undertaken in vehicles with a GVW >44 tonnes or with 7 or more axles. However, in countries that began trialling or permitting the vehicles more recently, the usage is much lower. In the Netherlands around 1.5% of HGVs are authorised as LHVs 20 years after they were first trialled. In Spain less than 0.5% of HGVs are LHV authorised after around 5 years of legalisation and similarly low levels are reported in Germany and Belgium. This evidence, combined with the very gradual build-up of LSTs to the initial 2,000 permitted in the GB trial, strongly suggests that demand in GB would be likely to start modestly and grow over time. This is quite different to what happened when the maximum mass of standard-length articulated vehicles was increased from 38 tonnes to 44 tonnes. In that case the 44-tonne option became the dominant vehicle within a very short time, but the only significant difference then was the need for one additional axle, with no other operational changes needed.

Quantitative data from a survey of freight operators involved in the LST trial (75 responses from companies of mixed size and operational type) suggested around three quarters of those who responded were interested in operating LHVs, but cannot be treated as a nationally representative sample, because their involvement in the LST trial already selects them as those that can, and are willing to invest in order, to benefit from increased capacity.

(The survey was limited to LST operators at this stage as a larger scale survey would not have been possible in the time and resources available for this feasibility study, whereas the LST operator community was easily accessible to the project team)

Qualitative feedback from industry associations also supports the view that there will be strong interest, and although a detailed survey of their members could not be completed in the time frame of this initial review, a second wave of the survey across the members of both RHA and Logistics UK is running in July-August, to improve the representativeness of the survey results available to any second stage of this work. (The Transport Association has sent the survey link to their members, but there have been few responses).

The industry stakeholder feedback we do have also highlights that the vehicles will not be suitable for every depot, every delivery or collection destination or every road and that only where there are large quantities of goods being transported on the same routes will there be advantages. Data from the survey of LST operators is consistent with international experience of usage which shows broad interest across the core configurations, except for a lower interest in the rigid and double drawbar (vehicle E). The B-Double was among the most popular in the short term and increased in popularity when viewed over the longer term. Most operators saw applications in longer hauls but some also saw applications in very short hauls (e.g., continuous delivery of bulk goods from ports to nearby warehouses or industrial sites in the hinterland). Most operators saw benefits in distribution centre to distribution centre work and palletised transport. These are very much the same conditions as seen in the LST trial, being use cases where there is consistent, high load space utilisation and good site access at both ends of the route.

Although some industry stakeholders believed LHVs could be generally permitted with minimum legal constraints, relying on the industry to manage risks appropriately, most generally accepted that the significant change in characteristics and the need to maintain the confidence of the public would lead to application of more restrictive rules, particularly in terms of where the vehicles could go, driver training and some level of monitoring.

Influence on policy options

The existence of at least some demand from a range of operators already involved in the LST trial, meant that it was worth creating ‘do something’ options. The approach internationally and the general acceptance by GB industry that there were additional risks and a need to both be safe, and to be seen to be safe, meant that it was not considered necessary to consider any highly permissive policy options. Each option presented is, therefore, restrictive in at least one sense. The relative popularity of the B-Double combined with the likely post Brexit ability to deviate (in national transport) from the requirements of Directive 96/53/EU, meant that it was viable to offer an option whereby complexity and risks were managed by a restrictive approach to the type and characteristics of vehicle permitted. Similar freedoms may make it easier to consider the most flexible approach of managing the risks with performance-based standards.

Additional work needed before road trials

Essential for any 'do something' option

In order to provide a more representative estimate of the level of GB demand, an extension of the freight operators survey is required, to include members from industry organisations such as RHA, Logistics UK and CILT. The fieldwork for this is already underway with the existing survey being sent to members of these trade associations in June-July, so that the results can be merged with those from the LST operators and analysed, once DfT have determined what, if any, next steps are to be taken in this work. However, it is also necessary to move from the establishment of the existence of some demand, to quantifying that demand, and from generalisations about where LHVs will be used to specific identification of use cases where there are strong benefits for both industry and Government. Confirmation is needed that operators are willing to apply for routes, vehicle manufacturers can supply the specialist equipment and that the specific road authorities affected are prepared to invest the effort in assessing route risks and developing approval procedures. This will involve significant stakeholder engagement and possibly the use of formal expressions of interest to solicit interest from industry, with objective criteria to justify the selection or rejection of early applicants for the first stage of a trial.

Conditional on policy decision

The identification of use cases from within the population of 'variants' where there is sufficient economic benefit for the applicant to consider the use of a 'performance-based standards' approach to approving the vehicle.

4.2 What emissions effects are expected?

Evidence summary

One of the main aims of a trial in GB would be to reliably quantify the emissions reduction potential in terms of: greenhouse gases (GHGs) such as CO_2 or Methane, and contributors to poor air quality such as Nitrogen Oxides, NOx, and particulate matter PM) of LHVs specifically in a UK context. However, the literature reviewed was very clear on the principles that have been found in other countries and would be expected here.

Per vehicle km, the energy used (and hence fuel used, and carbon emitted) by LHVs would be more than standard HGVs. However, the additional carrying capacity of LHVs, even used imperfectly such that utilisation was similar to standard HGVs, was such that per tonne km (or m^3km for loads constrained by the available payload volume rather than the available mass) a significant reduction in emissions was found. Studies present this in different ways and measurements and estimates varied considerably. However, the expectation was typically in the range of 6% to 28% depending on the exact size of vehicle, country and utilisation situations covered. The low end of this range is consistent with observations of the GB trial of LSTs where an average benefit of around 8% was observed, with the best performing operations (100% full on all trips) saving 13-14%, with an absolute saving of 60,000 tonnes of CO2 and 92 tonnes of NOX on the trial to the end of 2020. (Evaluation of the Longer Semi-Trailer Trial: Annual Report 2020 Update - Risk Solutions June 2021 https://www.gov.uk/government/publications/longer-semi-trailer-trial-evaluation-annual-report-2020).

Although the magnitude of the effect was variable depending on the capacities of the larger vehicles assessed, the accessible road network and other localised features of the freight market, the effect was always a significant reduction in emissions per unit of freight moved. The only factor that has been identified in the literature that has the potential to increase emissions is the possibility of a substantial shift in freight from less energy or carbon intensive modes. The prior UK study (Knight, et al., 2008) is one example of this where it was found that the emissions benefit from 25.25m, 60t LHVs (with a Euro 5 engine) was a reduction of around 13% at typical loads. However, this would be eliminated if 11% of the tonne kms carried by rail freight was shifted to road as a consequence of road transport being more cost competitive. This is issue is discussed in detail in section 0

Several studies in the literature review (Knight, et al., 2022) and some stakeholder input (Brand & Smallwood, 2022) considered the interaction of the electrification of goods vehicles and permission of LHVs. At one end of the scale, some stakeholders questioned the value of LHVs over the medium term as standard HGVs became electrified. The concern was that the standard HGV would eliminate air quality pollutants and emit lower GHGs than the LHV because the higher mass of the LHV would make it harder to electrify. However, the literature showed that Scania are already marketing a battery electric HGV for use in a 74 tonne longer combination in Sweden, fuel cell electric HGVs at the heaviest duty levels are under development, and that UK trials of overhead catenaries as a power source for HGVs could also electrify LHVs. When an electric HGV at standard weight and length is compared to an electric LHV, then the efficiency improvement means less electricity is used per unit of freight moved. Given that the UK grid remains a long way from zero carbon, then using less electricity for freight transport will mean that fewer wind turbines, solar panels etc will be required to achieve a zero carbon grid, thus minimising the time and cost to achieve it.

Input from stakeholders suggested that one of the major perceived advantages of LHVs in emissions terms was the fact it was purely mechanical, and it could be implemented almost immediately (similar to the thinking for LSTs). It would also improve the efficiency of the newer parts of the existing fleet, not just brand new vehicles entering the marked. This compares to electrification strategies that still require much technical development in vehicles, charging technology and the grid, which takes time. Electric vehicles will also only penetrate the fleet slowly as old vehicles are replaced with new. Thus, LHVs can have a much earlier impact on emissions reduction.

Of course, the magnitude of any emissions reduction effect will also depend on how much of existing road freight movement moves from a standard HGV to an LHV (the level of demand).

Influence on the policy options

The potential for LHVs to make a step improvement in the emissions from road freight (in the absence of excessive mode shift) led to freight industry stakeholders suggesting the benefits should be exploited by maximising the increase in capacity and the routes that can be used and implementing a trial as quickly as possible. To reflect this aspiration, all of the proposed 'do something' policy options include the ability to operate at the full 25.25m and 60 tonnes considered as the scope of the work, subject to confirmation of findings on bridges (see section 4.3 and 4.5). The desire to see fast progression to a trial has possible trade-offs with the need to ensure infrastructure protection and safety and the desire to have an LHV option for as many routes as possible. This trade-off, and a means to break it, has been represented in the range of policy options presented.

Additional work needed before road trials

<u>Essential for any 'do something' option</u>

The key aim of the trial will be to quantify the efficiency improvement and hence emissions reduction potential in the UK, so it is essential that a robust mechanism for measuring the achievements is developed. As a minimum this should be based on the methods used in the LST trial, which required operators involved in the trial to report three types of data to the DfT: company information; qualitative information; and LST operational data.

Company information was submitted once only, when the operator entered the trial (when their first VSO was granted). This includes some basic information about the size and nature of the operator's business and a set of summary figures about their non-LST semi-trailer fleet.

Qualitative information is submitted when the operator enters the trial and then optionally at later times. This is a set of open questions about the experience of the company, its staff and clients in operating the new trailers. The questions varied as the trial developed.

LST operational data was submitted every data period and covers all LST operations in that period. This was the primary trial data and included an aggregated journey log of all LST journeys on the public road network in the period. The log included details of locations and times, the nature of the journey, load and mode of appearance (MOA) types, load weight and two measures of utilisation. A set of trailer reference information relating trailer IDs to their vehicle identification number (VIN), basic design details and numbers of days 'off the road' in the period. An incident log covering all LST incidents on the public highway and certain types of incident on private property (e.g. in depots, at client sites).

As a minimum, this set of data would require adaptation to the different vehicle configurations. Most configurations use one element of non-standard equipment in the form of either a convertor dolly or an interlink semi-trailer (for B-doubles) which could be the tracked element instead of the longer semi-trailer. However, a configuration where a normal tractor semi-trailer combination tows a drawbar trailer does not include any specialised element such that a form of identifying when an LHV combination is used may be required.

In line with variation in the policy options, this could be self-assessed and reported by the operator or monitored by a government body or an independent 3rd party.

Conditional on policy decisions

More demanding monitoring options could also include monitoring of the standard HGVs replaced, at least in early stages of the trial to verify the approach. This would allow much better assessment of the counterfactual (what would have occurred if the LHVs had not been used). Automated electronic measurement of a range of parameters is also possible to provide much closer control and assessment of compliance with trial conditions. This would be implemented through standard, or mildly modified, telematics approaches already employed by many operators. Parameters measured could include geographic location (assessing route compliance, enabling safety and environmental comparisons that take differences in road types used to be accounted for), time of day, speed, driver behaviour (braking/acceleration profiles), activation of safety equipment (e.g. collision warnings, AEB or roll stability controls as possible proxies for safety performance assuming likely low collision numbers), or even weight compliance if on-board weighing systems were required (e.g. to provide confidence to bridge owners that it was safe to permit LHVs).

At least in pilot cases, it may be possible to go further and to use video and/or research-quality sensors to detect other possible safety proxies such as headway to the vehicle in front, relative motion of other vehicles around the LHV and degree of roadspace utilisation during cornering manoeuvres to consider route safety and accessibility questions. Similar techniques were used successfully in the recent HelmUK trial but can imply significant cost and analytical burdens.

If it is considered beneficial to try to promote electrified LHVs in the trial, then further studies of how e-dollies and trailers could be approved for use in the trial and integrated with existing vehicles would be beneficial. Consideration could also be given to incorporating an LHV in the existing trials of catenary powered HGVs and fuel cell vehicles. Battery Electric Vehicles are not considered to need additional research given that production models are technically available so that operators would be free to use one if it were viable.

In line with variation in the policy options, this could be self-assessed and reported by the operator or monitored by a government body or an independent 3rd party. At the maximal end of the range, it could also include monitoring of the standard HGVs replaced, at least in early stages of the trial to verify the approach.

Conditional on policy decisions

If it is considered beneficial to try to promote electrified LHVs in the trial, then further studies of how e-dollies and trailers could be approved for use in the trial and integrated with existing vehicles would be beneficial. Consideration could also be given to incorporating an LHV in the existing trials of catenary powered HGVs and fuel cell vehicles. Battery Electric Vehicles are not considered to need additional research given that production models are technically available so that operators would be free to use one if it were viable.

4.3 Can highway structures sustain the vertical loads imposed?

LHVs will only be able to pass over structures that are capable of sustaining the loads. If the effects they induce in structures exceed those of the load models designed around existing 44 tonne vehicles, then in the absence of a bridge upgrade programme, the navigable route network will be severely restricted, limiting the benefit.

Evidence summary

In general terms, the highway structures referred to here are bridges. However, it also includes structures that are very similar but may not be recognisable to road users as a bridge, such as culverts. Damage or collapse of a bridge deck due to loading in excess of capacity would have very significant safety, social and economic implications. Although the literature reviewing the use of LHVs in other countries suggests that LHVs can be used safely on existing bridge stock, this is not an area where international experience can simply be transferred. Each countries' bridge stock is unique and, until relatively recently, there has been little harmonisation in design standards. One of the main reasons that Germany has limited their usage of 25.25m EMS vehicles to existing weight limits (40 tonnes, or 44 tonnes in intermodal traffic) is concern over their bridges. Bridges have been one of the primary concerns of road owners consulted in this project.

WSP's own appraisal and stakeholder input from key road owners has shown the critical factor is whether the LHVs considered would create more or less bending moments and shear forces in bridge decks (known as load effects) than the load models that are embedded in modern design and assessment standards for bridges. If the load effect (e.g., shear forces, bending moments) that an LHV creates within a structure, falls within the envelope that would be produced from the load models used in both bridge design standards and assessment standards, then their effect could be considered consistent with normal (existing) traffic. LHVs could then be considered not to pose an increased risk of structural collapse as a result of vertical loading.

If the load effects from the LHVs fall outside of the envelopes produced by design and assessment load models, then further work would be needed to identify which bridges have been designed or assessed for more abnormal traffic or have adequate reserves of capacity to accommodate load effects in excess of those from normal traffic. For some structures, the maximum capacity is governed by a fatigue limit (the cumulative effect caused by multiple passes over the structure rather than the collapse risk from a single pass). The effect of the introduction of LHVs on the fatigue life of structures would need to be considered in these cases.

The literature review (Knight, et al., 2022) highlighted in the simplest terms, that LHVs were longer than some very short structures, particularly culverts for example. In these short span structures, the dominant influence is, therefore, the axle load or the load from a group of closely spaced axles. Based on the fundamental scope limitation of this research, the maximum load on individual axles, tandem or tridem bogies will not increase in comparison to existing 44 tonne vehicles. On longer spans, when a vehicle is travelling on its own, i.e., not in convoy, the total weight of the vehicle in relation to the vehicle length governs the behaviour. For the same total load and span length, a vehicle with its axles packed closely together (short wheelbase) will induce higher bending moments than a vehicle with the same number of axles spread over a longer wheelbase.

Overloading of either individual axles or vehicles as a whole has been highlighted by literature as a significant risk for bridges, so compliance with agreed weight limits is also a concern. An allowance is made for overloading in both design and assessment load models for normal traffic, and so overload of vehicles is considered in the comparison of load effects from LHVs and normal traffic load models.

The literature review (Knight, et al., 2022) identified several different standards for bridges in the UK. Design standards (including BD37 and EuroCode) specify the loading that bridges should be built for. Assessment standards (including BD21 and CS454) are used to monitor the condition of existing bridges on the network.

The review showed that each core configuration of LHV at the maximum 25.25m length and 60 tonne weight (with 8 axles and existing axle load limits) induces load effects in structures that fall within the envelope of the design load model from BD37. In simple terms, this implies that LHVs can be considered equivalent to normal traffic when it comes to bridge loading. However, the reality is that there are important complexities that must be considered given the potential consequences of making the wrong choice.

For normal traffic, BD37 requires application of a uniformly distributed load (UDL) and a knife edge load (KEL), which is referred to as HA loading. BD37 was current at the time of the reported analysis (2008). However, the load effects from the LHVs were not compared to the HA assessment load model from BD 21, which was similar to that from BD 37, but imposed slightly less load due to the removal of an allowance for future load increase. A bridge designed to BD37 will periodically be assessed during its life in accordance with BD 21/01. The lower load in BD21 means that the bridge that was designed to BD 37 can deteriorate in service but still pass its assessment. So, it is important that the load effects of LHVs also fall within the envelopes defined by assessment model.

Since 2008, new design and assessment codes have been introduced. The Eurocode load model for design consists of tandem systems and a UDL. CS454, the current assessment standard, has 2 load models for normal traffic: ‘ALL, model 1’ which involves applying a reference vehicle to a structure, on its own or travelling in a convoy; ‘ALL, model 2’ is identical to the HA load model from BS 21 described above. The assessor can choose which load model to use. “ALL, model 2” which was derived based on deterministic analysis using a mix of traffic and a statistically representative distribution of vehicles, is typically used for long loaded lengths, as it is deemed unlikely that long spans will have convoys of vehicles at their maximum laden weight, travelling over them nose to tail (as is implied in convoy scenario in ALL, model 1).

Road owners have expressed concern about the effect on longer span bridges of multiple LHVs travelling nose to tail in traffic. As such, a key question is whether LHVs (at full load) will be more or less likely to travel in convoy than the 44 tonne vehicles they are replacing. If they are more likely, then the statistical distribution assumed in load model 2 may no longer be adequate and convoys of traffic should be compared against assessment and design load models, including, if deemed necessary by road owners, consideration of lateral bunching of vehicles at their speed limit.

Previous analyses have suggested that 60 tonne LHVs would impose acceptable loads on bridges designed for 44 tonnes. However, the fact that this did not explicitly consider deterioration in service and assessment models and that the standards themselves have changed since that time, leaves significant uncertainty about the number of bridges in service that would currently have the assessed capacity to accommodate LHVs without increased risk of damage or collapse. This is particularly true if vehicles are more likely to travel in convoy than the 44-tonne traffic they replace.

Engagement with road owners suggested that analyses of parallel DfT proposals to consider 48 tonne vehicles at existing 16.5m length (only in intermodal transport) had shown that the effects from these vehicles would fall outside of current assessment load models. The scope of this work was for LHVs of **up to** 60 tonnes and 25.25m which could be considered to include a vehicle of 60 tonnes at a length of 16.5m. The input from stakeholders suggests that this would fall further outside of the load models, and such arrangements would clearly not be consistent with the loading from normal traffic.

No work was identified that had explicitly examined the loading in comparison to UK load models for all of the variety of different vehicle permutations (core configurations and variants) that could potentially fall within the scope definition of a future trial as defined by the proposed policy options. However, reference was identified to other countries (e.g., USA, Australia) where a simplified bridge formulae had been developed and, in fact, a very basic version of this concept is also used in the Special Types General Order (STGO) regulations in the UK. One research team had investigated the possibility of using such a formula to identify LHVs that could be permitted in cross border traffic within the EU but had found the additional complexity of the many variations of the loading standards in different countries hampered efforts and meant that significant additional work was required. The basic concept of this approach is to develop a formula based on key vehicle parameters such as axle weight, number of axles, wheelbase, or overall length that determines the maximum GVW that can be carried by that vehicle while still being acceptable on bridges. These formulae are designed such that they are a conservative approach that never permits a vehicle that would overload the bridge, accepting that in some circumstances the GVW imposed may be significantly less than specific bridges could tolerate if a full analysis with specific vehicles was undertaken. Their advantage is that, once developed, the process of approving vehicles/routes for bridge loads becomes very easy and low cost for all involved.

Influence on the policy options

For any LHV that imparts load effects falling outside those of design and assessment load models, the capacity of bridges to take the vertical loading is expected to be a very significant constraint on the route availability because it is considered extremely unlikely that bridges will be upgraded based only on the need for a defined trial. The severity of safety risk or cost implications if a bridge failed or major repairs or upgrades were required is one of the key reasons why option 0 (do nothing, do not implement a trial) has been retained from the start.

Where the load effects of LHVs are outside those of the design or assessment load models, very careful approval of routes will be needed. This could incur significant time, effort and cost. Some road owners have suggested that a programme of bridge evaluation comparable to that undertaken before introducing 44 tonne weight limits could be required and the previous review reportedly took 12 years. Avoiding such a programme was a significant factor in the recommendation to undertake additional research to assess the relevant vehicles against the assessment codes and new standards. If it is found that there is a problem, it may be that alternatives, such as a reduced GVW could be considered as an alternative to bridge assessment and upgrade. That is, undertake further analysis to assess what is the maximum GVW at which such an exercise is not necessary.

Even where the load effects from LHVs do fall within those produced by the standard load models, there will be bridges unsuitable for 44 tonnes (particularly away from the trunk road network) that will constrain the available routes, although in those cases they should be signed and drivers/operators of 44 tonne vehicles well used to avoiding them.

Some countries have defined a whole permitted route network ahead of permitting LHVs. However, others have taken a demand led approach where one route at a time is permitted and either, that route is then permitted for all operators, or each and every operator that wishes to use it needs an approval. Note that for a route to be permitted without notification an appraisal of the impact of the LHVs on accidental actions would need to be carried out and find that there is no step change in the effect on the level of safety. See section 4.5 for more discussion on risk of accidental actions on structures.

The potential high time and cost of bridge assessment on a national basis ahead of a trial, combined with likely low prevalence of vehicles, at least to begin with, strongly contributed to the decision to propose route by route approval of LHVs in all ‘do something’ policy options. The potential for some LHVs (i.e., the full 25.25m long variations) to fall within the load models and others (heavier but significantly less than full length) to fall outside the load models also led to 1 of the 4 approaches excluding vehicles of less than the full 25.25m length (subject to tolerances to be determined) and another that excluded them from the initial use cases to allow a solution to be developed over time.

Particularly for options that permit vehicles that fall outside of the envelope of normal traffic, it will be very important that the vehicles are used only on the routes approved. This was one of several elements that contributed to all of the options including telematics based monitoring of route and weight compliance, based on a GB specific adaptation of the principles used in the Australian Intelligent Access programme (see literature review for more details).

Additional work needed before road trials

<u>Essential for any 'do something' option</u>

Analysis to establish whether the effects of the single 'lowest risk' 25.25m, 60t B-Double vehicle fall within the envelope produced by the latest UK bridge assessment and design load models.

Discussion with the freight industry and road owners around likely changes in the probability of LHVs travelling in convoy or side by side (lateral bunching) at their speed limit and how best to consider any differences in the assessment of loading effects on longer span bridges.

If the base configuration does fall within the load models, consideration of the degree (if any) to which reasonably foreseeable small variations in length wheelbase, axle spacing, or legal load distribution of that configuration need to be controlled.

If the base configuration does not fall within the load models, identification of the maximum GVW at which the same configuration would fall within the load models.

Consideration of the effect of the base configuration LHV in particular cases, i.e., for structures that are governed by fatigue.

In conjunction with assessment of load effects from vertical loading, an appraisal of the change in risk of accidental actions on structure will need to be carried out to ensure there is no step change in the level of safety, see section 4.5.

<u>Conditional on policy decision</u>

Expansion of the 'essential' analyses to include the remaining 4 'core configurations'

Where the load effects induced by LHVs fall outside the envelope of standard load models, compare with the load models intended to represent loading for abnormal indivisible loads (AIL). Note this may not be straightforward because of potential variability in spacing between axles.

Assessment of the effect that including the 2 tonne allowance for zero emission vehicles (ZEV) on top of the 60 tonnes would have on the relevant configurations.

Investigation of options for a simplified bridge formula to allow quick, conservative assessment of any new vehicle/route variant in future.

What will the effect be on modal split?

If a modal shift from rail or waterway was large enough it could substantially erode or reverse the emissions benefit of LHVs, but it may also be possible to control this risk through careful trial design.

Evidence summary

A vast body of literature considers the subject of modal split between road and rail and an exhaustive study was not the main aim of this feasibility study. The literature review covers enough studies to identify mode shift as one of the more controversial areas of potential impact for LHVs. Almost any value of predicted mode shift is available somewhere in the literature, from no effect to very large effects in excess of 50%. The previous UK study estimated a range of 8% to 18% based on a combination of elasticity values and theoretical case studies. The more sophisticated and academic analyses (independent of potential ‘special interests’) have tended to be critical of the theoretical methods used in many studies. These have generally found that mode shift is a genuine risk associated with LHVs but the expected reduction in rail traffic is smaller of the order of 1% to 5%, a level at which studies generally show the efficiency gain within the road mode outweighs the disbenefit of mode shift to produce net benefits.

Despite the range of more recent studies suggesting the mode shift expected would be substantially smaller than estimated for the UK in 2008, limitations remain due to a lack of well controlled empirical data.

Some stakeholders in the freight industry have provided input highlighting mode shift as a significant ongoing concern if a GB trial were to progress and responses to EU consultations on similar subjects also suggests strong concerns remain among the rail industry, though several stakeholders have pointed toward the advantage that could be gained for intermodal traffic if they were permitted for those operations only.

The Belgian trial aimed to avoid adverse effects on rail container traffic by limiting the carriage of containers to journeys that started or ended at a railhead.

Influence on policy options

The potential of excessive mode shift to reverse the benefits of LHVs is another of the main reasons that DfT have retained the “do nothing” option from the start. If a ‘do something option is chosen, then there is a choice to simply trial LHVs and accept the risk that the more moderate studies are wrong. Alternatively, the trial could be designed to allow competition with rail in controlled circumstances only and to more accurately measure the risk to better inform the analyses of this subject and reduce the controversy. This would better inform any potential future decision on whether to permit LHVs beyond a trial and, if so, under what conditions. Finally, the risk of mode shift could be excluded from a trial as has been attempted in Belgium.

The project team has assumed that simple acceptance of this risk without any constraint will not be acceptable. The route by route approval process was considered to have strong potential to allow the assessment of the extent of competition any particular road route would pose to rail. This would allow special provisions to be put in place for operators wishing to trial LHVs on this route in order to better monitor the effect on the competing rail route. Alternatively, it would also be possible to decline approval for any route where the assessment suggested significant scope for competing with rail.

Finally, the route by route approval method also means that under any of the policy options it would be possible to prioritise, or otherwise incentivise, applications for use of LHVs as part of intermodal operations.

Additional work needed before road trials

Essential for any 'do something' option

A method of identifying, for any given route application, the extent of potential competition with rail would need to be developed, potentially on the basis of the principles of the mode shift benefits calculation used to determine eligibility for Government grants to promote mode shift from road to rail or water.

Consideration should be given as to whether promote or incentivise intermodal routes within the first use cases trialled.

Conditional on policy decision

The development of evaluation criteria, thresholds and guidance for when route applications should be rejected on the basis of modal competition.

Data requirements, monitoring and analyses for measuring the potential for LHV operation to cause mode shift.

4.4 Will LHVs pose increased risk to highway structures from collisions?

Evidence summary

The literature reviewed and stakeholder input consistently identified collisions with highway infrastructure as an area of concern relating to the introduction of LHVs. The basic premise is that the increased mass and hence collision energy could increase the forces applied to infrastructure in the event of vehicle impact, thus increasing the damage and failure risks.

The literature (Knight, et al., 2022) and stakeholders (Brand & Smallwood, 2022) were also consistent in identifying that current applied loads representing impact on bridge piers, and the containment level of parapets have been derived based on consideration of vehicles that don't represent the maximum mass currently permitted (44 tonnes in the UK). It has been noted that a 30 tonne rigid vehicle, as used in the assessment of accidental loads on vehicle restraint systems and bridge parapets, was generally considered a worse case than a heavier articulated vehicle. A 40 tonne vehicle is used in the assessment of pier impacts.

It is, therefore, possible that LHVs with two articulation points will be a lower risk than the heaviest rigid vehicle (32 tonnes in the UK). However, a particular concern has been raised of a secondary impact between a rear trailer of an LHV and a pier, after the front has breached a barrier. No studies or results of impact tests or simulations to objectively quantify the risk one way or the other have been identified. This may be at least partly because of the limitations of a small number of tests representing the very large possible range of vehicle and infrastructure characteristics and impact scenarios. None of the countries reporting on the safety of trials or full implementations of LHVs referred to impact with bridges as causing a significant problem in service, including at least one country that highlighted the potential risk (though the vehicle numbers in service there were relatively low).

Some UK stakeholders and internal WSP analysis highlighted a potential increased risk to bridge decks if tall LHVs collided with low bridges, as a function of the additional mass compared with standard HGVs. The magnitude of such an increase would also depend on the stiffness characteristics of the body work and cargo at the top of the trailer, which may be quite variable and is not well known.

Theoretical models used to derive the pier impact loading adopted by design and assessment codes contain a large degree of uncertainty relating to the plastic deformation properties of the vehicle (e.g. stiffness) and variability in impact scenario. In a similar manner there is great uncertainty in the ability of bridge parapets to contain HGVs given the number of possible impact scenarios that could not possibly all be tested. Uncertainty in the magnitude of impact forces and the actual level of parapet containment is currently managed using a risk-based approach.

Influence on Policy Options

The risk that when collisions between LHVs and other heavy vehicles or rigid fixed object occur, they could be more severe, was the main driver behind the condition in policy option 2 (vehicle based risk control) to limit the maximum speed of LHVs to 80 km/h instead of 90 km/h for other HGVs (via the existing on-board speed limiter). This would mean that the kinetic energy of a 60 tonne LHV at maximum speed was approximately equal to that of a 44 tonne HGV at 90 km/h. All of the uncertainties inherent in assessing the extent to which the risk of infrastructure damage in collision with an LHV, mean that the exact effect of this measure is equally uncertain. However, it could be expected to mitigate the possible risk to some extent.

These collision risks were a smaller contributor to the decision to propose route by route approval. If an increase in severity of collisions was confirmed by a risk appraisal exercise, then it would be possible to reject routes with vulnerable structures without a large nationwide survey.

In general, the proposed telematics-based monitoring would be expected to increase compliance with route restrictions and reduce the probability of coming into conflict with structures compared with the general HGV population. For example, drivers that know they are closely monitored in an LHV may be less likely than an unmonitored driver in an HGV to deviate from their scheduled route and come into conflict with a low bridge. In addition to this, it could also be used to monitor speed compliance (in speed limit zones less than 80/90 km/h) with sanctions such as exclusion from the trial if certain thresholds were exceeded.

Additional work needed before road trials

Essential for any 'do something' option

A risk appraisal should be carried out considering anticipated changes to the probability and consequences of an LHV colliding with the infrastructure to assess any change in the level of safety. This could draw on data and information gathered from trials in other countries (where applicable).

If required, mitigating actions could include speed limitation or new vehicle safety measures not yet mandatory, but available in the market, such as lane keep assist which may further help to reduce the probability of collision. Any mitigating actions considered necessary would need to be written into assessment and sign off procedures.

Conditional on policy decision

Generate the thresholds and supporting rules for incorporating the monitoring of speed limit compliance within the telematics monitoring system.

4.5 How much of the road network can be safely accessed by LHVs?

Evidence summary

The literature review is unanimous that, in the absence of technical mitigations, most LHVs will have substantially worse manoeuvrability than a standard 16.5m articulated vehicle, with the exception of configuration E (Rigid towing two drawbar trailers). There is also no disagreement among literature or stakeholders that some existing routes will not be safely accessible by vehicles with reduced manoeuvrability performance. Considerable evidence was also identified to show that the use of steered axles at the rear of one or more modules in the LHV combination can mitigate many of the manoeuvrability issues. The extent depends on the exact technologies used but swept path can be reduced to a level comparable to existing vehicles. As such, the risks of not being able to safely access the route the vehicle intends to travel can be mitigated either by restricting the permitted routes to those that have more suitable radii, or by requiring vehicles to be designed with steering mechanisms to allow them to safely negotiate the radii that are there.

The evidence suggests steering mechanisms can add significant cost and mass (reducing payload), but this does not seem to have been a major barrier to investment in the case of LSTs. Restricting routes clearly reduces the potential overall take up and impact of LHVs. Most European countries that have permitted LHVs have restricted routes to those suitable, some have invested in upgrading infrastructure to expand the routes but only Germany is known to have imposed its existing national manoeuvrability criteria for standard HGVs, which requires many combinations to use steered axles.

In addition to this, both the literature review (Knight, et al., 2022) and stakeholders report (Brand & Smallwood, 2022) highlight that there are risks that are directly associated with the length of vehicles. These include additional difficulty with overtaking, the potential to block junctions (including level crossings), the length of emergency refuge areas (in UK, mainly relevant to smart motorways) and the ability to accommodate LHVs at parking facilities. Countries that use LHVs and have reported on overtaking and junction merging issues, have generally not been able to quantify the risks and have not found specific accidents directly attributable to these concerns. Surveys of drivers show that they encounter problems with these situations but that they also encounter those problems in standard HGVs.

Parking has been acknowledged as an issue in countries already using LHVs. In Germany it was found that initial numbers were sufficiently low that parking provision for abnormal loads could be sufficient. It was found that problems could grow with increasing traffic numbers, but studies also suggested the constraints were very different at different sites with some easily accommodating longer vehicles and others more difficult. However, a variety of solutions had potential to improve the situation before additional capacity needed to be built. These included a variety of reconfiguration options as well as several ‘smart parking’ solutions that were already being piloted for normal HGVs.

Most of the evidence found that other countries delegated public bodies to assess routes and approve them but relatively few published guidelines of the detail of how the assessments were undertaken were identified. It may be that as part of further work, a more formal approach could be made to the regulators or specialists in one or two European countries to explore their guidelines and experience in more detail, rather than ‘starting from a blank sheet’.

Input from UK stakeholders suggested it was very important to work with them from an early stage to develop route approval guidance and criteria. National Highways have a formal safety risk assessment framework, referred to as GG104, that it may be necessary to apply to parts of the trial on their roads.

Influence on the policy options

Alongside bridge loading, accessibility was a key reason for proposing a route by route approach in all options. The cost of investigating parking and road geometry only on routes where demand existed will be much less effort than doing so on a national basis. However, the options were designed to give a range of choices as to whether to control some of the risks of accessibility via route restriction or vehicle performance standards (options 1 and 2) and how flexible the scheme could be in terms of requiring one or the other or trying to match different levels of vehicle performance to different standards of route (option 3 and 4).

Additional work needed before road trials

<u>Essential for any 'do something' option</u>

Early identification of, and engagement with, the relevant stakeholders from freight industry, road owners (national and local), regulatory and enforcement bodies directly affected by the first use cases and routes identified.

Developing technical methods for assessing the risks on each route from initial high intensity high quality candidates, with the aim of using the results from sophisticated but time consuming and expensive approaches to develop and prove a much lower effort solution for future use in reviewing routes at much greater scale. All to be undertaken in partnership with the stakeholders. Candidate methods include:

- analysis of collision data involving existing HGVs
- surveys of principal routes and potential diversionary routes via mapping and satellite imagery,
- analysis of telematics and CCTV fitted to existing HGVs in service on routes to assess near misses, behaviour through difficult junctions, curves etc.,
- assessing the need for on-route parking and, if relevant, its availability, geometry and current usage via surveys and stakeholder engagement, and
- pilot runs with specially instrumented standard HGVs and/or LHVs,

<u>Conditional on policy decision</u>

Identification of worst-case vehicle for each important aspect of evaluation.

Development of a route categorisation method to allow road owners to divide the network into different capability levels to allow vehicles with certain performance levels or better to access. Parallel development of performance-based standards for accessibility based strongly on derivation from the original Australian standards as adapted for Europe by (de Saxe, et al., 2019) (see (Knight, et al., 2022) for a more detailed summary of that work).

4.6 How can the proposed approval processes be resourced?

Evidence summary

There was little evidence available from the literature review that quantified the effort required to develop all the procedures required for approving LHVs and the routes that they would use, or the ongoing costs associated with maintaining and growing the available route network. However, as part of a toolbox for policy makers the OECD (reference 2019 ITF report) acknowledge that "the introduction of HCVs requires the support and collaboration of a myriad of stakeholders.". GB stakeholders engaged as part of this project have highlighted that the effort required by a variety of public bodies to put in place all the controls and procedures highlighted in the options and the above rationale could be very significant. They also highlight that this goes well beyond business as usual for those bodies such that resources need to be available to achieve this.

The literature review estimates the annual economic benefit of 60 tonne, 25.25m LHVs in the UK to be between around £215 million and £1.5 billion, split across a reduction in direct cost savings for operators or their shipper clients and societal benefits from reduced emissions, casualties and road damage. The large number of variable that influence the economic benefit, many with significant associated uncertainty is one factor influencing the very wide range quoted. The other major factor is that on major study estimated take up based on feedback from an industry which has no experience about where they would expect to use LHVs if they were permitted. Another study attempted to repeat that analysis but based more on what was possible to achieve if the UK could achieve the levels of use in each commodity sector that had been achieved in Finland, over its long history of using larger vehicles. As previously noted, there is a large difference between the usage of LHVs in places like Finland compared with places that have trialled and introduced LHVs more recently (e.g. Netherlands and Spain).

The previous UK study of LHVs (Knight, et al., 2008) which identified benefits at the low end of the range above, found that a benefit to cost ratio of one could be achieved within 5 years of an investment of £1billion to £2.7billion.

Literature and stakeholder input from Australia has highlighted that they consider the 'special permit' method of allowing LHVs helps to ensure that the economic benefit to shippers and carriers can be used to drive outcomes. The ability to refuse an operator access to a permit and the significant economic benefit it can bring, or to provide the access only under certain conditions, provides the operator with a powerful positive incentive to agree to conditions that would normally be seen as too costly if they were to be imposed on standard HGVs allowed within existing laws "by right". The ability to revoke the permit provides powerful incentive to keep complying with conditions.

The intelligent access concept employed in Australia is based on the premise that an independent 3rd party brings together all the stakeholders involved and the costs to each stakeholder must be exceeded by the benefits they gain from it. Under the Australian approach, the government bodies have developed the approval mechanisms but the applicant for vehicle certification under the performance based standards has to pay an accredited assessor to get the vehicle approved, they pay a modest fee to the road authority to gain the access permit to the route, and (where a condition of permit, or sometimes voluntarily) they will pay to enrol in a relevant intelligent access scheme where a telematics provider will charge for an accredited service and the operator agrees to share compliance data with the road authority and sometimes other data that is of value to them.

Influence on policy options

The resources and costs to create the system were another important factor behind the proposal that all options are based on route by route approval, to avoid the costs of examining routes for which there may be no demand. However, within that a spread of options were presented that may represent significantly different levels of effort, initially to develop approval procedures and then to provide ongoing route approval until the ‘approved’ network reaches saturation point. Option 2 is likely to represent the lowest effort. Option 1 is also low effort but likely slightly more because of the need to establish which vehicle types are worst case for different parameters. Both are somewhat restrictive on take up. Option 3 requires much more up-front development effort but once developed, a lower ongoing cost would be expected, and it would be expected to facilitate higher take up and economic benefit in the long term.

The ability of the system to place the burden of proving compliance much more on the operator than the authorities is one reason that telematics based monitoring modelled partly on the Australian intelligent access concept has been proposed across all options.

Additional work needed before road trials

Essential for any ‘do something’ option

The development of a stakeholder group comprising of road authorities, local authorities, compliance, and enforcement agencies is required to help review and sign off the process and approvals needed for the trial including pilot/trial management, monitoring (including route compliance where required) and evaluation arrangements.

Extensive stakeholder engagement with all those involved in the approval process, including road authorities, DVSA/VCA, vehicle operators and manufacturers in order to quantify costs, gain commitment to actions and, where applicable, agree how costs and benefits can be shared equitably to engender a win/win philosophy.

Conditional on policy decision

None.

4.7 What needs to be done to ensure drivers are competent with LHVs?

Evidence summary

LHVs have been trialled or fully legalised in many countries in Europe and around the world. All, where evidence was identified, appeared to have implemented some form of specialist driver training requirement, some requiring accredited courses and/or drivers passing independent certification.

Influence on policy options

It was assumed that all options would include a requirement for accredited driver training, specific to LHVs. In general, it is considered that training would not represent a barrier to introducing LHVs because operators are already under a legal duty of care obligation to train drivers in the use of new equipment, and most will routinely do this. However, the rationale for assuming that this training should be from a formally accredited supplier was that some stakeholders suggested that some training within the industry was of a low standard. Given the significant difference in LHV characteristics and the importance of maintaining safety, those stakeholders considered that accreditation would be beneficial in ensuring that the training is of a high standard. In this case, they also said that it would be equally important to ensure that the accreditation scheme itself is cost effective and accessible so that it does not become a barrier to adoption.

Additional work needed before road trials

Essential for any 'do something' option

Identify suitable content and format for driver training to develop accreditation and identify potential suppliers of training services. One option may be to base this on the model used in the Netherlands, which was also adopted in the Belgian trial so that they could benefit from the experience of the Dutch.

Conditional on policy decision

None.

4.8 What are the casualty risks, appropriate mitigations & approval standards?

Evidence summary

At the highest level, the number of casualties expected from any road vehicle operation is a function of both the level of risk inherent in that activity and the exposure to that risk. There are many ways of measuring exposure to risk, but the most commonly used is the vehicle km, the distance any given vehicle type is collectively driven. A very high risk activity will produce a very low number of casualties, if it is undertaken only rarely. A much lower risk activity can result in many more casualties if it is undertaken very frequently

All countries that have legalised or trialled LHVs acknowledge that operating LHVs carries some element of inherent additional risk per vehicle km. All employ at least some additional safety measures (compared with the standard HGV fleet) in order to mitigate those additional risks. However, the basic premise of LHVs is that the increased capacity will result in fewer HGV trips to transport the same quantity of goods, that is, it will reduce the exposure to risk in terms of vehicle km. So, even if there is a modest increase in the risk per vehicle km, a reduction in the total number of casualties could still be achieved from the reduced number of vehicle km. Another way of expressing this is to consider the number of casualties per unit of freight transported (e.g. per tonne km).

There is now considerably more evidence of the casualty record of LHVs in-service than there was when the UK last considered the use of LHVs (Knight, et al., 2008). Where the evidence is from trials, the numbers are small and may be influenced by trial monitoring or control requirements that are subsequently removed when fully legalised. These studies typically take a case study approach, investigating each collision that occurs and assessing whether any aspect of causation or consequence could be attributed to the additional length or weight of the vehicle. These studies typically report no confirmed influence, sometimes citing the possibility of some minor length related effect.

In several countries permitting LHVs more widely, such that statistically significant numbers are possible, it has been found that, with their chosen safety mitigations in place, even collisions per vehicle km fall. This implies that the safety regimes implemented over and above those of standard HGVs have been so effective that they actually reduce the inherent risk of LHVs to below the level of standard HGVs. In these countries, the reduced exposure to risk adds to the effect of reduced risk and collisions per tonne km fall dramatically.

However, there are some limitations in study techniques and available data that may be slightly misleading. For example, there can be issues with bias. for example, it is possible that only the safest operations, routes, or drivers transfer from standard HGVs to LHVs so that analyses cannot easily compare like with like. In these cases, the numerical difference measured is genuine but cannot be attributed to the vehicle alone. It is the net effect of the difference in safety between those operations suited to using larger vehicles and those that are not, combined with any difference inherent in the vehicle performance. In theory this could mask an underlying increase in risk per vehicle km, associated with the inherent properties of the LHV, which would be consistent with engineering risk analyses. However, all of those engineering analyses predict that the increase in risk per vehicle km would be exceeded by the effect of a decrease in the number of vehicle kms such that there is a net decrease in casualties.

There is no evidence from rigorous statistical analyses, predictive engineering analyses or case studies that would suggest LHVs cause an overall increase in the number of casualties.

In most respects, the vehicle dynamics aspects affecting safety are well documented and understood. However, most of these analyses have been undertaken using simulation and do not account for the performance of modern safety systems such as steered rear or trailer axles, ABS, EBS, ESC or AEB. In general, there is a trade-off between low-speed manoeuvrability and high-speed stability. Most LHVs are more stable than the highly manoeuvrable standard 18.75m drawbar combination already permitted in the UK, but less stable than the less manoeuvrable 16.5m tractor semi-trailer. The B-Double is the most stable LHV but is the least manoeuvrable if not fitted with additional steered axles. The rigid vehicle with two drawbar trailers is by some margin the least stable configuration but is very nearly as manoeuvrable as a 16.5m tractor semi-trailer. The literature has not been able to quantify precisely the extent to which steered axles, or stability control for example, can be used to break the trade-off.

Apart from steering axles, the other safety systems are required by regulation on most new vehicles. However, older vehicles without the systems remain available in service.

One area where the available evidence remains weak is in relation to dynamic roll stability and cross wind stability with longer combinations of trailers at the sort of heights (4.6m to 4.9m) often found in UK double deck vehicles.

Input from stakeholders suggested that it should be possible to grant a Vehicle Special Order to an operator that lists all equipment (tractive units, trailers, dollies etc) that are authorised to be used as part of an LHV, on routes that have been suitably approved for that LHV combination or within other conditions as may have been imposed for the trial.

Influence on the policy options

There is strong evidence (Knight, et al., 2022) that LHVs do not cause a deterioration in safety overall in terms of total number of casualties from road freight transport. Almost all research of different types suggests that they are associated with a significant improvement in the number of casualties per tonne km. There is strong evidence in some countries that LHV operations run at a net lower safety risk than standard HGV operations that do not transfer to LHVs but this may or may not be directly attributable to the vehicle itself and will likely be influenced to at least some degree by other operational characteristics (road types used, driver experience, training, special safety measures etc). Clearly all except the evidence from the LST trial come from outside of GB. The transferability to a GB context remains a valid question, but the consistency in findings between places as variable as Australia and the Netherlands suggests no obvious reason to expect a substantial difference in GB. It is also important to note within an overall decrease in risk, there remains a risk that some specific types of collision could get worse.

However, all of the evidence is based on implementations (full legalisations and trials) that contain strong safety requirements over and above those applied to standard HGVs. As such, it was assumed that it would not be acceptable for any option to contain no specific safety requirements. Although not explicitly proven in the testing and simulation literature identified, the expectation is that EBS, ESC and AEB in particular will offer substantial benefits when installed in LHV combinations and this is why an additional rule to make sure they are always present in LHVs is proposed across all options. This will likely exclude older vehicles and trailers from participation in the trial, but also possibly some specialist vehicles that are exempt from those requirements for new vehicles.

The evidence showed that a B-Double is fundamentally the most stable of the core configurations of LHVs and that steered axles could compensate to a very large degree for the poor manoeuvrability such that it could perform similarly to a standard articulated vehicle. Together this means that this particular combination would be the version of LHVs that could safely access the widest network of roads. Combined with feedback from the survey of LST operators suggesting it was one of the two most popular configurations, this led to the development of option 2. That is an option that may represent the path of least resistance to progressing to a trial quickly, allowing development of real experience in route assessment, load planning, driver training and other processes, even if the restriction on the permitted combination might ultimately limit take up.

Additional work needed before road trials

Essential for any ‘do something’ option

Although the literature provided strong evidence around the expected vehicle dynamics of these configurations and the observed data that they at least did not worsen safety and likely improved it significantly, it was considered likely to be a benefit to validate this specifically for a UK vehicle with physical testing. In addition to this, it would be beneficial to quantify the effect of the safety systems proposed (ABS, ESC, AEB). A key question for the UK is also whether accepting LHVs without a height restriction would involve any additional risk compared with accepting unrestricted height HGVs at 16.5m/18.75m and LHVs at a 4m height limit.

It is proposed that this assessment is based on the version of the Australian PBS concept as proposed for European vehicles by (de Saxe, et al., 2019). The minimum requirement of any option is to undertake this programme on a B-Double with steered axles, for selected procedures where it is relevant, at 4m and 4.9m height (using appropriate density of loads) with the safety systems active and inactive. It is not considered essential that all tests are full physical track tests. Sufficient physical tests to calibrate and validate a computer simulation that then completes the matrix is acceptable at a technical level.

Work is required to identify the process for the assessment and sign-off of vehicle readiness prior to undertaking trials on the road network. These should include vehicle test & simulation on key gaps / GB issues (up to 4.9m height, ADAS effect) and hazardous goods (fire loading analysis).

Work is required to identify the process for the assessment and sign-off of vehicle readiness prior to undertaking trials on the road network. This will require input from the test and simulation work and engagement with stakeholders responsible for certification and vehicle special orders as well as legal checks.

Conditional on policy decision

If options other than option 2 are selected, then the verification exercise may need to be extended to the remaining vehicle configurations. However, exhaustive analysis of every PBS standard against every vehicle, load configuration and safety system permutation is not required. Sufficient work is needed to confirm the risks of additional height are not significantly different with other configurations and also to assess the extent to which ESC can mitigate the risks of reduced high speed stability of some of the other configurations compared with a B-Double.

5 Trial design

This section of the report has been developed on the assumption that policy option 4 is adopted (a combination of options 2 and 3) because this is likely to involve the most comprehensive set of actions. As such, selection of the alternatives will principally result in some tasks being deleted.

Although all types of approach to implementing LHVs were found in the literature from other countries, most had implemented in a staged fashion. In this proposal, we have identified two staging mechanisms:

- Preparation and testing moving to commercial trial
  - Two stage approach is applicable to all policy options.
  - Within the commercial trial phase, continuous improvement in policies can also be implemented in sub-stages (e.g., for first implementation route approval may be quite in-depth and burdensome but learning from that approach may enable progressively more streamlined processes in future phases),
- Additional use cases
  - Principally relevant to option 4
  - Each use case becomes a developmental stage aiming to expand the application of the trial progressively to all use cases where it is safe and economic to do so. Learning from existing use cases will better inform evaluation of new use cases, and vice versa.
  - Each use case will replicate the 3 phase approach of feasibility assessment, preparation and testing, and then commercial trial. However, it is expected that as time goes on, each use case will need less and less feasibility and preparation work.

If option 4 is selected, the preparation and testing phase for the first use case will involve all the work identified in the previous section as being essential for all policy options. The amount of the work that was identified as dependent on policy decisions will depend on what use cases gain industry support and require assessment. This approach will allow the project to maintain momentum by minimising the key tasks that must be completed before a multi vehicle / multi route commercial trial can be implemented and minimised the timeframe for delivering measurable decarbonisation benefits. Unlike option 2 though, it does not overly restrict industry in the longer term because all other use cases can be considered, but it will spread the effort of assessing and, if suitable, implementing these over time, while incorporating learning from the trial(s) already underway.

We anticipate there being engagement with a community of operators and stakeholders to both shape each new phase of trial work and learn from the experience gains. The format and nature of this engagement and composition of the community will change of time, much as was seen in the LST trial.

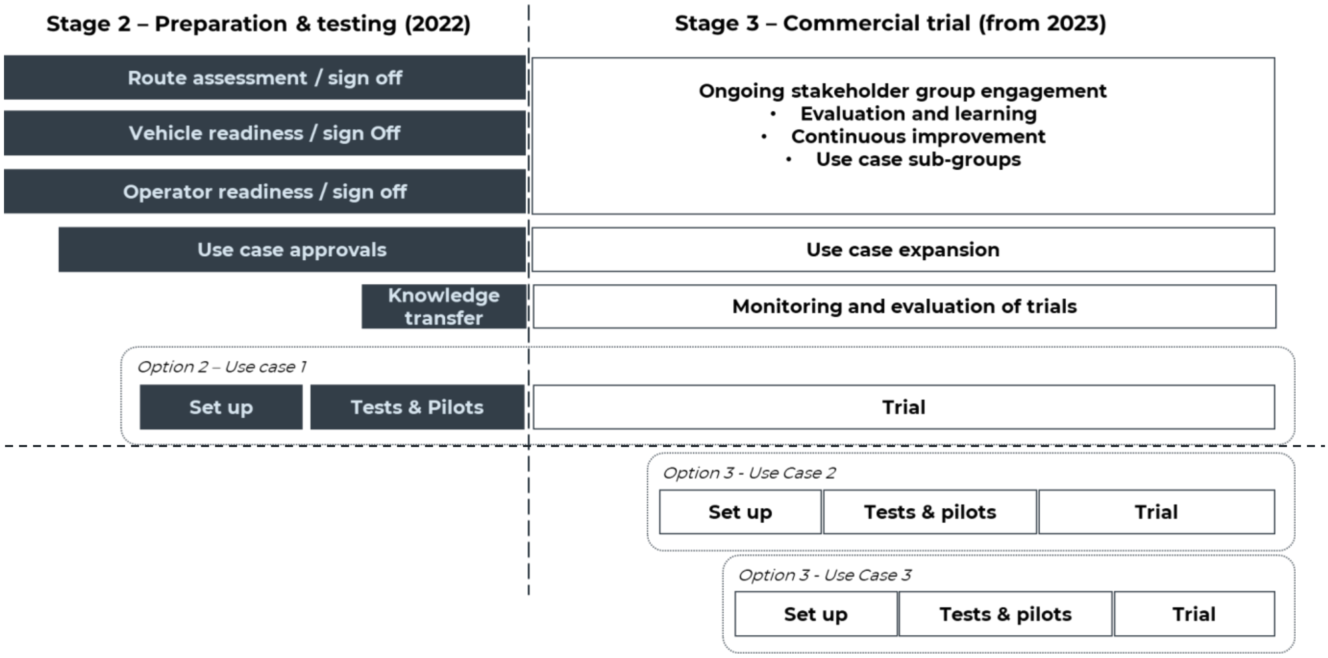

Figure 7: Overview of the staged approach to trials under option 4.

Other options will essentially have only one use case so that the bottom part of the figure above, relating to 2nd and 3rd use cases would disappear. It is just that it will be a wider use case requiring more work in the preparation and testing phase of the first (only) use case.

5.1 Stage 2 - preparation and testing

The preparation and testing stage will continue to build on the findings from this report, delivering the identified essential work items, working with key stakeholders to design the commercial trial (setting up the first use case in the process), including the role and terms of reference for a commercial trial project team and the process for knowledge transfer from this work to that project team.

Activities for use case 1 are expected to include:

Route Assessment / Sign Off

- Stakeholder work (shippers, carriers, rail representatives, NH/TS, local authorities, MSA operators, recovery operators, OTC, DVSA, Police),

- EOI/working group to identify shippers, carriers and local authorities willing to host trial routes. Identify specific route candidates,
  - work with stakeholders to integrate analytical work with specific route factors, resolve resourcing issues etc to develop route assessment methods.
- Analytical work,
  - analysis of vertical structural load effects (60t/25.25m/8 axles) and comparison with assessment and design load models
  - appraisal of the risk from LHVs of impacts with infrastructure including structures and parapets.
  - develop mechanism for quantifying route competition with rail and thresholds for route exclusion,
  - develop approach to swept path assessment (desk based, standard vehicle instrumented, LHV instrumented),
  - develop risk assessment approach for overtaking/junction blocking.
  - diversions / diversionary route response,
  - parking availability, vehicle recovery,
  - appraise candidate routes in accordance with research and commercial needs while complying with necessary processes such as NH GG104 or equivalent,
  - develop guidelines for use of ESDAL, undertake adaptations of ESDAL or develop the necessary software for a bespoke alternative,
- Route approval by all notifiable road's authorities and stakeholders.

Vehicle Readiness / Sign Off

- Stakeholder engagement (Vehicle manufacturers, carriers, DfT, OTC, DVSA, VCA, Police),
  - EOI/discussion with manufacturers/operators to identify sources of vehicles for physical track tests, road pilots,
  - engagement with manufacturers and enforcement bodies to develop vehicle approval processes.
- Analytical work,
  - vehicle test & simulation for verification of literature, assessment of height and ADAS influence,

- legal process design (VSO or other).

- Process 1st use case vehicle approvals.

Operator Readiness / Sign off

- stakeholder engagement (shippers, carriers, NH/TS, local authorities, MSA operators, telematics companies, Driver training bodies, Unions, OTC, DVSA, Police),
  - widening the existing industry survey to include the Road Haulage Association, Logistics UK and Chartered Institute of Logistics members to assess demand and understand the potential take up of a trial, scale of route assessments needed etc.,
  - develop the Operator Undertaking for participation in the trial and the detailed conditions based on analytical work and stakeholder input.
- Analytical work,
  - develop the specification for driver training,
  - develop information / monitoring requirements for analysing trial results including decarbonisation, safety and infrastructure protection objectives,
  - develop the telematics based compliance monitoring system,
  - develop the Legal process (VSO or other) to approve an operator's involvement in the trial
- Process the 1st operator approvals.

Knowledge transfer

If a 'do something' option is selected, then the work could be organised in different ways, either with internal resources, with a single external contract, with multiple external contracts etc. Whatever method is chosen, the move from a preparation and development phase to a phase of expanding number of use cases, routine monitoring and continuous process improvement is likely to involve a change in personnel and it will be important to ensure the knowledge is appropriately passed between teams.

It is considered that all of the stakeholder work could be integrated into one committed working group, perhaps with special interest sub-groups or task forces to tackle more specific elements. It is also anticipated that the outputs from this work could be used as the inputs to a Government Impact Assessment of the proposed trial and any related or subsequent policy proposals, if required.

Use case development

In parallel to the above work aimed at use case 1, implementation of option 4 would require work to be commenced in parallel on how to expand the trial through other use cases. This work will be partly dependant on what use cases industry and government may wish to prioritise, so the list of tasks below is by way of example, that may vary.

- Identification and prioritisation of new use cases,
  - particularly opportunities to support other DfT decarbonisation initiatives (Electrification, Rail Freight).
- Assessing whether a UK bridge formula able to cope with a wide range of LHV configurations, is feasible and, if so, developing it.
- For each new use case,
  - assessing the key areas in which it differs from use case 1 and creating (or wherever possible, adapting existing) performance based standards for those technical areas to quantify how much the performance varies in comparison to standard HGVs and use case 1,
  - assessing whether the magnitude of performance variation justified the creation of a new 'level' of vehicle performance and infrastructure access.

To illustrate this process, it is possible to consider two hypothetical examples,

- Use case 2: An operator wishes to use LHV combination D (rigid towing semi-trailer on a dolly) so that it is easier to integrate at depots/destinations focussed on rear loading and has identified the potential to use a specialist dolly with steered axles. However, GVW, length, number and spacing of axles is very similar to use case 1,
  - analysis of high-speed stability of the vehicle, when equipped with ESC, at 4m and 4.9m height and for low-speed manoeuvrability will be undertaken based on the PBS assessments. Bridge loading assessment not needed because inputs are the same as case 1,
    - results show that ESC adequately controls the currently documented lower stability of the base vehicle, and the steered axles allow the manoeuvrability of use case 1 to be matched,
    - no change to performance levels means the vehicle can be accepted on any route already approved, and approval for new routes is identical to use case 1,

- Use case 3: An operator carrying very high density goods (petrochemicals) wishes to use a tractor unit with single longer semi-trailer at a length of 18.55m, a GVW of 50 tonnes and with 7 axles, including two steered trailer axles,
  - analysis of the effect on road and bridge loading is required (latter via simple bridge formula if available) due to the concentration of the mass over a shorter overall length. In addition to this, manoeuvrability, high speed stability, traction and speed maintenance on an incline all require assessment. For manoeuvrability and high speed stability any adaptation to UK specific circumstances will already have been done in use case 2. However, relevant standards for traction, gradeability, road damage etc will require review, selection and/or adaptation for UK,
  - results show that the vehicle falls outside the bridge loading envelope for existing traffic such that only bridges suitable for STGO category 2 are able to carry the load. Thus, it cannot be assumed that existing use case 1 routes are passable, and a second level of infrastructure access suitability must be developed, if these vehicles are to be permitted. This requires following the same sort of processes followed in use case 1 to create the route approval procedures, though this may be much less effort because a lot of information would already exist at that time that could be reused or adapted.

In this way, a UK specific system of performance based standards and infrastructure access might evolve over time. Depending on the degree of innovation shown by industry and the diversity of vehicle performance characteristics found, this may evolve into the ongoing regulatory solution, if the trials prove successful and the Government wish to regulate.

Alternatively, the use cases that come forward from operators might highlight a few specific variations that between them account for the vast majority of UK demand and applications for new use cases dwindle to a very low level over time. In that case, it may prove to be a mechanism for identifying those most effective UK use cases based on industry demand, but then be replaced in Regulation with a simpler and more traditional prescriptive approach. This shares some similarity with how Canada have used PBS.

5.2 Stage 3 – commercial trial

Whilst the management and monitoring activities will be confirmed during the early part of stage 2 the key elements are likely to include:

Ongoing stakeholder group engagement

- Management of a stakeholder working group (NH/TS, local authorities, OTC, DVSA, Police etc.) to evaluate all elements of the trials, define key learnings and sign off continuous improvement recommendations.
- Establishment of a stakeholder sub-group (shippers, carriers, NH/TS, local authorities, MSA operators, local Police) for each use case during set up, testing and trial phases.

Use case expansion

- Expansion of number of operators/routes using use case 1 initially and other use cases as they are added.

Set up, test and pilot

- Delivery of the test and pilot activity for use case 1.
- Set up and delivery of the test and pilot activity for subsequent use cases.
- Detailed project planning of each commercial pilot alongside the associated use case stakeholder group (road authorities, local authorities, local compliance and enforcement agencies, operators, equipment providers etc.).

Monitoring and evaluation of trials

Monitoring and reporting of performance data and operator compliance for each use case trial.

Defining continuous improvement initiatives, considering new issues that come up during the trial, industrialising processes from the initial cautious approaches to more streamlined, but proven safe, processes etc

Developing an M&E framework alongside the Stage 2 design of the trial would be the ideal approach. It allows for two-way interaction between the trial design and the M&E design. This would then help ensure that the trial meets the anticipated requirements for information as far as possible, while working around inherent limitations on what is possible in the trial.

Good examples of likely trial limitations are related to safety include:

The 'ideal' control group in terms of driver training would be to permit a cohort of untrained drivers to run LHVs to compare with those receiving training, to assess how much of any effect could be attributed to training. Another option could be to allow a set of LHVs to be towed by tractors without Auto-Emergency Braking to see whether future policy should demand AEB. Such control groups would not be acceptable, so the M&E design has to find other approaches.

Even if such control groups could be permitted, the anticipated scale and duration of an LHV trial means it unlikely that it will generate sufficient data to give a statistically robust comparison of injury incident rates between the control and treatment groups. Indeed, it is unlikely to allow robust comparisons between the cohort of LHVs and standard HGV injury accident rates. So, the M&E will need to look at gathering other forms of data and proxy data for safety assessment.

We can foresee a number of approaches for formal M&E design timing.

Approach A: Basic M&E Design in Stage 2 Programme

No formal M&E design by specialists, but each core tasks in stage 2 would develop information / monitoring requirements for analysing trial results including decarbonisation, safety and infrastructure protection objectives".

- a set of evaluation questions (similar to the 7 applied for the LST trial),
- a high level Programme Logic Model (PLM) showing how the planned elements of trial design link to the questions,
- an initial set of trial data gathering requirements at a high level.

This option would then require a separate M&E design exercise – after Stage 2 – to expand the basic work into a formal design including the level of detail outlined in Approach B.

Approach B: Full M&E Design in parallel with Stage 2 - DfT Internal Resource

In this option the formal M&E design would be developed alongside stage 2, iteratively, with the necessary specialist resource would be provided internally by DfT.

This would allow for evaluation specialists to work alongside the Stage 2 team, and would, in our view, result in a better outcome as the M&E design would be created with a full appreciation of the challenges and constraints of an LHV trial, whilst also being able to influence trial design to deliver the best available evaluation data.

The result would be a fully developed M&E framework, 'ready to go' at the start of Stage 3, covering,

- agreed evaluation questions,
- programme logic and theory of change,
- planned monitoring points in the trial with data collection requirements,
- planned counterfactual approaches, data requirements and collection,
- expansion from core trial data (vehicles, performance, routing etc) to cover economic and other derived outcomes.

The M&E plan should already be acceptable to DfT and well suited to provide information in a form to support later impact assessment.

Approaches C and D aim for the same level of detail and an M&E plan 'ready' for stage 3, but using specialists other than those inside DfT.

Option C: Full M&E Design integrated into Stage 2

In this option the M&E design would again be carried out by specialist M&E resource, but using external resources (not DfT) fully integrated into the Stage 2 team, under the same project management.

This option provides the greatest opportunity for an integrated, iterative exchange between the trial design and M&E design.

We would assume this approach would also allow time for liaison with DfT evaluation specialists to gain as much of the Approach B advantages as possible, but without the burden on DfT resources.

Option D: Parallel M&E development with Stage 2 by peer group

As per C, but with the M&E design team separate from the main Stage 2 project but working in parallel.

The potential value in introducing an external peer challenge to main Stage 2 design which could be useful.

The downside is a potentially delayed start on M&E design; Less integration of trial design and M&E design; Additional hidden costs of integration management and procurement process; Design disagreements between two teams (low likelihood – but could emerge as one or other team limiting the willingness to 'go the extra mile' for the programme as a whole); Gaps between the two designs fall back on DfT. Could create a significant time gap between project stages, impacting on momentum gained with stakeholder groups.

6 Conclusion

The work in this initial desktop study has taken an agile approach, beginning from what we knew from the previous UK study (Knight, et al., 2008) on the potential use of LHVs and updating that knowledge in the light of the experience gained in trials across the world, especially in Europe, and developments in vehicle technology.

LHVs are now used in many countries both within and outside Europe. Exact estimates vary, but all countries using the vehicles report substantial gains in efficiency, translating to reductions in traffic, emissions, casualties and costs. We have identified risks associated with their use but also examples of a range of methods used in different places to mitigate those risks. From this, a framework has been developed within which DfT can explore a range of approaches, that could be taken to such a trial, based on different mechanisms to managing the primary sources of risk to Infrastructure (especially bridges and vehicle restraint systems), other road users and mode shift. This has been achieved by defining different permutations of,

- Vehicle configurations permitted.
- Vehicle performance required.
- Network access control and compliance.
- Degree of monitoring.

We have also identified 3 example options associated with different approaches to controlling risk. The options highlight trade-offs in the level of risk tolerated the speed to trial and simplicity of rules and the flexibility and benefit for industry.

In discussion with DfT, we agreed that speed-to-trial, and maintaining momentum from the current work were important and so have put forward the possibility of a hybrid approach that resolves the trade-off between maximising the range of LHV configurations and take up in the long term, and the significant development effort required to design and set up a trial with a large number of vehicle and network access permutations.

Finally, we have set out a possible programme model for such a hybrid approach, which starts with an extension of the current work into a ‘Stage 2’ in which key areas of analysis and process design identified in this report are executed, alongside the next stage of stakeholder engagement. It would move on into the early formation of a core group, including operators willing to take part in pilot work, and ideally some very early on road assessments which would evolve into the LHV trial ‘Use Case 1’.

Stage 2 would aim to develop all the groundwork required to enable DfT to then move into a Stage 3 – Commercial Trial - in which the range of use cases and routes would expand in response to operator demand, while the processes for managing LHVs and adding new uses, would be continually improved, as part of a learning and impact evaluation framework.

7 Stakeholder list

We have sought to engage widely, even at this early stage of DfT thinking on LHVs.

All of the bodies and roles listed below have been offered the opportunity for input but in some cases, contribution was not possible in time for the drafting of this report.

Regulators and compliance

- DfT Road Freight Regulation (RFR)
- DfT International Vehicle Standards (IVS)
  - Vehicle Safety
  - Structures
- Office of Traffic Commissioner (OTC)
  - Head of Central Licensing Office
- Driver and Vehicle Standards Agency (DVSA)
  - Head of ITC delivery
  - Heavy Vehicle Process Manager
  - Head of Vehicle Testing Policy
  - Head of Enforcement Policy
- Vehicle Certification Agency (VCA)

Industry

- Logistics UK (formally, FTA)
  - Head of Road Freight Regulation Policy
  - Head of Engineering Policy
- Road Haulage Association (RHA)
  - Head of Licensing and Infrastructure Policy
  - Policy Director
- The Society of Motor Manufacturers and Traders (SMMT)
  - Technical Manager
- Chartered Institute of Logistics and Transport (CILT)
  - Director of Public Policy and Communications,

- Insurers
  - Thatcham, Allianz, Aviva and ABI
  - AIG
- Association of Vehicle Recovery Operators (AVRO*)*

Road owners

- Highways England
  - Structures
  - Operations
  - Customer Service
  - Abnormal Loads team / ESDAL
  - Customer and Perceptions of Safety
  - Impact on Emergency Refuge Areas
  - PAU and Data implications
  - NTIS and Data implications
  - NGVR
  - MSAs and Lorry Parks
  - CAV
  - VMS and visibility thereof
  - Diversion routes
  - Roadwork standards
- Transport Scotland
  - Bridge Specialist
  - Structures Team Manager
  - Head of Major Bridges and Bridges Asset Management
  - Chief Bridge Engineer
- Local Authorities
  - LGA Senior Policy Adviser (Transport)
  - LGA Policy Adviser (Transport)

8 Glossary

Acronym	Title	Description
ABS	Anti-lock braking system	A system that detects when a wheel is about to lock and modulates the brake pressure to prevent it.
ADAS	Advanced Driver Assist System	A general name given to systems intended to help drivers with discrete aspects of the driving task, typically information systems, warnings and collision avoidance technologies.
AEB	Advanced Emergency Braking	Also known as Automated or sometimes Autonomous emergency braking. External sensors detect the risk of an imminent collision and, if the driver has not responded appropriately, the system will apply heavy braking to avoid the collision or reduce the impact speed.
AIL	Abnormal Indivisible Loads (AIL)	An Abnormal Indivisible Load (AIL) is any load that cannot be broken down into smaller loads for transport without undue expense or risk of damage.
BEV	Battery Electric Vehicles	A type of electric vehicle (EV) that exclusively uses chemical energy stored in rechargeable battery packs, with no secondary source of propulsion.
CEDR	Conference of European Directors of Roads	A non-profit organisation established as a platform for the Directors of National Road Authorities.
CMS	Camera Monitor System	A system that provides the driver with a view around the vehicle via an external camera and images viewed on a monitor inside the cab. When complying with applicable regulations, these can be used to replace mirrors.

Acronym	Title	Description
DfT	Department for Transport	The Department for Transport is the government department responsible for the English transport network.
EBS	Electronic Braking System	EBS and its components reduce the build-up times and response in brake cylinders.
EMS	European Modular System	A concept of allowing combinations of existing loading units (modules) in longer vehicle combinations to be used on predefined parts of the road network.
EC	European Commission	The EU governments administrative branch (similar to the UK civil service).
ESC	Electronic Stability Control	A system that detects if a vehicle is not following the directional path intended (as calculated from steering wheel angle and speed) or is rolling over and applies braking at selected wheels in order to prevent or correct the instability.
EU	European Union	The political association of 27 Member States.
GB	Great Britain	England, Wales and Scotland.
GVW	Gross Vehicle Weight	The total weight of large trucks, hauling trailers and other large vehicles.
HCT	High Capacity Transport	Bigger than conventional road freight vehicles, able to transport a larger weight or/and volume of cargo in one trip than a normal vehicle would.
HFCEV	Hydrogen Fuel Cell Electric Vehicles	Hydrogen Fuel Cell Vehicles Hydrogen Fuel Cell Vehicles (FCVs) are similar to electric vehicles (EVs) in that they use an electric motor instead of an internal combustion engine to power the wheels. However, while EVs run on batteries that must be plugged in to recharge, FCVs generate their electricity onboard.

Acronym	Title	Description
HGV	Heavy Goods Vehicle	A goods vehicle in excess of 3.5 tonnes GVW but in the context of this report used to denote a standard legal vehicle of up to 16.5m length for an artic or 18.75m for a drawbar.
IAP	Intelligent Access Programme	A telematics based monitoring system used to monitor compliance with route restrictions and other conditions attached to permits to operate vehicles.
ICE	Internal Combustion Engine	The internal combustion engine is a heat engine in which combustion occurs in a confined space called a combustion chamber.
IVU	In-vehicle Unit	An item of technology fixed into a vehicle.
LHV	Longer Heavier Vehicle	A vehicle combination that is both longer and heavier than the standard current authorised weights and dimensions (e.g. 44 tonnes and 18.75m).
LKA	Lane Keep Assist	A system that monitors the position of the vehicle relative to lane markings and/or road edges and applies small steering inputs to encourage the driver back into the correct lane if the boundaries are crossed without the direction indicators being activated.
LST	Longer Semi-trailer	A semi-trailer that is longer than the standard EU length of 13.6m.
PBS	Performance Based Standards	Rather than assessing a vehicle based on prescriptive length and weight limits, PBS focuses on how well a vehicle behaves on the road, through a set of safety and infrastructure protection standards.

Acronym	Title	Description
RIM	Road Infrastructure Management	An application that provides a way of collecting road use data from vehicles to inform and optimise the management of road networks.
SOA	State of the Art	The best and most recent technology or standard currently available.
STGO	Special Types General Order	The Special Types order allows special types of vehicles some concessions from the standard Construction & Use regulations.
TCA	Transport Certification Australia	TCA has oversight on the role of service providers to deliver telematics applications through the National Telematics Framework in Australia.
TEU	Twenty Foot Equivalent Units	A TEU or Twenty-foot Equivalent Unit is an exact unit of measurement used to determine cargo capacity for container ships and terminals.
TMA	Telematics Monitoring Application	A platform provided by the TCA in Australia to interface with companies' telematics systems.
TRID	Transport research international documentation	An integrated database that combines the records from TRB's Transportation Research Information Services (TRIS) Database and the OECD's Joint Transport Research Centre's International Transport Research Documentation (ITRD) Database.
UK	United Kingdom	The United Kingdom of Great Britain and Northern Ireland.
ZEV	Zero Emissions Vehicle	A vehicle that does not emit exhaust gas or other pollutants from the onboard source of power.

9 References

Aarts, L. et al., 2010. *Longer and heavier vehicles in the Netherlands: Facts, figures and experiences in the period 1995-2010,* Netherlands: Rijkswaterstaat Ministry of Transport, Public Works and Water Management.

Brand, P. & Smallwood, J., 2022. *LHV Trial Feasibility Study: Stakeholder Report,* Leeds: WSP report xxxx.

de Saxe, C. et al., 2019. *Definition and validation of a smart infrastructure access policy utilising performance based standards,* Brussels: Conference of European Directors of Roads (CEDR) contractor report 2019-03.

Knight, I., Brand, P. & Smallwood, J., 2022. *LHV Trial Feasibility Study: Literature Review,* Leeds: WSP report.

Knight, I. et al., 2008. *Longer and/or longer and heavier goods vehicles (LHVs) - a study of the likely effects if permitted in the UK,* Crowthorne: TRL Published Project Report PPR 285.

NTC, 2018. *Reforming the performance-based standards scheme: Policy paper,* Australia: National Transport Commission.

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