Evaluation of the Longer Semi-Trailer Trial: Annual Report 2016

A report for the Department for Transport

September 2017

Issue 1

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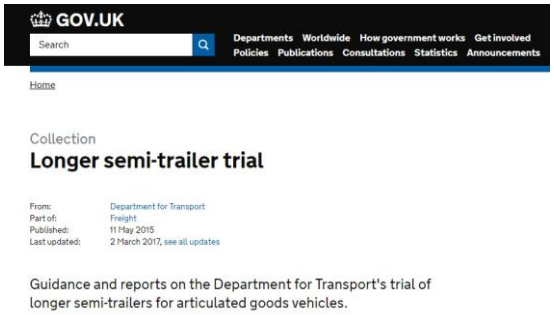
LST Trial information and contacts

The latest information regarding the trial, including participation criteria and data collection requirements, are always available from the DfT website.



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The project is sponsored by the DfT Freight Policy Group. All communications should, in the first instance, be directed to the project manager.

Acknowledgements

Risk Solutions and the Department for Transport (DfT) would like to record thanks to all operators on the trial, especially the individual data contacts, for their continued positive cooperation and hard work in collating, cleaning and submitting data in keeping with the operator undertaking. Without this effort evaluation of the trial could not take place.

Report status and accessibility

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LST TRIAL EVALUATION: HEADLINES

(Rounded figures – as at 31 Dec 2016)

TRIAL TAKE UP AND JOURNEY SAVINGS

Trial Take Up	Trial target total: 1,800 LSTs
1,806 (100%)	LSTs registered on Vehicle Special Orders (VSOs) (% of trial target of 1,800 trailers)
1,775 (99%)	LSTs on the road and submitted trial data (% of trial target of 1,800 trailers)
161	Number of operators with trailers on the road
Utilisation and km saved	
2.6m	Journey legs travelled by LSTs during the trial
319m	km travelled by LSTs during the trial
15.1 –17.8m	Vehicle km 'saved' by LST operations (end 2015) Lower - Upper bound (includes some return legs)
Journeys saved	Estimates of equivalent 'standard trailer' journeys saved across whole trial period and all operators
125-150,000	Journeys by 13.6m trailers saved by using LSTs Lower - Upper bound (includes some return legs)
1 in 19 (5%)	Average saving across all operators 1 in 'n' journeys (x% distance saved)
1 in 9 (11.5%)	Highest saving achieved by individual operators

Continued >>>

TRIAL SAFETY AND DAMAGE PERFORMANCE

Injury incidents – National

Collisions	Casualties	*Collisions / Casualties where LST involved **on public highways or public access areas** (2012-2016) resulting in injury*
18 (3)	**23 (3)**	**All personal injury incidents involving an LST** (Brackets show incidents judged to be 'LST Related')
54	**72**	**Three-year average safety incident rate (ALL collisions or casualties per billion vehicle km, 2014-2016)**
165	**237**	**Equivalent rate for all GB articulated HGVs**
0.33	**0.30**	**Collision / Casualty rate ratio (LST vs All GB Artics)**

On a per kilometre basis, nationally, LSTs have been involved in around 70% fewer personal injury collisions and casualties, than the average for GB articulated HGVs.
(95% statistical confidence level)

Injury incidents – Urban (Based on ONS Urban areas - excluding motorways)

Collisions / Casualties	*Collisions / Casualties where LST involved **on public highways or public access areas** (2012-2016) resulting in injury*
3	**URBAN Personal injury incidents involving an LST** (All – regardless of any 'LST Related' judgement)
117-159	**Safety incident rate (collisions per billion vehicle km) over whole trial for urban distance est. of 6-8%**
573	**Equivalent rate for all GB articulated HGVs**
0.2 - 0.28	**Urban collision rate ratio (LST vs All GB Artics)**

On a per kilometre basis, considering only operations in urban areas (excluding motorways), LSTs have been involved in 70-80% fewer personal injury collisions, compared with the urban average for all GB articulated HGVs.
(95% statistical confidence level).

Damage-only incidents 1 damage-only event reported to the trial for every:

1 in 2.8m km OR **1 in 23,000 legs**

A small study suggests that increased risk of property damage collisions compared with standard trailers in the same operator's fleet, may occur in some situations. The sample is too small to generalise to the whole LST fleet. We recommend further work in this area, with a particular focus on issues of drivers' awareness when operating LSTs (and other less 'standard' trailer types) and route familiarity / frequency.

Executive Summary

Background and key facts

The Department for Transport (DfT) is evaluating the impact of the operation of longer semi-trailers (LSTs) on Great Britain's (GB) roads. These trailers are up to 2.05m longer than the standard 13.6m units commonly seen on the roads in this country. DfT launched the 10-year trial in 2012, permitting up to 1,800 to operate under Vehicle Special Orders (VSOs) granted by the Vehicle Certification Agency (VCA). Following a consultation process during 2016, DfT announced an extension to the trial with a further 1000 trailer allocations being offered from 1 April 2017. At the time of writing all of these further trailers have been allocated and are expected on the road within the next 12 months

The trial is designed to evaluate the impact of LST operations on efficiency, emissions and safety. A reduction in emissions may be expected because the increased trailer length should allow the same quantity of goods to be transported in fewer journeys. Evaluation of the trial will determine whether this potential reduction in emissions is realised, without a detrimental effect on safety. The trial is also considering the issue of non-injury incidents resulting in asset damage.

This report contains a full analysis of the data to the end of 2016. A summary of the key trial statistics is given in the preceding 'Headline' pages.

LST Trial Public Summary

This main report will be published in parallel with a Public Summary, also authored by Risk Solutions. This is in response to an increased interest from individuals in the public sector, haulage industry and civil society groups who have a valid interest in understanding the key results of the trial and the evidence supporting them, but do not necessarily have the resources to study the main report in depth. The public summary will contain references to the relevant sections of the main report to allow direct access to the source of all key results.

This summary

The Public Summary will, for most readers, serve the purpose of an executive summary to the main report and so we have not sought to reproduce that overall narrative summary of results in this report summary. We have instead focused on summarising the main results and recommendations for the informed reader, without detailed explanation. A slightly fuller summary of the report can be found by reading Section 9 of the main report. Recommendations are summarised in the table at the end of this summary and referred to in the text in the form R2017-n.

Summary of key results

Trial inputs and activities

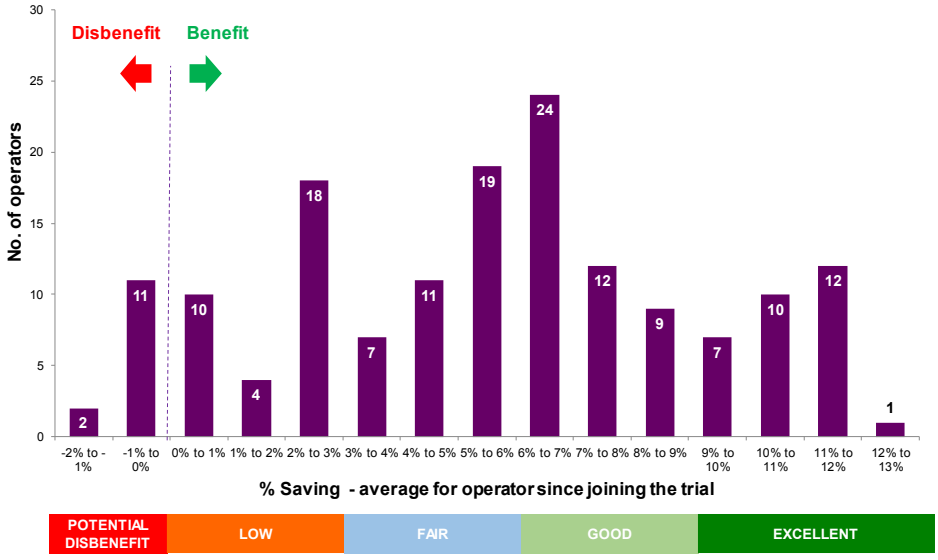
- **The original planned LST fleet of 1800 trailers was on the road or on VSO at the end of 2016**. There is a good mix of trailer designs, including single/dual deck, flatbed and skeletals, including a design carrying bespoke 50-foot ISO containers on a road-rail operation.
- While the terms of the trial do not require tracking, a significant percentage of the LST fleet can be tracked using GPS data and in many cases this data is being

used to generate the journey logs on which the trial is largely based. The terms of the trial do not require that raw GPS is made available. (See section 8).

- Qualitative feedback suggests that experience with the trailers continues to be positive for a clear majority of participants.
- High quality engagement needs to be continued as the trial expands to maintain the quality of data being submitted and exchanges of views with participants regarding key results. (R 2016-1)

Trial outcomes 1: Distance/journeys saved

- LSTs are operated at high levels of utilisation.
  - Empty running of LSTs is only 2/3 that for regular semi-trailers
  - LSTs have used the full additional length for 34% of their distance travelled, with all or part of the additional length in use for around 54% of all distance.
- We estimate that around 30% of all distance covered by LSTs includes a leg to or from a retail site, taking into account the analysis of empty return legs.
- Since the start of the trial, the use of LSTs has removed between 15 and 18 million vehicle kilometres of freight traffic from the roads of Great Britain, equating to 125-150,000 journeys saved. The chart below shows the percentage distance saved by different numbers of operators on the trial.



Distribution of % distance saved using LSTs by operator

- To account for potential increases in fuel use when pulling an LST, the calculation of savings incorporates a deduction in the claimed savings representing a nominal figure of 1.8% increase in fuel use.
- Over the whole fleet and across the trial we have calculated that the average percentage distance saving is 5.3%, which **equates to 1 in every 19 journeys**. The most efficient LST operations are saving up to 1 in every 9 journeys, the theoretical maximum (after the fuel use adjustment).
- There are a small number of cases where little or no saving from LSTs is being reported, which warrants further investigation (R 2016-2).
- Individual company LST utilisation results have been checked with operators, who confirm that they are consistent with their understanding of performance.

Trial outcomes 2: Safety impact (Injury incidents)

Safety benefit from saved journeys

- **There is a direct safety benefit of around 5% reduction in collisions in delivering a fixed quantity of cargo using LSTs rather than standard 13.6m trailers due to the reduction in the number of journeys.**
- This is in addition to the safety comparison discussed below on a 'per km' basis.
- This is equivalent to around 2-3 collisions and 3-4 casualties saved during the period of the trial.

Incident collection and categorisation

- All incidents involving LSTs on the road or in public places, whether or not an injury took place, must be reported to the trial as part of the undertaking sign by operators. Injury incidents in depots/private land must also be reported.
- There have been no fatal accidents involving LSTs in 319 million km of operation.
- The injury events reported on the trial are broken down by location and severity in the table below. Events are also classified by whether it was judged to be LST related (i.e. it would not have happened with a regular 13.6m trailer). However, all injury analyses presented in the report are based on the figures for ALL incidents occurring on the road or in other public places.
- In each year, we review the incidents not only for the statistical calculations, but to explore 'events of special interest'. During 2016 there was an event in which an LST damaged a car on the hard shoulder of a motorway resulting in a slight injury to the driver. We have recommended that DfT/VCA look more closely at this event to determine whether some further technical study of the scenario is needed (R 2016-3).

Injury Collisions from Trial Logs	Total Collisions	Total Casualties	Fatal	Serious	Slight
All Injuries (inc depots etc.)	**23 (15)**	**28 (20)**	0	7 (4)	21 (16)
All Injuries in Public Road/Place	**18 (11)**	**23 (16)**	0	7 (4)	16 (12)
All Injuries judged LST-related (any location)	**7 (5)**	**7 (5)**	0	0	7 (5)
All injuries – LST-related AND in public place	**3 (2)**	**3 (2)**	0	0	3 (2)

Figures in (brackets) show the totals at the end of 2015. The injury incident analysis in this report is based on all public incidents, i.e. the figures in the row outlined in RED

Injury incidents involving LSTs reported on the trial (2012-2016)

Injury incidents comparison to other semi-trailers - NATIONAL

- **When measured across all road types, the LSTs on the trial are being operated as safely if not more safely per km, than the trailers they replace.**
- Nationally, LSTs have been involved in around 70% fewer personal injury collisions and casualties, compared to the average for GB articulated HGV Injury incidents (based on STATS19 data) operating over the same distance (based on DfT Data), at a 95% confidence level.

Injury incidents comparison to other semi-trailers – URBAN

- A key question for the trial has always been whether an acceptable safety record overall might mask an increase in risk on the relatively small proportion of distance on urban operations. Until this year we were not able to produce a statistically significant result addressing this issue.
- We have now used route modelling based on the start and end postcodes in the 2016 journey log, covering 35,000 unique routes, relating to 1m individual legs.
- By mapping the routes against the ONS 'Urban Areas' – the same basis used in all DfT freight statistics, the model estimated that in 2016 the LSTs ran on roads in urban areas (excluding motorway) for 8.0% of their total operating distance, compared to an average of 5.9% for the GB articulated HGV fleet as a whole.
- **Based on 8.0% urban operation our analysis suggests that the LSTs on the trial are being operated as safely, if not more safely, than the trailers they replace, when considering running only on roads in ONS defined urban areas (excluding motorways).**
- This result is statistically robust at a 95% confidence level.
- This conclusion remains statistically valid for all cases where the proportion of LST operation on urban roads (excluding motorways) is assumed to be the same as or greater than that for the wider GB semi-trailer fleet.

Trial outcomes 3: Property damage

Analysis of LST incident rates vs tail-swing measurement

- The trial data includes 161 damage only incidents (2012-2016) in which the fact the trailer was an LST was noted as being, or possibly being, part of the cause. There is limited information on the extent of damage.
- In 2016 we have been able to match the trial data to the trailer 'model report' data held by VCA. This allowed us to look for any relationship between the different kick-out (tail-swing) measurements and (damage) incident rates, within the LST fleet.
- **Our analysis found no simple relationship between LST kick-out and the overall rate of injury and damage incidents on either trunking or 'delivery' routes**.
- However, we have recommended that DfT consider studying the rationale behind the adoption of the (many) different trailer designs, including the geometry, axle choice and hence tail-swing measurements. This might provide some insights to inform design guidance in any future expansion of the trial or general roll-out of LSTs (R 2016-4)

Comparison of LST incident rates to other trailers in operator fleet data

- A small study suggests that increased risk of property damage collisions compared with standard trailers in the same operator's fleet, may occur in some situations. The sample is too small to generalise to the whole LST fleet.
- Because of the small sample, and the choice of operators based on a prior assessment of their likely (higher) incident risk, these results cannot be scaled up to the whole fleet.
- Based on the observations in this small sample, we have recommended further work in this area, with a particular focus on issues of drivers' awareness when operating LSTs (and other less 'standard' trailer types) and route familiarity / frequency. (R 2016-5)

Future focus on damage incident data

- Based on the two studies described above, we have recommended that if DfT goes ahead with a revised data collection framework, the design should collect more substantive damage incident date from all operators. (R 2016-6)

Wider Impact

- The results from the data collected on the trial can only reflect the position within the trial fleet and under trial conditions. Now that we have a substantial trial dataset we recommend that during 2017-19, DfT should plan to conduct initial 'scaling up' analysis – applying the data gathered so far on the trial to a theoretical scenario where LSTs were widely available at some point in the future. The would also require work to translate the journey saving results into measures of emissions reduction. (R 2016-7)
- We have also recommended that DfT start conducting evidence based conversations between DfT, the haulage industry and other interested parties such as Local Authorities and civil society groups, regarding what guidance or regulation might be required to maintain the positive results seen on the trial under post-trial conditions. (R 2016-8)
- **By making these last two recommendations, Risk Solutions is not stating that the trial data is now 'complete' and we are not making a recommendation at this point that LSTs be made part of standard equipment.** The recommendations are simply suggesting the exploratory work that could now be started, based on the evidence gathered so far.

Trial extension, the data framework revision and GPS data

- We note that in view of the 2017 extension to the trial (to add a further 1000 trailer allocations), and the DfT statement regarding a possible revision to the data framework later in 2017, we may wish to bring forward further recommendations in this area in due course.

We have summarised the key results and collected the recommendations (R 2016-n) in the table that follows.

LST Trial 2016 Annual Report: Summary of Recommendations

2016-1 Industry Engagement

We recommend that DfT liaise with FTA, RHA and other stakeholders to arrange a further LST Trial industry forum, ideally during 2017, to communicate with the operators and retain participant engagement, as the trial enters its sixth year and the trial community is extended.

2016-2 Understanding low efficiency use of LSTs

Once the Qualitative Survey (QSF2) analysis is completed, the scope of work for 2017-18 should include further enquiry with operators whose results suggest limited benefits from using LSTs to better understand the range of factors involved.

2016-3 Technical appraisal of LST 'course correction at speed'

DfT / VCA should consider the questions raised in this report relating to the likely response of an LST using a self-steering / command steered axle to a sudden course correction 'at speed' (e.g. 50 mph).

2016-4 Understanding the underlying basis for LST design variation

DfT / VCA should consider working with the industry, including manufacturers, to better understand the design and operational choices or requirements that have led to the variety of LST designs with different kick-out measurements.

2016-5 Increasing data on the relative rate of LST damage incidents to those of all trailers in the fleet of each operator

DFT should consider working with the industry and/or amending the data framework, to assess how many operators experience a difference in damage only incident rates between their LSTs and standard length trailers. This should include work to better understand the impact of route familiarity and equipment awareness, especially on non-trunking operations, on the ability of drivers to operate LSTs without an increased risk of collisions resulting in property damage.

2016-6 Increasing data on the nature and severity of damage incidents involving LSTs

If DfT wish to assess the impact of damage only incidents in more detail, then operator in-house incident severity data for both LSTs and ideally standard length trailers would need to be gathered as part of the standard trial submissions. To achieve this, we would recommend that the incident log template be revised to incorporate including at least narrative evidence of the severity of damage to the trailer and any objects hit in the collision and, potentially, a simple damage impact ranking. This recommendation is subject to DfT determining whether the value of this additional data justifies the additional reporting requirement on operators.

2016-7 Preliminary assessment of 'future impact' of LSTs – scaling up and emissions assessment

DfT should consider including an initial 'scaling up' analysis in their 2017-19 plans for the trial evaluation, to begin assessing the potential future impact of LSTs. This would include work to translate the current distance/journey saving results into measures of reduced emissions/air pollution.

2016-8 Preliminary exploration of possible post-trial requirements or guidance for operating LSTs

DfT should consider conducting evidence based conversations between DfT, the haulage industry and other interested parties such as Local Authorities and civil society groups, regarding what guidance or regulation might be required to maintain the positive results seen on the trial under post-trial conditions.

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FIGURES

1 INTRODUCTION

1-1 The LST Trial

The original GB longer semi-trailer trial launched in 2012

1.1 The Department for Transport (DfT) is running a trial of the operation of longer semi-trailers (LSTs) on roads in Great Britain (GB). These trailers are permitted to be up to 2.05m longer than the standard 13.6m units commonly seen on the roads in this country.

1.2 A trial was created to gather evidence about the operational performance of LSTs in terms of safety, environmental impact and economics.

1.3 The trial was scheduled to last for 10 years from its launch in 2012 and allowed up to 1800 LSTs to be built and operated. The first semi-trailers were granted Vehicle Special Orders (VSOs)[1] early in 2012 and data collection began on 1 May 2012

1.4 In order to participate in the trial, hauliers sign an 'Operator Undertaking'. Submitting data to inform the trial evaluation is a key condition in this undertaking.

1.5 The outputs from the trial will feed into a decision about whether to permit an increase in the length of semi-trailers authorised for operation on roads in GB under normal regulatory requirements (i.e. without a VSO).

1.6 More broadly, subject to acceptable outcomes in terms of safety and property damage, the trial will contribute to DfT's work to:

- identify de-regulatory measures to reduce burdens on business; and
- identify measures to reduce carbon emissions from HGVs.

1.7 Further details about the trial can be found on the DfT website[2].

DFT is extending the trial from 1 May 2017

1.8 In January 2017, DfT agreed to extend the number of Semi-trailers in the trial by 1000 trailers and extended the prospective trial length by 5 years, to 2026/7. This followed an industry consultation during 2016.

1.9 In March 2017, DfT invited operators to bid for a share of this additional allocation. Operators will be able to put the new LSTs on the road from 1 May 2017.

1.10 Details of the trial extension and consultation can be found on the DfT website[3].

1.11 At the time of writing, the requirements of the trial have remained broadly the same since the start of the trial. DfT recognise that data submission is time consuming, and are currently reviewing requirements for this in the light of the information analysed to-date. The possibility of adjusting the data collection framework to focus more on safety (and other road incidents) is being discussed.

1.12 **This report deals exclusively with the LST fleet on the road up to the end of 2016**

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[1] A VSO grants permission for a specific operator to operate specific special trailer(s) on GB roads for the duration of the VSO. All LSTs require a VSO to operator. The operator must apply to the Vehicle Certification Authority (VCA) for a VSO before the trailers are used on the road, citing all the trailer Vehicle Identification Numbers (VINs). This is often done as soon as the VINs are fixed by the manufacturer during build.

[2] Trial general information: https://www.gov.uk/government/collections/longer-semi-trailer-trial

[3] Trial extension 2017: https://www.gov.uk/government/publications/longer-semi-trailers-guidance-and-application-form

1-2 The evaluation of the trial

The trial is being evaluated independently

1.13 In December 2011, the Freight, Operator Licensing and Roadworthiness Division (FOLR) of the DfT commissioned Risk Solutions to:

- Design a process to collect data to support the evaluation of LST operational performance
- Set up the initial systems for data collection
- Initiate the process and support participants during the first year of the trial (2012)
- Report on progress achieved during the year.

1.14 Having an independent evaluator serves two purposes:

- The raw operational data remains confidential – it is not seen by or available to DfT or any party other than the originating company and Risk Solutions. The details of individual operations are commercially sensitive to operators and without this arrangement many of them would not have been willing to participate or would have only agreed to provide summary data.
- The analysis of the data and the conclusions are being made independently of DfT. While it is the case that Risk Solutions are commissioned by DfT, we are clear that our role is to bring forward only analysis and conclusions that can be reasonably supported by the data. We provide an effective challenge function for DfT, helping ensure, as far as possible, that press releases and department briefings are fully consistent with, and supported by, the evidence. Our experience has been that DfT has always responded well to this aspect of our roles as independent evaluators.

1.15 Risk Solutions were re-commissioned to continue in the role of independent evaluation consultant for the trial in 2013, in 2015 and again for 2017. The evaluation from 1 January 2018 to 31 December 2019 is being procured via a competitive process.

The evaluation framework follows broad HM Treasury principles

1.16 The primary objective of the trial is to provide evidence to DfT to support long term policy decisions on **"…. the most socially beneficial length of Heavy Goods Vehicle semi-trailers"**[4]. The specification of the trial, to allow trailers of the two length categories (up to 14.6m and up to 15.65m) that other matching all existing regulatory standards, flowed out of the impact assessment and the analyses done to support it.

1.17 The evaluation process needs to operate at two levels:

- Primary evaluation of outcomes – analysis that can inform the response to core questions:
  - Do longer trailers carry at full capacity?
  - Do longer trailers result in fewer vehicle trips or vehicle kilometres?
  - Do longer trailers result in more or different types of accidents? Is there potential for using extra safety devices on longer trailers?
  - What kind of operations are longer trailers used for? For example, what routes, trips, commodities and roads are they used on?
  - Does the pattern of usage differ significantly from the assumptions made in the original Departmental Impact Assessment[4]?
  - Can the existing infrastructure (including roads, delivery depots and parking) cope with longer trailers? Does existing infrastructure limit their potential use?

[4] 'Impact Assessment of Longer Semi-Trailers', DFT00062 15/12/2010.

- Do real world operations identify any additional operational issues, risks, costs or benefits not identified in the Department's original research?

- Secondary evaluation – analysis to assess the extent to which the trial process and the resulting data have produced a robust data source, and the applicability of any results.

1.18 The HM Treasury Magenta Book ('Guidance for Evaluation')[5] recommends use of a programme logic model (PLM), for all policy evaluation. The PLM provides a structure for evidence gathering, collation and analysis, mapping how the inputs, key activities and outputs are used to deliver the desired outcomes.[6]

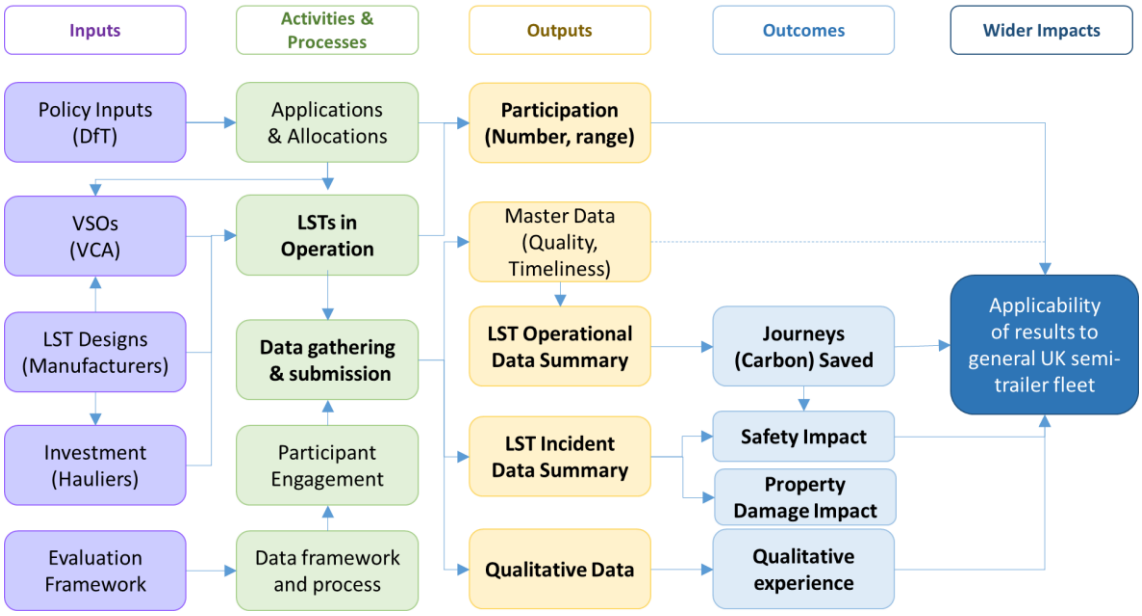


Figure 1: LST Trial Evaluation Programme Logic Model

1.19 Figure 1 shows the PLM for the LST trial evaluation. Some elements of the model, and the progress being made on them, can be expressed as metrics (e.g. How many operators have been signed up? How many LSTs are operating compared with the planned total?). Others may only be expressed qualitatively as no numeric target was set at the start of the trial (e.g. Has the trial attracted a broad range of operator types and sizes as was hoped?).

1.20 Where metrics were explicit in the original formation of the trial (e.g. 1,800 LSTs on the road), they are clearly identified in this report and progress against them will be evaluated as the trial continues. Where no quantitative measure can be established, progress is reported qualitatively.

1.21 Annex 2 summarises the extent to which the evaluation to date covers the PLM.

[5] 'The Magenta Book: Guidance for Evaluation' HM Treasury April 2011 (available from .GOV) See also 'Logic Mapping: hints and tips for better transport evaluations' Tavistock Institute for DfT October 2010.

[6] An expanded explanation of PLMs as outlined in the HMT guidance is given in Appendix B of the 2014 Annual Report.

1-3 This (fifth) trial annual report

Evaluation updates are published annually

1.22 Results from the LST operations have been reported annually for the first four years of the trial, 2012-15[7]. Terminology used in the trial and data collation, is also defined in those earlier reports.

1.23 This **fifth** annual report largely follows the same structure as previous years. Previous reports described the trial data collection and analysis methodology in detail. The core processes have not changed significantly since 2013, so this information will not be repeated and can be found in last year's report[7].

1.24 The report has been structured to align with the evaluation stages

Part 1: Trial inputs, activity and outputs

1.25 Section 2: Discusses **inputs** to the trial, including progress on the allocation of places on the trial and the process of collecting data for the evaluation

1.26 Section 3: Discusses progress on the **activities and processes** of bringing participants into the trial and managing the data collection and submissions.

1.27 Section 4: Presents and discusses trial **outputs**, including the key raw results.

1.28 Section 4 also contains a summary of the results from the qualitative surveys of the operators' experience of using LSTs.

Part 2: Trial outcomes and conclusions

1.29 Section 5 presents the analysis of **potential savings in journeys and distance travelled** (and hence carbon emissions). This is important as it provides it will later provide the basis for analysing carbon savings being realised on the trial.

1.30 Section 6 presents the analysis of **personal injury incidents**. This is vital to establish whether there are any indications that LST operations are increasing **safety risk** (relative to other traditional trailers), particularly to other road users and vulnerable groups.

1.31 Section 7 presents the analysis of **non-injury incidents**. This seeks to assess the **damage to property** (infrastructure or other vehicles) caused by LSTs, in comparison to other trailers. This work has been expanded since the 2015 report.

1.32 The outcomes in **qualitative experience**, based on the original QSF1 responses and the recent QSF2 survey, have been inserted into relevant sections throughout this report rather than in a separate section. We took this approach because, particularly for QSF2, the questions were designed to check our understanding of the data in different areas of the analysis.

1.33 Section 8 discusses **wider impact** issues relating to the future use of LSTs.

1.34 Section 9 brings together **the key conclusions** from the work to date and **recommendations for the next stages of the evaluation**.

[7] Evaluation of the high volume semi-trailer trial: annual reports for earlier years https://www.gov.uk/government/collections/longer-semi-trailer-trial.

1-4 New analysis in this report

This report introduces a number of new or extended evaluation analyses

1.35 The data sources, collection and analysis methods have been fully described in earlier annual reports. In this report we have only included notes of any amended or new methods or processes.

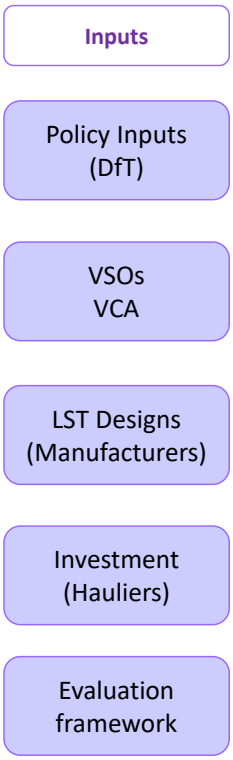
1.36 We have highlighted specific sections of this report that cover new or extended analysis compared to the 2015 report in Table 1.

Table 1: New or extended analysis since the 2015 annual report

	Special topic analysis	Location in report
1	Analysis of new qualitative survey data of trial participants, including general experience, current extent of trailer tracking, rationale behind the utilisation performance of each operator and early indications of possible future LST uptake	Section 4 Page 24 and relevant parts of other sections
2	Analysis of extent of LSTs in urban areas based on modelled routes using journey leg start and end points	Section 6 Page 45 and Annex 3
3	Analysis of the relationship between trailer 'kick-out' measured by VCA for each LST model and operational experience / incidents	Section 7 Page 57 and Annex 4
4	Analysis of 'damage only' incidents using operator's own in-house data. Extension of sample analysis reported in 2015	Section 7 Page 60

PART 1: TRIAL INPUTS, ACTIVITY AND OUTPUTS

2 TRIAL INPUTS



2-1 Policy inputs

The policy framework for the trial is currently as defined in 2011

2.1 The framework for the trial, established by DfT at the end of 2011, has remained largely unchanged. Full details are on the DfT website[8]

The allocation process has been completed

2.2 The final round of LST allocations held in the autumn of 2014 shared out the remaining places from the initial trial allocation between a mixture of existing trial participants and new applicants. The successful applicants were required to provide a proof of order, even if there was likely to be a delay before manufacture began.

We expect all the LSTs to be in service throughout 2017

2.3 A steady flow of new trailers has entered service during 2016 and now all the anticipated 1,800 LSTs are on the road or are the subject of a Vehicle Special Orders (VSOs) which suggests that they will be operational in 2017. The exact number of LSTs on the road or on VSOs at the end of 2016 is described in Section 3 (para 3.1).

A few trailers have been transferred between participants

2.4 Operators have transferred a few LSTs to other companies on the trial. The main movements have been between companies where there was already a relationship, for example between subsidiaries of a parent company, or between a client company and their contract haulier who was already running the trailers. There have also been a small number of sales of manufacturers' demonstration trailers to hauliers.

2-2 Vehicle Special Orders (VSOs)

The system of Vehicle Special Orders (VSOs) is largely robust

2.5 The Vehicle Certification Agency (VCA) issues the VSOs under which the LSTs are permitted to run on GB roads. For new designs, this involves rigorous testing by VCA at Millbrook Proving Ground, or at the manufacturer's site. This results in production of a 'Model Report' that records the design parameters of the design being approved, and its performance in the tests. For further builds of an existing design, each new trailer is subject to a simple conformance test.

2.6 The VCA provides advice to DfT, operators and Risk Solutions on matters relating to LST operations under VSOs and on errors found in the recording of vehicle identification numbers (VINs) in the data.

[8] https://www.gov.uk/government/collections/longer-semi-trailer-trial

2.7 There have been a small number of cases where the operator has not obtained a VSO, usually because they believed the manufacturer did this. These errors have been picked up when they start to submit data, or when they have initiated contact about doing so.

2.8 In 2014, we reported that Risk Solutions and VCA were working together to codify key data from the VCA model reports[9] so that we will be able to match operational data back to design features, such as tail-swing distance. VCA's work on this is now complete.

2-3 Manufacturers' LST Designs

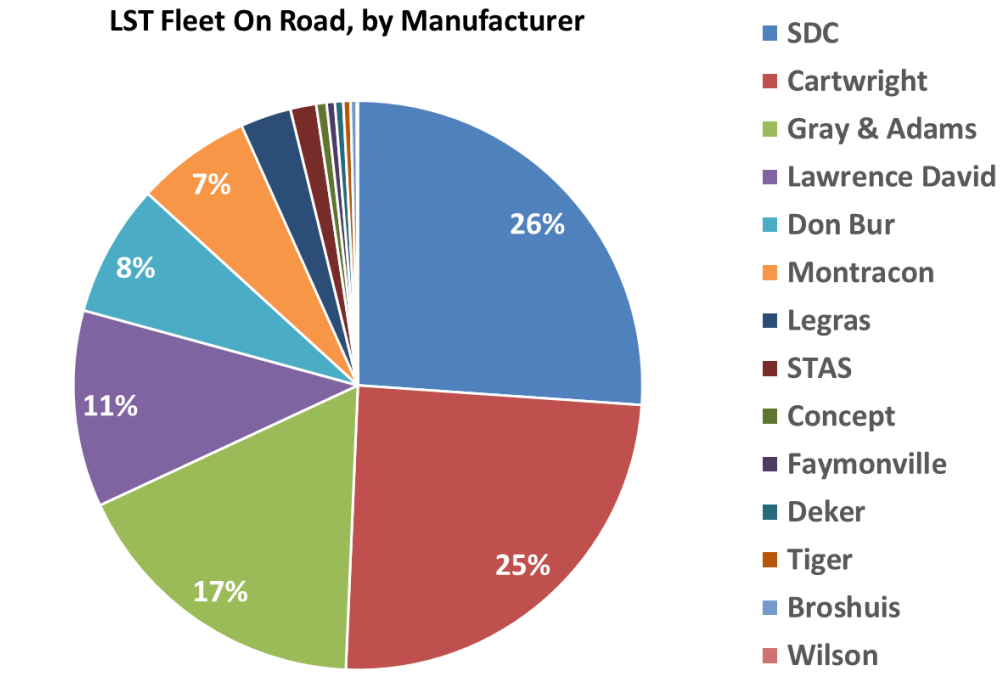
Operators have commissioned LSTs from 14 manufacturers

2.9 At the time of writing, 14 manufacturers have constructed LSTs – see Figure 2.

2.10 LST designs have emerged from manufacturers or bespoke requirements of users. The numbers of each design has been driven by market demand.

2.11 The main UK manufacturers have been responsible for construction of most LSTs. Thirty four LSTs came from manufacturers who have built fewer than ten LSTs each.

2.12 Most LSTs are single deck box/curtain sided designs. More detail is given in Section 3



Source: LST Trial data

Figure 2: LST fleet by manufacturer (at end Dec 2016)

2-4 Investment in the trial

Both DfT and operators continue to invest in the LST trial

2.13 DfT's financial commitment under the trial covers: project management of the trial; the time required by VCA for the testing of LST designs prior to issue of a VSO; and the contract with Risk Solutions for independent evaluation support.

2.14 The decision that the trailers would be funded by the market, without any subsidy from public money, was one of the drivers for setting the trial up as a ten-year programme.

[9] Each LST design is tested by VCA to ensure it conforms to the requirements laid down for the trial by DfT. This includes a practical test of the turning circle requirements, on-the-road tests of performance and stability, and measurements such as the cut-in and kick-out (tail swing) of each design under a pre-defined set of turning and speed conditions.

2.15 While the take up of allocations was initially slower than DfT anticipated, take up during 2012-13, and the oversubscription of the later allocation processes, suggest that many operators see a good business case to justify investing in the trailers. Quantitative research carried out during 2016/17 confirms this (see para 4.46 onwards), as does the quantitative analysis of efficiency gains discussed in Section 6.

2-5 Evaluation framework

The core data requirement and evaluation framework has been stable since 2013

2.16 A major policy input by DfT was definition of the original data requirement, which was first drafted in December 2011. Risk Solutions and DfT rationalised the data requirements to just those data elements for which DfT could see value[10]. This formed the first version of the data submissions to be completed by operators and, with two minor changes, remains the basis for data collection today. The key submission files and processes are summarised in Risk Solutions developed MS Excel templates and user instructions for use by operators to collate the data. The latest versions are available on the DfT website[11].

2.17 In 2016 an additional qualitative and semi-quantitative survey was run (the QSF2 survey) this collected information to provide a deeper understanding of the way in which operators are making use of the trailers, a check on our summary of their individual company efficiency in using the trailers and a focus on their plans for the future.

2.18 The data gathering processes provide for basic reporting of trial statistics after each four month data collection period, reported to DfT.

2.19 The general data analysis is expanded and refined as the trial dataset grows, which will permit finer segmentation and cross-referencing of findings. Where appropriate these deeper analyses will draw on experience from outside the project team or from special topic studies involving selected volunteer companies from among the trial participants.

2.20 The annual reports contain the public analysis of the data.

[10] DfT's rationale and justification for each data item is described in Appendix A1 of the 2014 Annual Report.

[11] The latest trial data process templates, user guide and management summary are available on the DfT website at https://www.gov.uk/government/publications/longer-semi-trailers-trial-data-guidance-and-documentation.

LST data submissions and process

Company Information File (CIF)

This is submitted once only, when the operator enters the trial (when their first VSO is granted). The CIF includes information about the size and nature of the operator's business and their non-LST semi-trailer fleet.

Qualitative Survey File (QSF)

This is submitted when the operator enters the trial and then optionally at later times. The QSF contains open questions about the experience of the company, its staff and clients in operating the new trailers.

From time to time we may run additional surveys to collect qualitative and semi-quantitative information from operators using a modified QSF process. Such surveys may seek for example: feedback from operators once they have been on the trial for more than an agreed number of periods, to capture the longer term experience, information to support validation of data collected by other methods, data to support deeper analyses.

LST Data Submission File (DSF)

This is submitted every data period and covers their LST operations in that period, including:

- An aggregated **journey log** of all LST journeys on the public road network in the period. The log includes 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).

Periodic Quality Survey File (QSFx)

From time to time, with the agreement of DfT we may request operators to

Data checking and compliance management

All files submitted are checked for basic errors and inconsistencies by Risk Solutions:

- comments and requests for revisions are sent back to the operator, **OR**
- an 'Accepted' email is sent, signifying the completion of the process.

All three sets of data are collected using MS Excel templates provided by Risk Solutions.

The submission process and all communication with operators is managed using a CRM (Customer Relationship Management) system called 'Gold-Vision', installed and tailored to the needs of the trial by Risk Solutions in 2015. The Gold-Vision system is only accessible to the project team members in Risk Solutions. The company contact data and some summary submission progress charts are accessible to the DfT trial project team.

A full description of the data requirements and framework, including DfT's original rationale for each data field is available in past annual reports published on the DfT website. The website also contains the current version of the data templates and the user instructions.

https://www.gov.uk/government/collections/longer-semi-trailer-trial

Figure 3: LST Trial - data submission framework and process summary

3 TRIAL ACTIVITY AND PROCESSES

3-1 Establishing the LST fleet

The full LST trial fleet is now on the road or a VSO

3.1 We track the growth of the fleet in two ways:

- the number of LSTs known to be on the road by the date on which they appear in the journey logs submitted by the operators.
- the number of LSTs on VSOs. VSOs are granted before or during manufacture, some time before they appear on the road.

3.2 Table 2 shows the size of the fleet at the end of December 2016 (the trailers in the data analysed by this report).

Table 2: LSTs on the road/VSO

	On the road	On VSO
At end Dec 2016	1,775	1,806
Source	*LST Trial Data*	*DfT/VCA Data*

3.3 Note that the figure of 1,775 'on the road' is an underestimate as it counts only those trailers for which we had data submitted. A small number of operators have not yet submitted data for all their trailers – any trailers on the road after 31 December 2017 will not be included in the dataset although they may already be included on a live VSO.

The projected LST fleet is now large enough to meet the data analysis requirements of the trial

3.4 When the trial was launched, DfT set a goal of 1,800 LSTs – around 2% of the UK semi-trailer fleet at the time - based on an estimate of the minimum number of trailers that would be needed to generate data to ensure the findings were sufficiently robust to inform policy.

The most common LST design is 15.65m box or curtain sider.

3.5 Figure 4 shows the growth of the LST fleet from the start of the trial to the end of 2015.

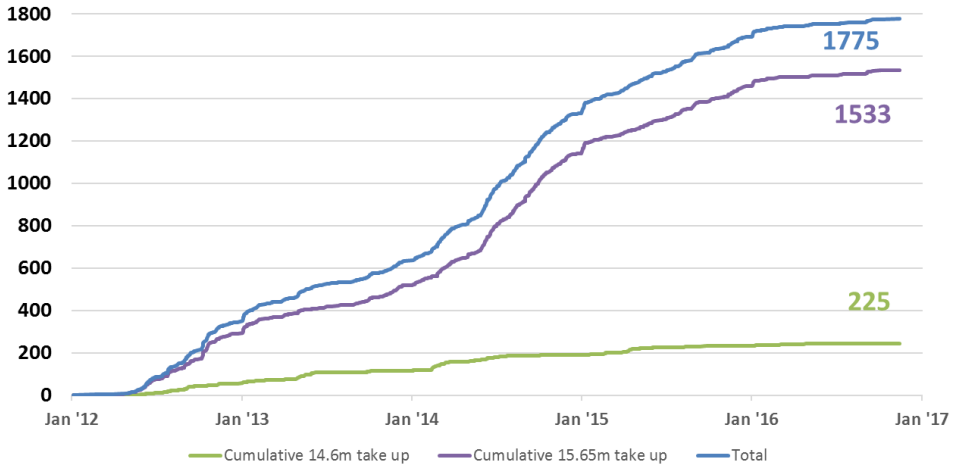


Figure 4: Growth of the LST fleet 'On the Road' (from journey logs)

Source: DfT trial data

3-2 LST designs in operation

3.6 Figure 5 to Figure 8 show a summary of the LST fleet mix by major design features[12].

Figure 5: LST body design mix

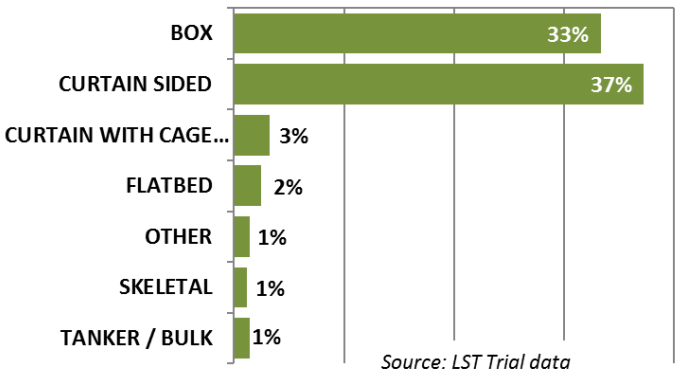


Figure 6: LST deck layout mix

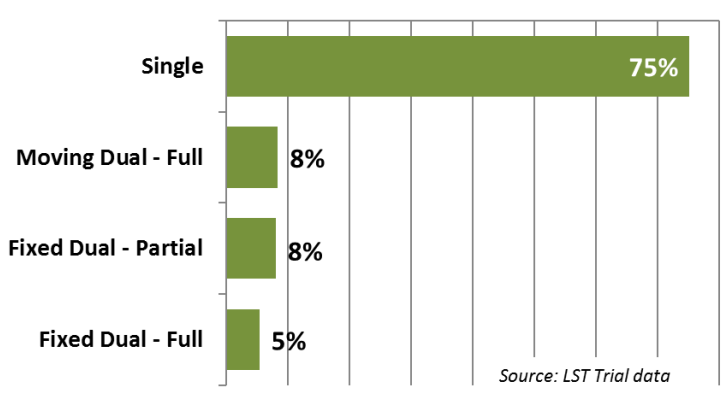


Figure 7: LST steering design mix

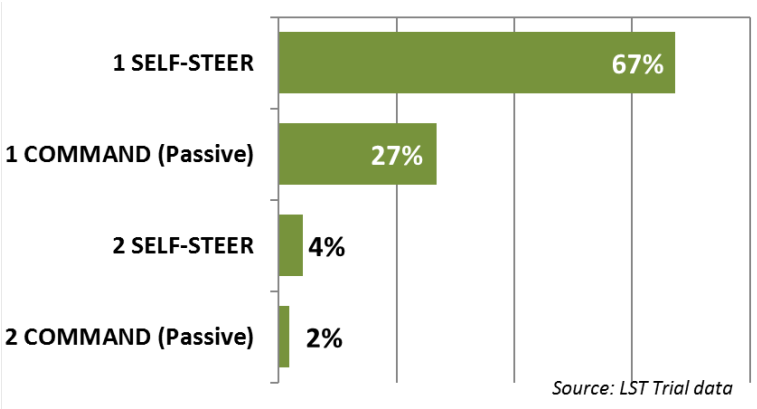
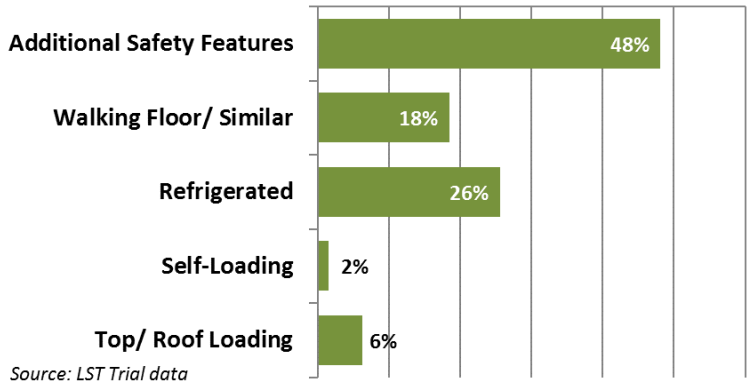


Figure 8: LST other features mix



Source: LST Trial data

[12] Further details of the design mix categorisation and the history around the choices of steering arrangement can be found in earlier trial annual reports – see 7.

The most common steering arrangement is a single moving axle (94%)

3.7 When the trial was first launched, some designers suggested that to pass the required turning circle test, two steering axles might be required. Early in the trial, manufacturers demonstrated that this was not the case and most of the trailers produced have either a single self-steer or command steer axle. The few LSTs with more than one steering axle are a handful produced at the very start of the trial, or flatbed 'heavy haulage' trailers.

The fleet includes some dual deck, flatbed & ISO container carrier designs

3.8 Just over 30% of the LST fleet are of more specialised designs.

- Dual Deck LSTs (both flat and step-frame) are carrying low-density goods that cannot be stacked without damaging them, such as parcels or FMCG[13] pallets. There is one Triple Deck LST, designed to carry very low density products (toilet rolls).
- LST ISO carriers have been developed by a single operator for use on their road-rail operation. They also designed a matching '50 foot' ISO container. These designs have been widely reported in the trade press[14].
- LST flatbeds / low loaders are largely being used for specialist heavy haulage or vehicle transport. They are generally telescopic with a 'pin' that fixes them at 'LST length'. They often make their return leg 'retracted' to 13.6m, these legs do not therefore appear in the trial data. On other occasions, they might be extended beyond 'LST length' in which case they would operate as specialist loads with a journey specific VSO outside of the trial.

3.9 While the results from the dual deck trailers might give a usable sub-set of data for analysis, the numbers of flatbed and ISO carriers mean that we can only elicit qualitative insights into the potential for such vehicles, as the numbers of journeys will not yield statistically meaningful insights for these specific designs.

60- 70% of the LSTs can be tracked using GPS/Telematics data

3.10 We updated our information on the number of LSTs with GPS tracking as part of this year's QSF2 survey. At the time the data for this annual report was 'frozen" we had received QSF2 responses from 92 operators. The remaining operators are being followed up so that we can give a more complete analysis in next year's annual report.

3.11 Based on the operators who have responded to the survey to date, 39% of operators representing **70% of the LST fleet are now able to track the location of their LSTs**, either with a GPS on the trailer itself or linked to a GPS on the tractor unit. More conservatively, dividing the 834 trailers we know can be tracked, by the number of trailers in operation with those companies sent a QSF2 (1,691[15] trailers) we can say that we currently know that 60% of the entire LST fleet should be trackable.

3.12 This is much higher than was declared by the earliest trial participants in their initial QSF submissions from 2012 onwards. From conversations with operators we know that the expansion in the use of GPS, particularly on trailers, reflects later LST orders being fitted with GPS at manufacture. We also know of some larger and mid-sized operators back-fitting GPS to LSTs or to their entire trailer fleet.

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[13] FMCG – Fast Moving Consumer Goods

[14] The skeletal trailers built to carry a 50 foot ISO container have been reported on several times by Commercial Motor and Motor Transport during the past

[15] The total here is not quite all of the trailers known to be on the road as a few companies were not sent a QSF form to complete because at the time it was issued, we were still awaiting their early 2016 data.

LST QSf2 Question Q3-2a. Do your LSTs have…	No. of ops	No. of LSTs	No. of legs	Total mvkm	% of operators	% of LSTs	% of km
GPS on the trailer itself	16	536	337,638	36.7	17%	45%	49%
GPS on the tractor unit with a trailer reference (allowing trailer locations to be tracked)	20	298	151,488	16.1	22%	25%	22%
Total Tracked	**36**	**834**	**489,126**	**52.8**	**39%**	**70%**	**71%**
GPS on the tractor unit, but not able to link to trailer ID	43	319	167,887	22.4	47%	27%	24%
GPS tracking not currently used in our company	13	41	30,573	3.4	14%	3%	4%
Totals for those responding to survey by Feb 2017	**92**	**1,194**	**687,586**	**78.6**	% values expressed as % of the 92 ops, % their LSTs and % of their km		
Survey not sent (no 2016 data at time survey ran)	5						
No response at time of writing to survey	65	497	176,118	28.9			
Totals	**162**	**1,691**	**863,704**	**107.4**			

Figure 9: Information on operators use of GPS for tracking from the QSF2 survey

(Results at time of writing from 92 responses out of 152 invited to participate)

3.13 Higher levels of GPS data usage to generate the journey logs gives us greater confidence that the legs are being properly recorded. In checking the data we can clearly see the improvement in data quality where it is derived from GPS downloads. Increased GPS usage also helped many operators with the requirement to report full postcodes for start/end from January 2016.

3.14 We would emphasise that while the use of GPS has benefited the trial by providing better data quality, **we do not have access to the GPS raw data**. Provision of such data was not part of the operator undertaking signed by the participant because when the trial started in 2012 separate GPS tracking of trailers (as opposed to tractor units) was not widespread and DfT judged that to have placed such a tracking requirement on the operators would have been considered an unreasonable burden on the industry and may have excluded smaller operators from participating, limiting the coverage and value of the trial.

3.15 DfT are currently considering options for obtaining a substantial sample of GPS data for LST legs to support and refine the existing analysis. This is discussed in Section 8.

3-3 Data submission process participation and compliance

The majority of operators are submitting journey data of reasonable quality and largely on time

3.16 We have found that the majority of operators are now able to collate, clean and submit their Data Submission File (DSF) in good time.

- Around a third of operators submit files that pass all of our completeness and consistency checks without any further intervention.
- Another third pass once they have addressed minor errors found in our tests.
- Of the remaining third, the majority are cases where the operator needs to improve their process in order to generate cleaner and more consistent data. Risk Solutions spends additional support time with these operators until their data collation process becomes more mature.

The compliance management of 'missing/late' submissions is effective

3.17 In each period, around 10% of operators fail to submit or to correct their draft data by the 'freeze' date when Risk Solutions close the period to new submissions. These are followed up in a 'missing/late' process and the data is incorporated into the dataset in subsequent periods.

3.18 A ranked list of these missing/late operators is submitted to DfT each period. The ranking determines whether the issue is minor and Risk Solutions can resolve it, or that the issue is more serious and DfT action is required. The initial DFT action is simply a warning call or email.

3.19 Where an operator has failed to submit their data, or has been late over several periods, DfT will request urgent action by company directors to rectify the situation in a timely manner, or to face suspension of their VSO, effectively putting their LSTs out of service. Since the start of this 'Missing/Late' process in 2013, only 4 such 'Cat 1 DfT warnings' have been issued and in each case the company has responded with appropriate action before further action was required.

3.20 **As the trial progresses, Risk Solutions and DfT will consider challenging non-compliance earlier, especially for operators who have already been on the trial for several periods, in order to reduce the support resource being taken up with missing/late cases**

The data checking process now includes an automated 'sequence' validation

3.21 Risk Solutions is continually improving our in-house tools to check data submissions for consistency and completeness. Robust checking as the data arrives, allows us to go back to the operator for corrections while the data is still current and fresh in their minds.

3.22 During 2015 we have added a test that examines the sequence of journey legs for each trailer in the submission. It checks for missing legs or errors in the date, time or origin / destination data. The test cannot be perfect, due to the multiple data entry errors that could lead to an apparent sequence problem[16]. However, it does allow us to highlight possible errors that the operator can correct using local operational knowledge. The test was introduced in 2015-P2 and operators are now asked to review the file if the

[16] For example, if a leg appears not to fit the sequence of the legs before or after it, the error could be that the trailer ID is wrong, or the date, rather than the data stating the original and destination.

sequencer flags up a significant proportion of issues associated with journey legs recorded in the file[17].

Raw data submitted by operators remains confidential

3.23 All datasets submitted by trial participants contain commercially sensitive data and are held securely on Risk Solutions servers or the encrypted computers of the project team. The data files are only accessible by members of the team who have a project-related reason to do so. Risk Solutions does not make raw data available to DfT or any third parties.

Participant engagement remains high

3.24 Risk Solutions continues to support trial participants in setting up efficient data processes and advising on possible improvements, based on good practice across the trial.

3.25 In general, engagement with operators continues to be positive with both managers and direct data contacts demonstrating good intent and a conscientious approach to data gathering. Where problems have arisen and more senior staff have become involved, this has also been done efficiently and without loss of relationships in almost all cases.

3.26 The Freight Transport Association (FTA) has generously organised three LST trial industry forums since 2012, with 30-40 operators attending each event. The events have been open to all companies participating in the trial (not just FTA members) and include input from DfT, VCA and Risk Solutions. DfT and FTA are discussing the timing of further event which, in our view, should be held in 2017 if possible, to communicate clearly with the operator community as the trial expands.

Recommendation 2016-1: **Industry Engagement**	Ref paragraph 3.26
We recommend that DfT liaise with FTA, RHA and other stakeholders to arrange a further LST Trial industry forum, ideally during 2017, to communicate with the operators and retain participant engagement, as the trial enters its sixth year and the trial community is extended.	

[17] We have not set a fixed % criteria on how much of the sequence needs to appear to be wrong for us to reject the file. We may consider doing this but we currently take other factors into consideration, such as the size of the submission, the likelihood that the operator will be capable of fixing the issue and whether the errors appear to be random or systemic.

4 TRIAL OUTPUTS: LST FACTS AND FIGURES 2016

4.1 This chapter provides an overview of the key statistics for:

- The number and range of participating companies
- The extent and nature of LST operations
- The number and nature of incidents involving LSTs.

4.2 This is followed by a summary of the Qualitative Survey results.

Outputs

Participation (Number, range)

Master Data (Quality, Timeliness)

LST Operational Data Summary

LST Incident Data Summary

Qualitative Data

4-1 Trial participants' summary

4.3 The data on who is participating in the trial and the nature and size of their operations is drawn from the company information file (CIF) completed by each trial participant, usually in their first data period.

4.4 The CIF data provides background information used to group companies for analysis. It also provides a data source for later comparison of the operational patterns of LSTs to those of the existing fleet of an operator.

Table 3: Company Information File (CIF) Status

CIF Status	Finalised	Draft/Missing
At end Dec 2016	128	34
Source	*LST Trial Data*	

4.5 The status of CIF submissions is shown in Table 3. During 2016 we have focused less on collecting further CIF data and have focused more of our efforts on developing the new qualitative data survey (QSF2) to gain a deeper understanding of the way in which operators are making use of the trailers with a focus on their plans for the future.

There is a broad range of company types on the trial

4.6 One of DfT's stated intentions was that the trial should be accessible to operators of all sizes – not just large operators. Figure 10 summarises the range of companies (based on their CIFs[18]) by size, Figure 11 by the nature of their primary operations.

4.7 Figure 10 shows that the trial does include a significant number of small and very small operators. Figure 11 shows the balance between a small number of own operation fleets (retailers, parcel companies) with larger numbers of LSTs, in comparison to a large number of general hauliers with fewer LSTs each.

4.8 We note that while a large proportion of the companies are general hauliers, some of their operations are associated with long term contracts for major retailers.

4.9 The 'Other' category includes cases with very few data points or specialist trailers.

Many operators applied special LST operational measures to LST operations

4.10 One of the earliest questions to be considered by all participants is the extent to which they would constrain the use of LSTs within their operation, at least during early use.

4.11 Figure 12 shows operator responses (again based on CIFs) to a series of possible special arrangements that could have been put in place, with operators selecting as many as applied.

[18] Further details of the categorisation of companies and all other data gathering in the CIFs can be found in earlier trial annual reports – see footnote 7

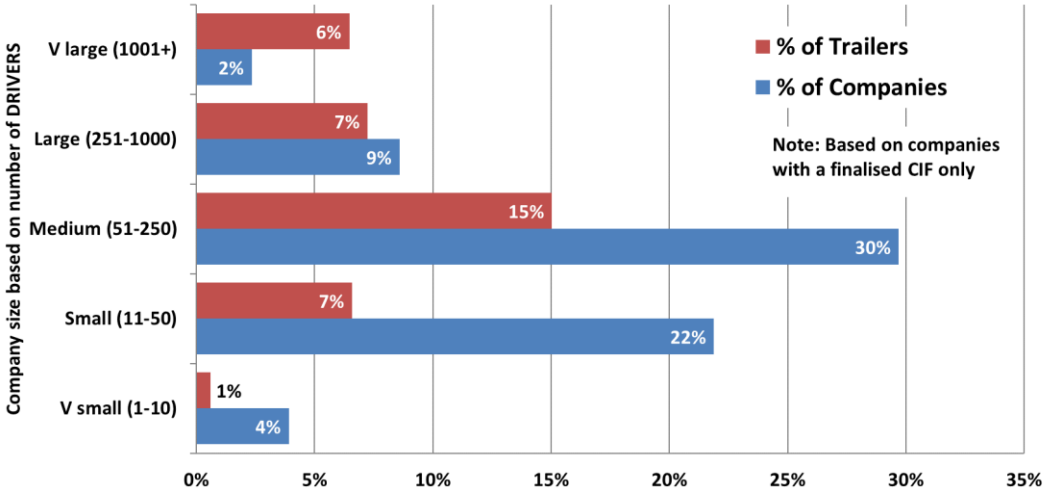

Figure 10: LST trial participants and fleet by company size

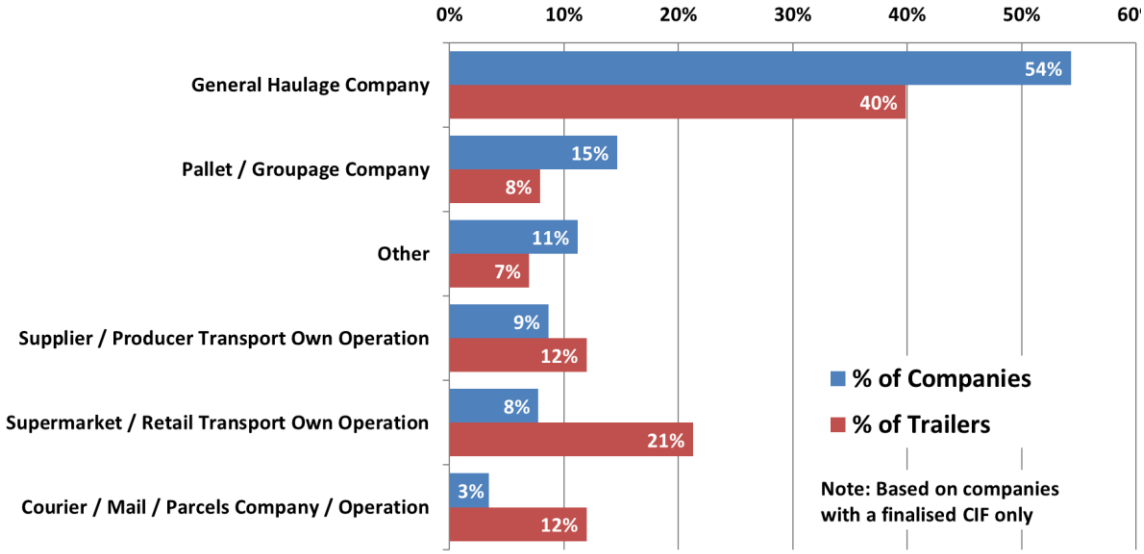

Figure 11: LST trial participants by nature of operation

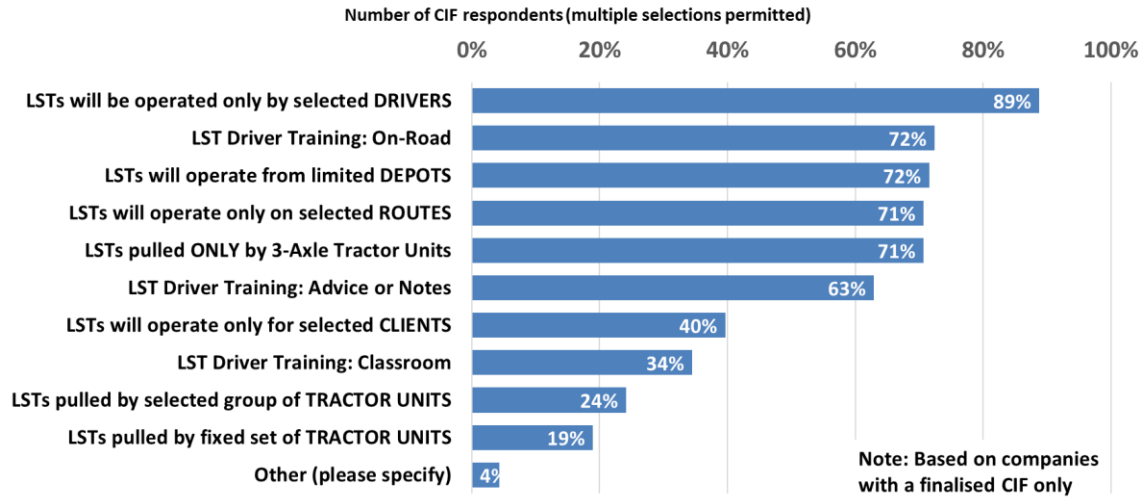

Figure 12: Special arrangements made for LST operations

Source for all charts- LST Trial data

4-2 Operational data summary

4.12 The outputs below give an overview of the operations of LSTs from the start of the trial to the end of 2016 based on the journey leg data submitted by operators.

4.13 Journeys are expressed as legs in the data, meaning a single point-to-point trip without loading or unloading stops en-route. Any multi-drop journeys with fewer than five loading/unloading points are recorded as individual legs for each part of the trip. Where there were five or more drops, the journey is recorded as a single record in the data, with the number of drops noted.[19]

Distance covered by LSTs

LSTs had travelled 319 million km by the end of 2016

4.14 The summary figures for LST operations to the end of 2016 are shown in Table 4.

4.15 The equivalent figures to the end of 2015 show that during 2016, with around 200 more vehicles on the road by the end of the year than at the start, the total mileage covered by the trial increased by over 50%. The fleet currently stands at the size originally envisaged for the trial, although a further 1,000 vehicles are now anticipated to join the trial during 2017 due to the trial extension announced by the DfT in January 2017.

Table 4: LST total km and legs

LST distance & leg count totals	To end 2016	To end 2015
Total vehicle km recorded	319 million	202 million
Number of recorded legs	2,647,018	1,727,559
Average leg distance	121 km	117 km

4.16 More than half of the distance covered by LSTs is between 'industrial' sites. Figure 13 shows that the primary uses of the LSTs continue to be in the areas anticipated in the DfT Impact Assessment[20].

4.17 The categories '3) Supplier to Distribution Centre (DC)', '4) DC to DC', '6) To/from industrial site' and '7) Palletised trunking' all relate to journeys between sites that might be considered 'industrial' - based on site access and the location of such sites in areas with lower public movement or limited public access. These legs represent 62% of all loaded distance covered and, we can assume, a proportion of all the empty distance.

4.18 In contrast, '5) To/from Retail Site' is the only leg type where we might expect operations in areas of high public movement and potential public access (on entry routes to the site). This leg type represents only 17% of the loaded distance, but by the nature of retail delivery operations, many of the return legs will be empty. Indeed, from our analysis we can infer that **retail legs represent around 30% of all distance covered and will very often include a portion which is going to or coming back from retail sites, which might be in urbanised areas**.

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[19] This approach is the same as that used in the DfT Continuing Survey of Road Goods Transport.

[20] Op Cit. Page 31 and Page 40 Table 5 of the impact assessment lists the categories of journeys which were assumed to see transfer of loads from regular 13.6m trailers to LSTs were the longer trailers to be generally available. This is a direct comparison of the percentage swaps since the table relates to assumed transfers of loads across the entire market.

The vehicle km are dominated by FMCG goods and other goods moved in cages or on pallets

4.19 The nature of the transported goods is shown in Figure 14 and the mode of appearance (MOA) is shown in Figure 15. These are dominated by FMCG goods and other goods moved in cages or on pallets.

Figure 13: LST km by journey type

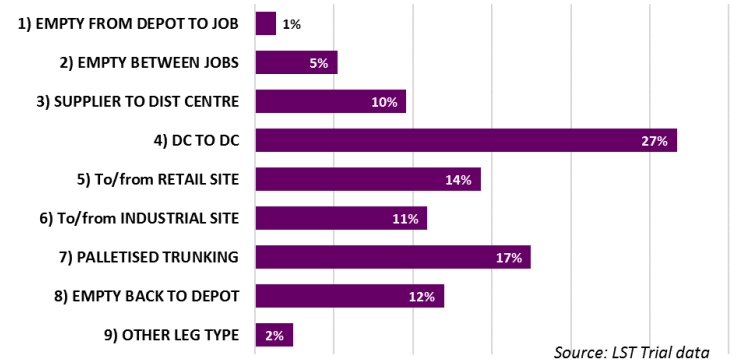


Figure 14: LST km by goods type

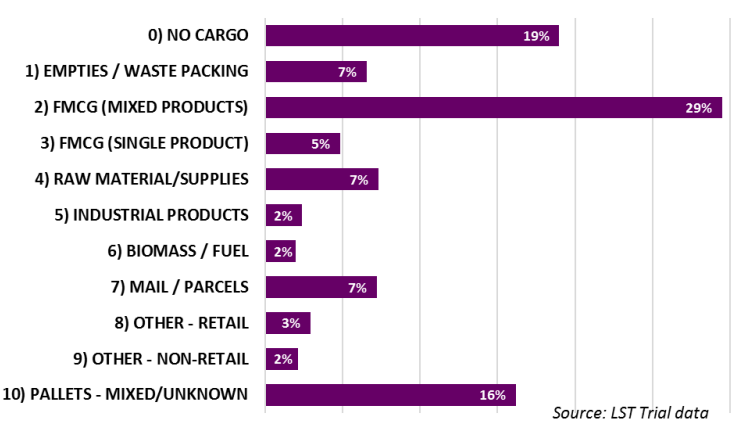
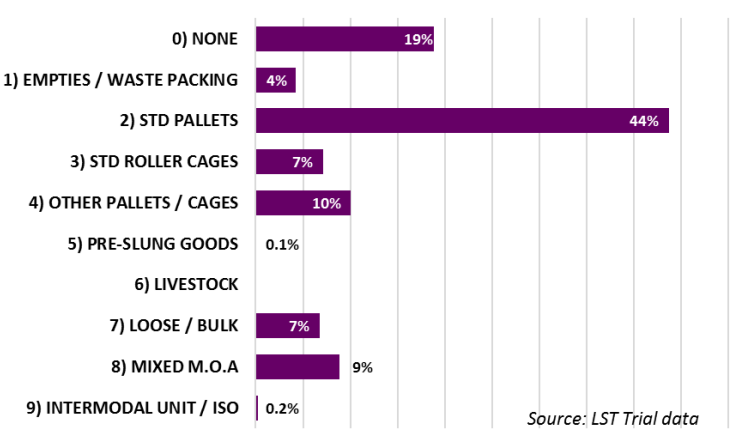


Figure 15: LST km by mode of appearance (M.O.A.)



4.20 There is a special case in which the **percentage** deck space gained by adding the additional length is greater than that for a single decker. Some of the dual deck trailers (both regular and LST lengths) have a profiled front edge to their roof, to offset the drag from the increased height required to make use of the dual decks. This reduces the loading space at the front of the upper deck, meaning that the total usable deck space is not double that of an equivalent single deck trailer. This means that as a **percentage**, the gain resulting from extending a trailer with a profile front roof, is greater than for an equivalent square fronted trailer, since the whole additional length is at the rear where the load area is full height. This potential further gain is noted, but no special additional benefits have been claimed for such trailers in the utilisation calculations in Section 5

Empty running of LSTs is 2/3 that for regular semi-trailers in the same period

4.21 The LSTs ran empty for around 18% of the total distance they covered, considerably lower than the figure of around 29% for all GB articulated HGVs in 2013-2015[21].

4.22 The lower empty running rate reflects the extent to which the trial participants are placing the LSTs on operations where there is more limited empty running, such as trunking and depot to depot routes. These are the operations where the routes are familiar to the planners and drivers, are most easily pre-assessed as being suitable for LSTs, and where the return on investment for the additional cost of an LST can be most clearly demonstrated.

4.23 The reduced empty running is evidence that many of the trial operators have such work available on which they can deploy the LSTs efficiently, making use of the additional length on both outbound and return legs.

Utilisation

4.24 Utilisation data is gathered by both deck % and volume %[22] to give both perspectives on how well the total load potential of the trailer is being used.

4.25 We also record whether the load was 'weight limited' so that we can identify cases where the deck or volume is not being used because no additional weight can be added, rather than because no further goods were available. Only 2.6% of legs are noted as being weight limited, as may be anticipated as LSTs are primarily of interest to those hauling lower density – higher volume goods.

4.26 If a significant proportion of a company's LST legs were to be weight limited and showed low deck % figures, it would call into question the value of using LSTs for that operation.

LSTs have been 100% full for 34% of their distance travelled

4.27 Figure 16 shows the utilisation by deck space covered.

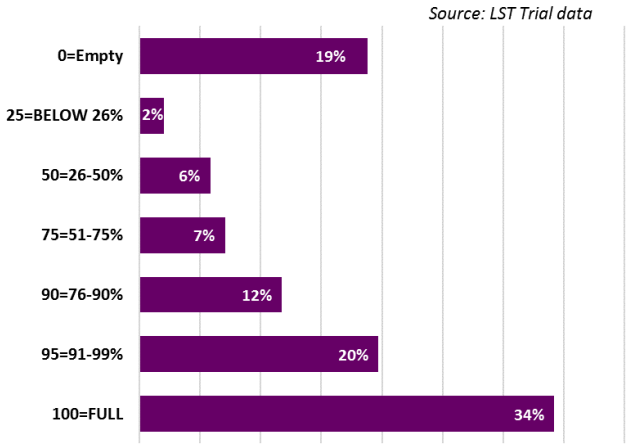


Figure 16: LST km by Deck% covered

4.28 The operators are instructed that they may record a trailer as 100% full if they could not load another 'unit' of goods (i.e. 1 more cage, 1 more pallet etc.)

4.29 The figures for 100% full journeys contain some conservatism as data for 2012-2013 did not include a distinct 100% category.[23]

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[21] Source – Road Freight Statistics for 2015 Table RFS0117 Percentage empty running and loading factors by type and weight of vehicle: annual 2000-2015.

[22] The values are expressed as % of the total deck space or volume, in many cases calculated by the operator using the number of standard pallets of cages loaded compared to the maximum possible.

[23] Annual Report 2014 (footnote 1) Appendix E, paras 22-30 for explanation of the changes made in 2014. Para 28 and 29 explain the conservative assumptions made in back-fitting the revised rules to earlier data for some operators.

The additional length of the LSTs was in use for around 54% of the total distance covered

4.30 As a rough measure, any journey with Deck % > 90% is making some use of the additional trailer length, i.e. the bottom two categories on Figure 16 giving a total of 54%.

4.31 Section 6 includes a detailed analysis of the deck % utilisation data and what it might mean in terms of a reduction in vehicle km compared to the same work being done on 13.6m trailers. The calculations also take into account the potential saving of empty legs where some entire 'round trip' journeys are saved by using LSTs.

4.32 Figure 17 show the utilisation by volume filled. which although important is not the primary focus of the analysis at this stage.

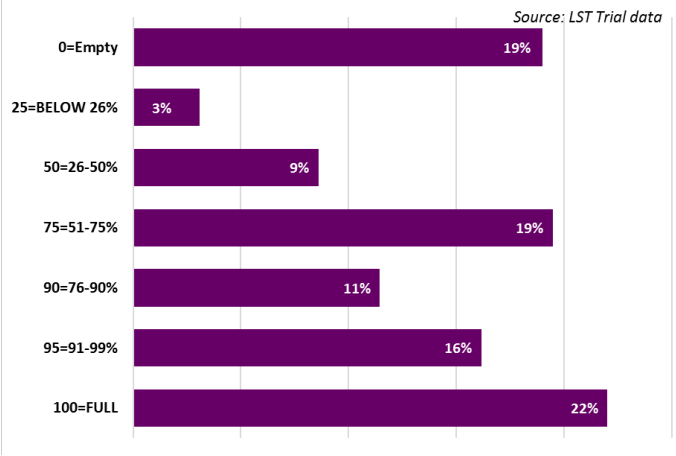


Figure 17: LST km by Volume% filled

4.33 We have not yet attempted any analysis s by volume %. This will require consideration of different types of operation and trailer type. For example, an assessment by volume needs to consider the trailer design:

- For refrigerated trailers, a free space of perhaps 20-30% of the volume may be required to permit circulation of the air and hence for such trailer designs, a figure of 70% may be regarded as 'full' by volume in analysis.
- For flatbed trailers, volume fill is not measurable in a meaningful way and so volume analysis will need to exclude these units.

Utilisation results check

4.34 As part of this year's QSF2 survey we sent out individualised summaries of our utilisation analysis to each operator, presenting them with their own results to check whether they broadly agreed with the summary. The options given in the survey (Question 4-1a) were whether our utilisation summary was:

- *More optimistic (higher utilisation) than you would have expected*
- *Broadly in line with what you would expect to see*
- *More pessimistic (lower utilisation) than you would have expected*

4.35 As already reported, at the time the data for this annual report was frozen we had received QSF2 responses from 92 operators. Of these, 86 agreed that our data was "broadly in line with what they expected to see" – with a few operators checking our results precisely matched their internal analysis.

4.36 No operator judged our analysis to be overly optimistic. Where the operator judged our data was pessimistic – just six cases - we have discussed the causes with them. In one or two of these cases, further conversation showed that they were being overly

conservative in their submission estimates of utilisation and plans made to adjust their approach to estimation.

4.37 The survey question also invited a narrative comment. In a few cases this revealed that the operator interpreted the question as comparing the results with their initial expectations at the start of the trial. Where possible we contacted the operator and explained the question, resulting in some amended submissions.

4.38 In summary, we are confident that the utilisation estimates are sufficiently robust to be used in the calculation of LST operational efficiency and the numbers of journeys saved, on the trial reported in Section 5.

4-3 Incident data summary

The analysis of incidents involving LSTs is a primary objective of the trial.

4.39 The low incidence of road traffic collisions involving LSTs on the public highway (both anticipated and actual) is one of the reasons the trial needs to collect data for an extended period of time. This is necessary to allow us to analyse trends or contributory factors to risk in a statistically meaningful way to inform future policy decisions

4.40 The primary focus of analysis at this stage is to assess whether or not there is any emerging evidence from the trial about the relative safety risk performance of LST operations compared to standard length trailers.

4.41 Figure 18 provides a summary of the incidents involving LSTs, reported by operators

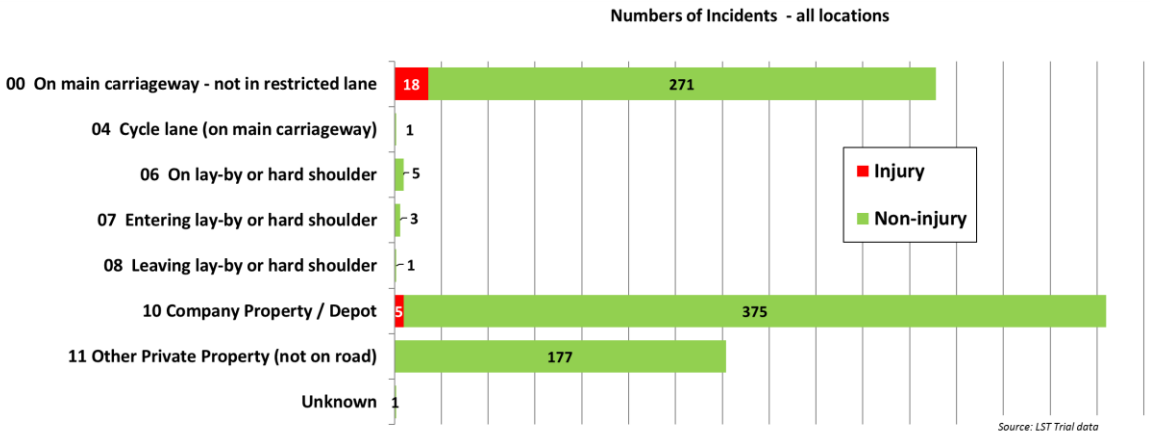


Figure 18: Incidents reported involving LSTs (Summary to end 2016)

There have been 23 injury incidents involving an LST reported of which 18 took place on the public highway

4.42 A detailed analysis of the incident data and resulting casualty figures is reported in Section 6.

4.43 Also in Section 6, we will discuss the question of whether incidents were 'LST Related', i.e. was the fact the trailer was an LST a factor that influenced either the occurrence or outcome of the event.

There are have been 834 non-injury incidents reported of which 234 were on the public highway and caused any damage

4.44 As in previous years, the quality of damage only incident reporting in depots and on other private land is highly variable. This is not surprising as it is not a requirement of trial participation. Some operators simply take the approach of reporting everything – others just the minimum required.

4.45 Of the 834 non-injury events reported, 282 were identified by the operator as occurring in areas they considered public and 234 were reported as resulting in damage. As with the safety incidents, more detailed analysis is presented later (see Section 7).

4-4 Qualitative surveys (1 & 2) summary

4.46 Since the start of the trial, all operators have been asked to complete a Qualitative Survey File (QSF1) which covered a number of areas of their overall experience of introducing LSTs into their operation and their subsequent use. It allows space to record both the benefits they are realising from running the LSTs as well as any challenges they have faced. It therefore provides evidence that can contribute to 'lessons learned', which might benefit future companies who decide to operate LSTs.

4.47 The QSF1 is usually completed at the end of their first or second period on the trial and so was a snapshot of their 'early' experience. It contains six open questions about the experiences of company participants in the trial, their staff or clients. In the 2015 annual report we presented analysis based on the first 111 QSFs received. As a relatively small number of operators joined the trial in 2016, the results of the QSF survey completed as companies join the trail, have not been updated since the 2015 annual report was published. Full details of the results of the survey can be found in the 2014 and 2015 reports[7] and are summarised here:

- Most operators reported no problems incorporating LSTs into the existing operation - Operators reported no significant issues in loading or driving. A small proportion of operators reported issues around negotiating **client** depots and a few noted 'other' issues.
- Most operators provided or insisted on LST specific driver training in advance of operating LSTs.
- The majority of operators stated that they did not make any special preparations (other than the driver training) in advance of operating the LSTs. Outside the QSF process, we are aware of operators who have made operational adjustments once they have gained some initial experience of using the LSTs, in particular, by arranging for them to be placed at the end of a line of loading bays at a depot.
- Just over half of respondents noted some self-imposed restrictions for LSTs, the most common being approved routes only and certain client depots. Others said they would not have to impose additional constraints as the nature of their general operation (for example, palletised trunking) is already suited to LSTs.
- It is worth noting that some of the companies who did impose some restrictions, did not see this as a problem, but simply a reflection of choosing to operate the LSTs in the most efficient or cost effective way.
- Feedback received by respondents from their key stakeholders (mainly drivers) was positive.
- Asked about the overall impact on their business replies were again positive:
  - Increased commercial returns
    "Excellent - an additional benefit to the operation and reduced costs and maintenance"
  - No problems-excellent
    "Overall the new trailers are ideal for the trunking work we do on the pallet network"

    "Excellent, they drive like any other trailer and even better than a wagon and drag"

- Reduced carbon footprint
  "Extra revenue for carrying goods and lower CO_2"

4.48 In December 2016, we launched a new qualitative survey (QSF2). We issued 157 invitations and received 92 useable responses by the time the data was 'frozen' for this report. The remaining responses are being followed up and an updated summary will be given next year.

4.49 The survey was designed to gather mostly qualitative and semi-quantitative information to help validate information and analyses carried out using other sources of information, and to inform further analyses. The results are reported elsewhere in this report.

4.50 The survey also provides an opportunity for operators to feedback some narrative about their experience of operating the LSTs from the perspective of a range of staff and the business as a whole. There is a small overlap between some of the areas covered in the QSF and those noted in the CIF.

4.51 The responses to the open question were consistent with those received in response to the QSF1. Specifically:

- A clear majority of operators reported positive experiences with the LSTs. Of these many mentioned the extra carrying capacity being cost effective.

  "we have seen a significant benefit by using the longer trailers both in overall operational efficiency and as a pure cost saving. If the opportunity arose, we would be interested in adding more of this type of trailer to our fleet"

  "Overall positive experience, increased capacity which in turn has reduced costs and given us greater flexibility."

- Other positive comments included: ease of handling and helping to meet corporate CO_2 targets.

  "on normal road driving the feedback I have received is that the trailer follows the tractor unit better that a standard trailer."

- Almost two thirds of the operators said that they restricted operations to set routes, either to maximise utilisation of the trailers (e.g. by running them on routes where they could use the extra space on all legs) or to avoid destinations where there were known access problems.

  "Good value for money once dedicated routes are formed"

- A number noted that the trailers were not suitable for ad hoc, or general operations because of access problems. A small number said they had carried out risk assessments and discussed operations with clients to make sure they could maximise utilisation.

  "They don't suit deliveries to a changing customer base (due to the various nature of the delivery site dimensions for example)."

  "General experience is good - not experienced any great operational issues provided routes, loading and unloading points are surveyed for suitability in advance."

- Where operators reported problems these mainly related to the access difficulties. Other issues raised included: the capital cost of the trailers, experience of, or fears of increased maintenance costs due e.g. to rear axle steering leading to extra tyre wear, and driver training requirements restricting their operation.

  "We have experienced issues with delivery areas for these vehicles and also manoeuvring them."

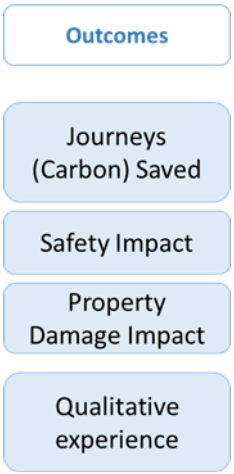
- Two operators noted negative experiences because of the data requirements of the trial and two because the type of work they had purchased the trailers for had reduced.

  "cut backs in local authority spending and customer load profile changes has meant the trailer has become almost redundant. We do try and use it on our general haulage operation but find it very difficult to utilise. The main problems are the weight carrying penalty of a standard trailer and manoeuvrability in tight spaces, although on normal road driving the feedback I have received is that the trailer follows the tractor unit better that a standard trailer."

  "No regrets in having our three LSTs as part of a mixed fleet. They have come in good use. Would not plan to expand the number at present due to hassle of buying and supplying data."

PART 2: TRIAL OUTCOMES AND CONCLUSIONS

We are interested in four anticipated outcomes of the trial:



1. The analysis of **potential savings in journeys and distance travelled** (and hence carbon emissions) is important as it provides a measure of the carbon savings being realised in real operations. This analysis is covered here in Section 5.

2. The analysis of **personal injury incidents** is vital to establish whether there are any indications that LST operations are increasing **safety risk** (relative to other traditional trailers), particularly to other road users and vulnerable groups. This analysis is reported in Section 6.

3. The analysis of **non-injury incidents** seeks to assess the **damage to property**, (infrastructure or other vehicles) caused by LSTs in comparison to other trailers. This work has been expanded since last year and is reporting in Section 7.

4. The outcomes in **qualitative experience**, based on the original QSF1 responses and the recent QSF2 survey. These have been used to inform analyses throughout this report.

Our analyses continue to develop and are refined as the trial dataset grows. This enables us to explore finer segmentations and cross-reference more findings each year.

Where appropriate these deeper analyses draw on experience from outside the project team or from special topic analyses involving selected volunteer companies from among the trial participants.

5 TRIAL OUTCOMES 1: DISTANCE / JOURNEYS SAVED

5.1 This section of the report deals with the analysis of LST distance/journeys saved compared to delivering the same goods using standard length trailers. The analysis of potential savings in journeys and distance travelled (and hence carbon emissions) is important as it provides a measure of the carbon savings being realised in real operations.

5-1 Expressing the extent of use of the additional deck length

5.2 The fundamental measurement in the analysis of how efficiently the LSTs are operating, is whether the additional length is being used, based on the declared 'Deck%' data reported by operators in the DSF.

5.3 The analysis classifies legs that are estimated to be using more than the standard 13.6m UK trailer length as being **'Fully Loaded'**, meaning they are using some or all of the additional length of the LST. To be clear, this 'Fully loaded' term is just used as a 'shorthand' for the analysis. It does not mean that all trailers where part of the additional length is filled are counted as 100% full. The actual extent to which that extra length is being used is calculated as part of the analysis for every LST leg, based on the deck % utilised, combined with the information on the length of that trailer.

5.4 There are two main categories of semi-trailer operated in the trial, trailers up to 14.6m in length and trailers up to 15.65m in length. The additional length in each case is used to assess the extent of the additional loading as a percentage of a 13.6m trailer load. Of the trailers put into operation during the trial to date 85% have been 15.65m length.

5-2 Distance saved by using LSTs

Since the start of the trial, the use of LSTs has removed between 15 and 18 million vehicle kilometres of freight traffic from the roads of Great Britain. This equates to removing around 125-150,000 journeys by the 13.6 metre trailers which are the longest standard articulated HGVs currently allowed on our roads.

5.5 One of the purposes of the LST trial is to understand the environmental impact of the LSTs. Table 5 shows the cumulative vehicle kilometres saved during the trial.

5.6 The vehicle kilometres saved shown in the tables can be converted into a simple estimate of the number of journeys saved by dividing by the 121 km average leg length recorded by vehicles in the trial. This gives us the estimate (rounded) of 125,000 (lower bound) to 150,000 (upper bound) 'journeys removed'.

Table 5: Cumulative vehicle km saved by using LSTs

Distance saved (million vehicle km)	At end 2016	At end 2015	At end 2014	At end 2013
Lower bound	15.1	8.7	4.2	1.4
Upper bound	17.8	10.6	5.2	1.7

Summary of data from Table 6 *and* Table 7 *below for 2016 figures. Earlier years from past annual reports.*

5.7 The savings calculation takes a number of factors into consideration and was described in detail in our previous Annual Reports[7]. The most important elements of the calculation are noted below.

Distance saved based on use of additional deck space on LSTs

5.8 The trial outcomes are being measured in terms of the estimated reduction in the vehicle kilometres, and hence numbers of journeys, through the operation of fully laden longer semi-trailers. This provides a good proxy for the reduction in direct environmental impact by operating the LSTs in place of standard length trailers [24].

5.9 The reduction in distance is made by comparing the actual distance travelled by the LSTs to an estimate of the distance that would have been travelled if the same quantity of goods had been transported using standard 13.6m trailers, because they would have needed to make more journeys. Quantity of goods here is measured by the Deck% utilised.

5.10 Savings are calculated only against 'fully loaded' legs (where the extra length is in use. Losses due to the additional fuel use are calculated for all legs. The detailed figures are shown in Table 6 and Table 7.

Empty legs saved

5.11 The upper bound takes account of some empty return journeys also being saved due to saving of whole round trips – loaded out and empty returns.

5.12 The lower bound represents the basic calculation, considering only loaded legs and is therefore a more conservative estimate.

5.13 Prior to 2016 we used the proxy of retail leg types to calculate this additional saving. During 2016 we improved the quality of the data and have created an algorithm to enable us to identify individual return empty legs matched to outward fully-loaded legs and assign round-trip savings to these whole trips.

5.14 We have been prudent in our calculation of empty legs saved, only claiming those where our search algorithm can directly connect the empty leg back to a related loaded leg in a simple A>B>A or A>B>C>A pattern. More complex patterns are ignored.

Additional fuel used when pulling LSTs

5.15 The distance savings calculated from the journey logs and loading data are moderated by a 'loss factor' (1.8%)[25] reducing the distance savings. This factor reflects the marginally increased fuel consumption and hence direct environmental impacts of the LSTs on all the legs travelled as assumed in the original impact assessment. This may be conservative as we have qualitative statements from operators that vary in their opinion on whether LSTs operations use any additional fuel. We are not aware of any formal comparison test of fuel consumption effects with LSTs.

5.16 We anticipate removing the fuel factor from these distance saving calculations once there is a formal emissions/air quality analysis (see Recommendation 2017-7) since the effects of any increased fuel use would be more appropriately handled there. This will further improve all the estimates of distance and journey saving given here.

[24] Assuming all other conditions are the same – journeys, mix of tractor units, traffic, road conditions etc.

[25] The 1.8% was the factor for increased energy consumption and hence tailpipe emissions in the original LST Impact Assessment.

Table 6: Distance savings to end 2016, lower bound

Source: LST trial data – Lower bound - loaded Legs Only **Trailer Length:**	**14.6m**	**15.65m**	**Total**
Total vkm for legs where LSTs are reported to be 'full'	24,235,495	155,439,263	**179,674,757**
Total vkm operated by all LSTs	45,511,162	273,696,163	**319,207,325**
Percentage of vkm operated by 'full' LSTs	53%	57%	**56%**
Range of potential saving for vkm operated by 'full' LSTs (additional load carried)	0-7%	0-15%	
Vkm saved (lower bound)	**1,339,467**	**19,556,826**	**20,896,294**
Vkm 'increase' on all LST vkm as a proxy for emissions increase of 1.8%	819,201	4,926,531	**5,745,732**
Estimated net vkm saved	**520,266**	**14,630,295**	**15,150,562**

Table 7: Distance savings to end 2016, upper bound

Source: LST trial data – Upper Bound includes some empty legs **Trailer Length:**	**14.6m**	**15.65m**	**Total**
Total vkm for legs where LSTs are reported to be 'full'	24,235,495	155,439,263	**179,674,757**
Vkm for legs where LSTs are reported to be 'full' and to/from retail site (to end 2015)	1,667,706	17,110,711	**18,778,417**
Vkm for legs which represent return empty leg of a 'full' outward bound round trip (2016 onwards)	696,861	5,377,112	**6,073,973**
Percentage of 'full' vkm operated to/ from retail sites	7%	11%	10%
Vkm saved in non-retail operations	1,264,563	17,742,374	19,006,937
Vkm savings for outward 'full' retail journeys	74,904	1,814,453	1,889,357
Total Vkm saved in retail operations (to end 2015)	149,809	3,628,906	3,778,714
Total Vkm saved in return legs of round trips (2016 onwards)	39,623	713,267	752,890
Vkm saved (upper bound)	**1,453,995**	**22,084,546**	**23,538,541**
Vkm 'increase' on all LST vkm as a proxy for emissions increase of 1.8%	819,201	4,926,531	**5,745,732**
Estimated net vkm saved	**634,794**	**17,158,016**	**17,792,809**

Notes: the term 'full' in these tables refers to any leg where the additional LST deck length was in use. The underlying calculation is based on the proportion of the additional deck space that was in use.

5-3 Journeys saved by using LSTs

5.17 The analysis above calculates total distance savings. In this section, we analyse savings as a percentage saving of distance operated and from this calculate an expression of the number of journeys saved compared with using standard length trailers to deliver the same goods.

Over the whole fleet and across the trial we have calculated that the average % distance saving is 5.3%, which equates to 1 in 19 journeys.

5.18 At this point we need to highlight the difference between our calculations and some of the headline statements used in the press and by operators – including on the trailers themselves – which state that LSTs provide "15% extra space". This 15% value is sometimes then informally translated into statements such as 'a 15% saving' or '15% fewer legs to move the same amount of cargo'.

5.19 While these headline statements are useful in conveying the scale of the potential savings, they confuse the % extra space with the % saving. The 15% value is the additional length of the trailer (or number of additional pallets) for a 15.65m LST compared to a 13.6m trailer. When estimating the saving in distance travelled or trips that would been required to move the same (actual) goods on standard 13.6m trailers, the maximum potential saving is 13%.

5.20 On this basis, on a fully loaded 15.65m LST, we would anticipate that **the maximum savings we would expect to see are** 13% (1 in 7.5 journeys) before the application of the 1.8% environmental impact factor (fuel use) or **11.5% (1 in 9) journeys after applying the 1.8% factor.**

5.21 Over the whole fleet (that is including the 14.6m, trailers) we have calculated that the **average % distance saving is 5.3% after applying the environmental impact factor,** which equates to **1 in 19 journeys** – the same as 2015.

The most efficient LST operations are saving up to 1 in 9 journeys.

5.22 This average figure masks considerable differences in efficiency of operation and levels of loading across the range of operators taking part in the trial. Figure 19 illustrates this distribution.

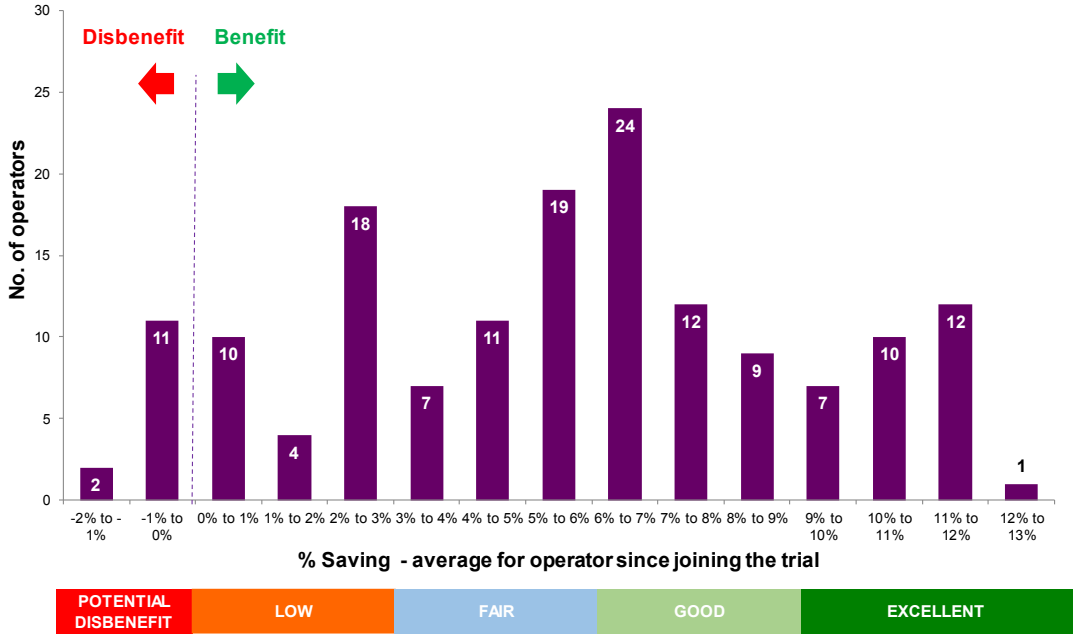


Figure 19: Distribution of % distance saved using LSTs by operator

There are a number of cases where little or no saving from LSTs is being reported

5.23 A more detailed study of the operators appearing at the lower end of the range of savings shows that there are possibly two groups.

5.24 The first group are operators where the data shows that their operation involves large numbers of 'out-full/back-empty' but we have not included these in our savings calculation as they are part of more complex operation patterns and so are not picked up by the algorithm described in paragraph 5.14. They are therefore not included in the 'upper bound' result which takes credit for the savings in numbers of return legs as well as outbound ones.

5.25 A more refined analysis of the operational patterns of operators could allow the upper-bound calculation to be applied to these operators. This would move them 'up' the savings range and the peak of the distribution in Figure 19 would move to the right.

5.26 This leaves the second group, those operators who do not appear to be making use of the additional length of their LSTs very often. A small number fall in the 'Disbenefit' section of the chart. Disbenefits arise due to the assumed additional fuel used to operate the longer trailer, while not utilising any of the additional length available in loading.

5.27 We have spoken to some, but not yet all, of these operators as part of the initial follow up to the QSF2 results noted earlier. In these cases, the common reason given was that the poor performance reflected periods when they could not find work for the trailer that consistently required the additional length.

5.28 This area merits further investigation once we have collected the remaining QSF2 results. We would want to understand why these operators are unable to make more efficient use of their trailers, as this could have implications for the overall evaluation of the performance of the trailers and their likely take-up more widely if they are approved for more general use.

Recommendation 2016-2 Ref paragraphs 5.23-5.27

Understanding low efficiency use of LSTs

Once the QSF2 analysis is completed, the scope of work for 2017-18 should include further enquiry with operators whose results suggest limited benefits from using LSTs to better understand the range of factors involved.

5-4 Distance savings checks with individual operators

5.29 As part of the QSF2 survey described above, we asked operators to consider whether our estimates of their savings from use of the longer trailers conformed with their own experiences and expectations. We did this at two levels – overall journey savings and the specific issue of how many empty legs were being saved.

Our estimates of overall journeys saved are consistently more conservative than the operator's perceived savings

5.30 The QSF2 survey explored whether our estimate of operators' overall savings through using the LSTs was in line with the operators' own experience and perceptions. In some cases their perception was a judgement, in others they had carried out similar calculations to ours to see what value they were getting from their LST fleet.

5.31 We provided each operator with a chart very similar to Figure 19 but with their own position highlighted so they could see our estimate of their savings and compare these with the overall trial fleet.

5.32 In most cases (85%) the operators considered their position on the chart to be in line with their own experiences.

5.33 Thirteen operators thought the picture we presented was more pessimistic than they were experiencing on the ground. In these cases we went back to the operators and explored with them why the data we had might not match their experience.

5.34 In several cases the operator realised they were under-reporting the utilisation of their trailers in the journey log returns. They agreed to modify their data collection processes to improve the quality of the data. This will increase the benefits reported by future trial periods for those operators, and for the trial overall.

5.35 As the remaining QSF2 results come in, we would anticipate doing more work in this area, in particular seeking to highlight cases where the operator has a perception that they are saving journeys, but the data suggests this is not the case.

Our estimates of empty-leg savings are consistently more conservative than the operator's estimates

5.36 We also asked operators whether our assumptions about round trips made with empty return legs were in line with their actual operation. Figure 20 below plots the calculated empty-leg based savings against the responses given by the operators in their QSF2.

5.37 In almost all cases, the operator's own estimate band is the same as or higher than the calculated savings estimate. This confirms that in calculating savings this way we do not appear to be over-estimating the savings.

5.38 This makes sense, because we exclude all return trips that are partially loaded when an outward fully-loaded trip has been made, and operators may consider these when thinking about the overall savings they are making.

5.39 This provided us with assurance that the upper bound calculation, where some claim is made for empty-legs saved, remains conservative.

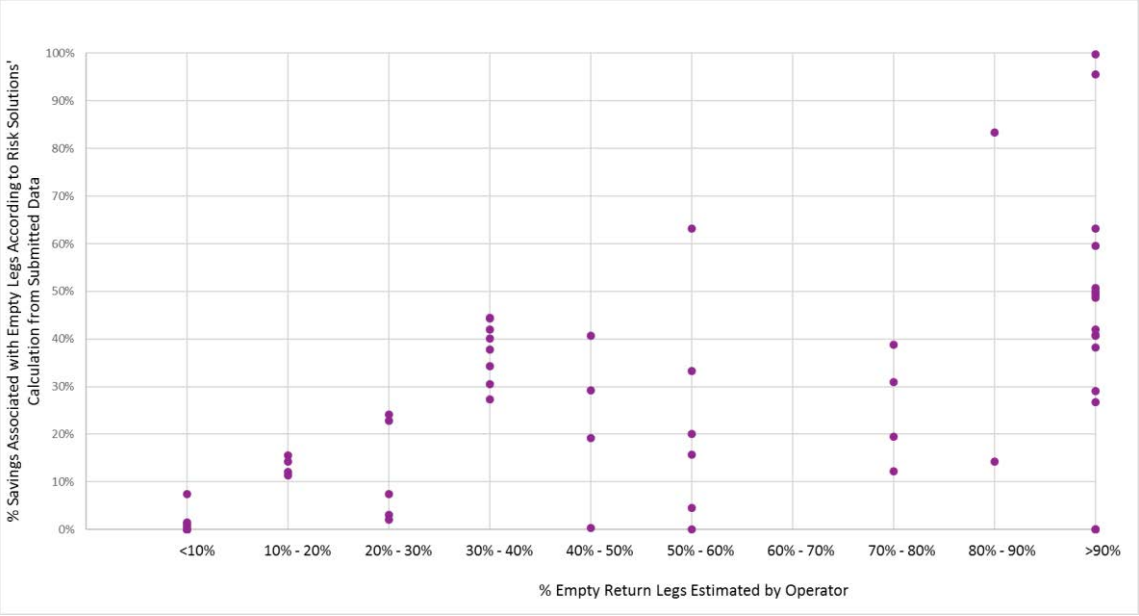


Figure 20: Relationship between calculated savings associated with empty legs and those estimated by operators

6 TRIAL OUTCOMES 2: SAFETY IMPACT

6.1 We analyse the safety impact of the LSTs in the trial by

- Estimating the absolute saving in injuries arising from the reduction in journeys
- Comparing the per km incident and casualty rates for LSTs to that published for the GB fleet of articulated HGVs as a whole. We analyse the incident rates nationally and then also for 'urban operations'.

6.2 We present the data on injuries that occurred in all locations, whether on the road or on private land (depots etc). The primary analysis focuses on incidents which took place on the public highway or in areas with public access, such as service stations.

6.3 We also review the LST injury incidents qualitatively. We examine not only the narrative given by the operator in their submission file, but in many cases we ask for further information or documents from the operator to ensure we understand the circumstances of the incident. We use this to form a view on the degree to which the incident may have been related to the trailer being an LST. However, this judgement is purely used for discussion – events that may not have been related to the presence of an LST are still included in all the primary analysis and statistical significance checks.

6-1 'Absolute' safety benefit from saved journeys: National

6.4 As described in Table 5, the additional capacity of the LSTs has been calculated to have removed between 15.1 and 17.8 million vehicle kilometres from the GB roads.

6.5 These vehicle kilometres would have otherwise been operated by the standard length HGV articulated fleet. It is therefore reasonable to calculate the additional incidents and casualties that would have been expected to occur if the trial had not taken place, by considering how many incidents and casualties the standard length fleet would have incurred over the 15.1-17.8 million vehicle kilometres. Table 8 shows the calculation.

Table 8: Collisions and casualties removed from GB roads over the trial period 2012-2016 through reduction in vkm operated

Injury incidents Public access locations	GB Artic HGV rate per million vkm	Million vkm removed from operation	Calculated incident reduction
Collisions	**0.166**	**15.1-17.8**	**2.5-3.0**
Casualties	**0.238**	**15.1-17.8**	**3.6-4.2**

Sources: LST utilisation and vkm reduction from trial data. GB rate from STATS19 and TRA3105.

If you save around 1 in 20 standard length articulated HGV journeys (5%) by using LSTs, you also eliminate 1 in 20 collisions, if all other factors remain the same

6.6 This is a small reduction compared to the hundreds of collisions involving articulated HGVs on GB roads over the trial period. However, it will become important in any future impact assessment examining the extension of LST use beyond the numbers on the trial. This potential saving in collisions would be multiplied up to apply to whatever proportion of the GB articulated HGV fleet was eventually replaced with LSTs.

6.7 Note that this 'absolute' saving in incidents from saved trips is independent of the actual number of LST incidents or whether the LST per km incident rate (discussed in the next section) 'post-trial' remains at the low levels seen on the trial, or rose to the same level as the general fleet. However, if the LST injury incident rate ever rose higher than that for the GB fleet as a whole, then it could offset this gain from making fewer journeys.

Effect of the 'fuel factor' on absolute incident saving calculation

6.8 The calculation above is slightly conservative since the distance saved figures used here were reduced by a small factor to reflect additional fuel use. The fuel factor was applied because up to this point in the trial, the distance saved was being seen as a rough proxy for the emissions savings objective of the trial. In this injury rate calculation, the fuel used is not relevant and removing it would increase the distance saved and hence slightly improve the incident reduction calculated here. We have not made this adjustment this year since the numerical change in the result will be small and we are anticipating that in the coming year there will be a formal emissions/air quality analysis that will include the issue of fuel use. When that is completed, the fuel factor can be removed from the distance saving calculations.

Consideration of road class in absolute incident saving calculation

6.9 This calculation uses the average national incident rate for standard articulated HGVs across all road types. We will be able to refine it to use national fleet incident rates by road type, if the route modelling work is extended to give modelled routes by road class.

6-2 LST injury incident 'data high level outcomes

Injury incident and casualty numbers

6.10 In Figure 18 earlier, we noted 23 injury incidents involving LSTs since the trial began. Table 9 expands on this to show the casualties associated with these events, classified by injury severity, where they were at the time and whether the event was judged to be 'LST-related'[26] - a judgement discussed later in this section.

6.11 From this table and the data that underpins it, we can note the following 'headlines'.

There have been no fatal accidents involving LSTs in 319 million km of operation.

Since the last annual report, there have been 8 additional personal injury incidents involving LSTs, resulting in 3 serious and 5 slight injuries.

Table 9: Casualties from 23 incidents involving LSTs (2012-16) reported to the trial

Injury Collisions from Trial Logs	Total Collisions	Total Casualties	Fatal	Serious	Slight
All Injuries (inc depots etc.)	**23 (15)**	**28 (20)**	0	7 (4)	21 (16)
All Injuries in Public Road/Place	**18 (11)**	**23 (16)**	0	7 (4)	16 (12)
All Injuries judged LST-related (any location)	**7 (5)**	**7 (5)**	0	0	7 (5)
All injuries – LST-related AND in public place	**3 (2)**	**3 (2)**	0	0	3 (2)

Figures in (brackets) show the totals at the end of 2015. The injury incident analysis in this report is based on all public incidents, i.e. the figures in the row outlined in RED

[26] An incident is judged to be LST-related if it is judged that the incident occurred because the trailer was an LST and would not have occurred had the trailer been a standard length.

6-3 All injury incidents in public locations - discussion

6.12 The personal injury incidents in public locations are summarised in Table 10. Note that:

- Identification of location (Urban/Rural/Motorway) is made by the operator, but is then checked, as far as is possible, against the ONS designation of Urban/Rural area.
- Casualty severity is determined by the operator, based on the STATS19 (police data) injury classes but are reviewed by Risk Solutions and, on occasion, adjusted based on further information provided by the operator.
- 'LST-related' is a judgement made initially by the operator. Where appropriate (e.g. to clarify certain details), we have reviewed specific event records with the operator and, in the light of better information, adjusted the original classifications UPWARDS i.e. classified an incident as LST-related where the operator had formerly identified it as not LST-related. Incidents are never reclassified 'down' to be not-LST related.
- The incident summary shown here is a simplified and cleansed version of events designed to convey the main points without identifying the operator.
- In most cases, the STATS19 record of the same event can be identified from the event details and has been used to further inform our understanding of the events and to compare incident locations to the STATS19 GIS position data.
- The national STATS19 data for 2016 has not yet been validated by DfT, so we cannot be sure that the 2016 LST events shown here will be included in that data.[27]

Our statistical analysis conservatively includes events that may not have been LST-related and would still have happened with a standard 13.6m trailer

6.13 All the statistical analysis that follows is based on all of the events listed in the table above, whether or not they are judged to be 'LST Related'. This is a prudent approach adopted because whether an incident would have occurred at all, or developed in the same way, if the trailer had not been an LST is a judgment. For example,

- In incidents 3,4,6,13 and 16 - a 3rd party vehicle ran into the back of the trailer due to poor judgement by the 3rd party driver. Here the length of that trailer is probably immaterial and the incident would probably have happened with a 13.6m trailer.
- In incidents 11,12,14,15 & 18, where the LST driver ran into the rear of another vehicle, usually in slow moving traffic, the operators see no effect from the trailer length. Operators as a whole, so far, have not reported any issues with braking or slowing instability when pulling LSTs compared to other trailers.
- In incidents 7,9,10 and 17 the cause was driver fatigue / loss of concentration, which would not be related to trailer length, unless it is argued that the trailers might be less stable when the driver makes a sudden steering or braking adjustment as a result of the lapse. Operators have not, so far, reported any increased braking instability related to LSTs compared to other trailers. Operators believe these events would still have resulted in the collision with a standard 13.6m length.
- In general, if the LST was manoeuvring and the impact is with the rear corner of the trailer, the default assumption was to classify it as 'LST Related'.

6.14 While not used to filter the quantitative analysis, discussing whether incidents were LST-related, does give us an indication of the level of conservatism in our calculations.

[27] The raw STATS19 data collected by police forces across the country are checked and validated centrally to ensure they meet a consistent set of criteria. Only the validated events are included in the national published statistics.

Table 10: Description of all reported LST injury incidents in public locations (Urban here is urban (excluding motorways), see section 6.5)

[#] Year	Location	Casualties (FATal, SERious, SLIGHT based on STATS19 police category definitions) Fat	Ser	Slight	Incident summary ['LST Related' judgement]
[1] 2012	Urban	0	0	1	LST driver turning left on mini-roundabout. A taxi entered the roundabout during the LST manoeuvre struck the trailer. Taxi driver slight injury. **Not LST related.**
[2] 2012	Rural	0	0	1	Early in the trial, LST being delivered from manufacturer to MIRA for testing, before delivery to operator. Agency driver misjudged roundabout at motorway junction and overturned trailer. Driver slightly injured - no other vehicles involved. Agency drivers generally not used on the trial. **'Maybe' LST related.**
[3] 2013	Mway	0	1	0	LST slowing down on motorway. Driver behind failed to brake and hit back of trailer and was injured. **Not LST related.**
[4] 2014	Rural	0	0	1	LST travelling on rural section of A-Road at night. Another road user ran into rear of the LST at high speed and was injured. **Not LST related.**
[5] 2014	Mway	0	1	0	LST encountered previous incident on motorway that had resulted in a jack-knifed vehicle partially blocking lane 1. It was night, motorway section unlit and damaged vehicle was unlit. LST driver was unable to avoid hitting it and was injured. **Not LST related.**
[6] 2014	Mway	0	1	0	LST travelling in lane 1 of motorway at night. Car driver approached from behind and hit the trailer. Car driver injured. **Not LST related.**
[7] 2014	Rural	0	0	1	LST travelling on rural section of A-Road when he lost control - vehicle left the road and overturned, injuring the driver. No other vehicles involved. Investigation attributed event to driver fatigue resulting from stress factors outside work. **Not LST related.**
[8] 2015	Urban	0	0	1	LST on driver assessment route making a turning manoeuvre in an urban location reported to have hit a pedestrian with the tail end of the trailer. Police did not attend scene but gathered information from pedestrian report and interviews with operator involved. The route is no longer used for driver assessment. **LST related**
[9] 2015	Mway	0	0	1	LST travelling on motorway in middle of the day. Vehicle left the road on nearside but did not overturn. No other vehicle involved. Investigation attributed event to driver fatigue. **Not LST related.**

[#] Year	Location	Casualties (FATal, SERious, SLIGHT based on STATS19 police category definitions) Fat	Ser	Slight	Incident summary ['LST Related' judgement]
[10] 2015	Mway	0	0	1	LST travelling on motorway mid-morning. Vehicle left the road on offside and overturned. No other vehicle involved. Investigation attributed event to driver fatigue. **Not LST related.**
[11] 2015	Mway	0	1	5	LST travelling on motorway in middle of the day. Traffic congestion resulted in a stationary queue. LST driver failed to react quickly enough and collided with the rear stationary vehicle. There were 1 serious and 5 slight injuries. **Not LST related.**
[12] 2016	Urban	0	1	0	Driver hit cyclist from behind when moving from slip road to dual carriage way. **Not LST related. See discussion in para 6.18 below**
[13] 2016	Mway	0	0	1	LST travelling on inside lane of motorway when a third-party vehicle crossed from outside lane and hit rear offside of the trailer at speed. **Not LST related.**
[14] 2016	Mway	0	0	1	LST travelling on motorway, collided with rear of another vehicle which then ran into a second vehicle. **Not LST related.**
[15] 2016	Mway	0	1	0	LST following another HGV in roadworks on motorway. The HGV made an emergency stop to avoid another vehicle swerving across the lanes. LST unable to stop in time and collided with rear of HGV. **Not LST related.**
[16] 2016	Mway	0	1	0	3rd party vehicle collided with rear of LST on motorway. Near side right under-run bar snapped. **Not LST related.**
[17] 2016	Mway	0	0	1	LST travelling on inside lane of motorway, drifted onto rumble strip and just over hard shoulder line. Driver observed a vehicle parked in hard shoulder. Steered to right to avoid the vehicle, but rear of trailer hit offside of parked vehicle. **LST related, see discussion in para 0 below**
[18] 2016	Mway	0	0	1	LST travelling on motorway, driver did not react in time to changing road conditions and collided with rear of another vehicle. **Not LST related.**

Sources LST Data, Operator communications and STATS19 data for validation (except 2016 – at the time of writing the STATS19 data has not been released)

Injury incidents of special interest

6.15 As in the 2015 Annual Report, we want to highlight a few of the incidents that are of special interest. The incident numbers in the discussion refer to the table above.

6.16 This part of the discussion focusses on the qualitative nature of these incidents and the possible further questions or areas for further study they pose for DfT in regard to LSTs. The quantitative analysis in the subsequent sections treats all 18 of the public injury incidents equally.

There has been one reported injury to a pedestrian, involving an LST

6.17 **Incident [8]:** During 2015 this incident was reported that involved slight injury to a vulnerable road user (in this case a pedestrian) who was hit by the tail end of a LST as it was making a turning manoeuvre in an urban location. This is the first and only incident of this type in the trial to date, and was discussed in detail in the 2015 annual report.

There has been one reported serious injury to a cyclist

6.18 **Incident [12]:** This is important because the injured party was a vulnerable road user; it is the one urban incident added in 2016. In addition to the information in the incident log, the operator released the official company investigation report to DfT and Risk Solutions.

6.19 The driver of the LST was moving from a slip road to join a dual carriageway which forms part of a bypass around a major town. The trailer was a 15.65m design and was loaded with approximately 2 tonnes of empty containers.

6.20 The driver reported checking mirrors before moving forward, but was dazzled by the evening sun. He saw the cyclist when they were about 2 metres in front of the vehicle.

6.21 The driver braked as hard as possible but collided with the cyclist from behind. The Police and Ambulance attended; the cyclist was taken to hospital with serious injuries.

6.22 The operator recorded this as an urban area in the original incident report. We have since confirmed that the location is within an ONS defined urban area, although we note that the junction involved it is entirely industrial, rather than a residential or retail area.

6.23 There is nothing in the information we have seen on this incident that would suggest the type of trailer being used was a factor.

There is an incident of interest involving a sudden course correction at speed

6.24 **Incident [17]** is not an urban incident; the resulting injuries were not serious. However, it is of interest because it raises a question which may require DfT to consider some additional technical analysis of LST dynamics in a particular scenario.

6.25 In addition to the information provided in the incident log, the operator released the official company accident report to DfT and Risk Solutions. The description below is based on that formal accident report which is completed for them by an independent third party. The validated STATS19 record is not yet available.

6.26 The incident occurred when the driver pulling an LST was moving in a line of other HGVs in the inside lane of a motorway at around 50mph.

6.27 The driver momentarily drifted left, attributing this to either a lapse in concentration or the profile of the road. In the initial report, the driver said the wheels of the vehicle caught the rumble strip and that this had also contributed to the deviation into the hard shoulder.

6.28 At this point the driver saw a car in the hard shoulder lane that was before this point, concealed by the other HGVs ahead in the inside running lane.

6.29 It is not clear whether the car was moving or stationary, but the person injured was in the driving seat at the time of the incident.

6.30 The HGV driver made a sharp course correction to bring his vehicle back into the lane, but the rear underrun bar of the trailer hit the car, causing very significant damage to the side panels of the car along most of its length.

6.31 The driver of the car suffered a cut on the surface of the skin to the right arm. The driver received first aid at the scene and attended hospital, but was not, as far as we know, admitted. The injury is therefore classified as 'slight' as per STATS19 guidelines.

6.32 We have discussed this incident with both DfT and VCA. As evaluators, we have put forward the following observations:

1. The incident was classified by the operator as LST related, we think rightly, as it is at least potentially so. If the trailer had been 13.6m long instead of 15.65m, the rear of the trailer would have been 2m further forward and might not have impacted the car.
2. Although not included in the formal attribution, the driver's explanation of the event did include the possibility that the rear axle was a contributor, (along with concentration loss) to the event.

6.33 This incident raises a question of how a steering axle, or the overall LST fixed/steering axle geometry, behaves when subjected to a sudden course correction at speed (50mph) and whether it has been fully assessed. DfT might want to consider issues:

1. **Specific to the incident:**
   a. The trailer involved had a single command steer axle - VCA would like to further investigate the specific design to see what 'lock-at-speed' mechanism it has
   b. From more detailed incident data (currently available) or additional information from the operator, can we establish any more information about the path followed by the tractor unit?
2. **General to the scenario / assumed tractor path (or range of paths):**
   a. Would an 'at speed' course correction' at 50mph be sufficient to result in a change of angle on a range of axle types?
   b. What would be the path of the rear of the trailer and would this be different to a 13.6m trailer for an LST with:
      - Fixed axles (i.e. any design where the steering axle would be physically locked in place above a given speed)
      - A single* Tridec /command steer axle
      - A single* self-steer axle?
   c. Overall – would an LST return to the original lane quicker, or more slowly than an equivalent 13.6m trailer and might the how might the 'swept area' differ?

6.34 VCA suggests that no test track in the UK where such a movement could be replicated, so it might require a controlled road test or computer simulation.

6.35 It is also important to note that even with data that could answer these questions, any results would then still need to be subjected to a risk based analysis based on the frequency of such events involving standard 13.6m trailers.

6.36 Although at present this single event cannot be shown to be statistically significant, we believe it would be prudent for DfT to consider further work in this area.

Recommendation 2016-3: Ref paras 6.26-6.35

Technical appraisal of LST 'course correction at speed'

DfT / VCA should consider the questions raised in this report, relating to the likely response of an LST using a self-steering / command steered axle to a sudden course correction 'at speed' (e.g. 50 mph).

6-4 Statistical comparison of injury incident rates: National

6.37 As the LST trial progresses, we have been analysing incident data to assess whether the LST trial operations pose an additional risk to other road users, when compared with the GB articulated HGV fleet (which includes the LST fleet) on a per km basis.

6.38 Our analysis focuses on the comparison of LST incidents in **public locations** (public highway, services areas etc.) as the best comparison to the background STATS19 data published for all personal injury road traffic collisions that take place on the public highway.

LST Incident Summary

6.39 There have been **18 personal injury incidents involving an LST in public locations in 319 million km travelled over 2.6 million journey legs from when the trial began in 2012 to the end of December 2016.**

6.40 Of these 18 public personal injury incidents, 3 events (resulting in 3 slight injuries) were determined to be LST-related.

6.41 This equates to:

- **1 injury event in a public place for every 18 million km travelled by the LSTs**
- **1 LST-related injury event in a public place, in every 106 million km travelled**.

GB Articulated HGVs summary

6.42 Table 11 summarises the number of collisions, vehicle km and casualties for the period 2012-2105 for the GB Articulated HGV fleet. Collision and casualty data is taken from STATS19 for all personal injury collisions involving articulated goods vehicles of 7.5 tonnes and over. Vehicle km data is taken from DfT statistics table TRA3105 for articulated goods vehicles with 3 or more axles.Table 12 summarises the data in Table 11 as a three-year average for the period 2013-15. This allows us to compare the rates of incidents and casualties for the GB fleet with the rate for the LST trial fleet, as described in the next section.

Table 11: Number of collisions, vehicle km and casualties for the period 2012-2105 for the GB Articulated HGV fleet

Number of Collisions	2012	2013	2014	2015	Total
All motorways	723	741	831	795	3,090
Rural roads (excluding motorways)	1,025	1,027	1,077	994	4,123
Urban roads (excluding motorways)	474	425	459	475	1,833
Total Collisions	**2,222**	**2,193**	**2,367**	**2,264**	**9,046**

Vehicle Kilometres (billions)	2012	2013	2014	2015	Total
All motorways	7.5	7.8	8.1	8.3	31.7
Rural roads (excluding motorways)	4.7	4.7	4.8	5.1	19.3
Urban roads (excluding motorways)	0.8	0.8	0.8	0.8	3.2
Total Vehicle Kilometres (billions)	**13.0**	**13.3**	**13.7**	**14.2**	**54.2**

Number of Casualties	2012	2013	2014	2015	Total
Fatalities	116	117	111	125	469
Serious injuries	355	443	410	430	1,638
Slight injuries	2,650	2,547	2,878	2,733	10,808
Total Casualties	**3,121**	**3,107**	**3,399**	**3,288**	**12,915**

Source STATS19 and TRA3105 2012-2015.

Table 12: Three-year averages (2013-15) for collisions, casualties and vehicle km for the GB Articulated HGV population – urban / rural split, public locations

GB Articulated HGV three-year averages 2013-2015	Collisions per year	Casualties (All killed or injured) per year	Billion vkm per year
Rural or motorway	1,822	2,692	12.9
All motorways	*789*	*1,216*	*8.1*
Rural (excluding motorway)	*1,033*	*1,475*	*4.9*
Urban (excluding motorway)	453	573	0.8
Total	2,275	3,265	13.7

Source STATS19 and TRA3105 – annual average 2013-2015.

LST comparison to the GB articulated HGV 3-year rolling average

6.43 In previous annual reports we have compared figures for individual years of data. Now the trial has been running for over four years, we can begin to look at the trend in annual incident rate and a three-year rolling average for LSTs (calculated from Table 11) and the GB fleet (calculated from Table 12), which helps to smooth out any natural variation in the data from year to year. This is shown in Figure 21 below.

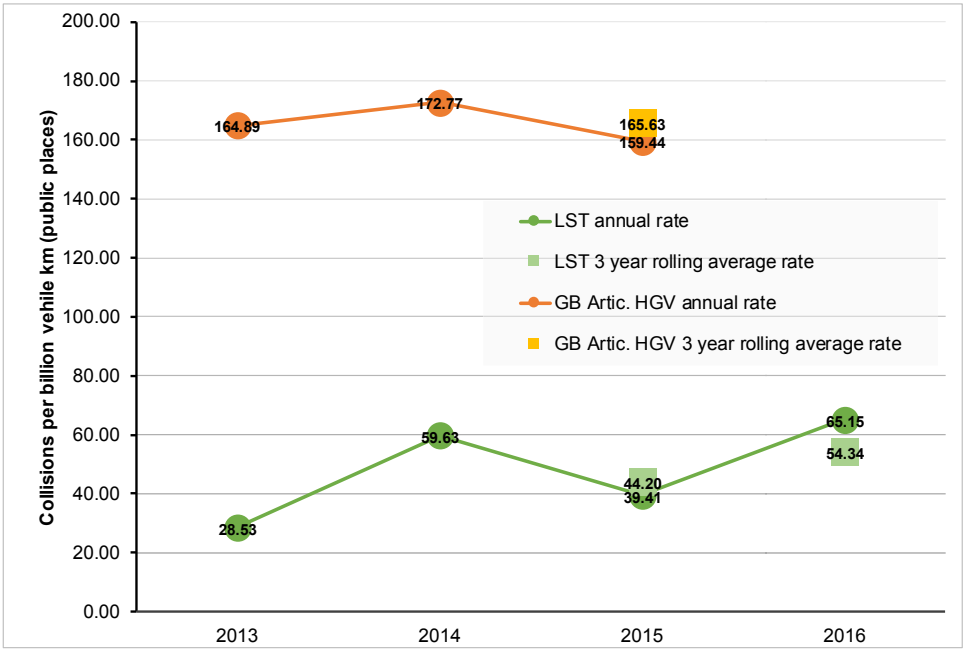


Figure 21: Annual incident rate and three year rolling average, 2013-2016

Overall incident rates for LSTs are substantially lower than those of the GB articulated HGV fleet.

6.44 To establish whether differences are real, rather than due to normal statistical 'noise' in the data, we carry out a series of statistical tests.

6.45 The first statistical test we have performed is a 'Poisson rate ratio' test. This calculates the '**mean rate ratio**' of the LST incident rate (per billion vehicle km) to that for the background population of all GB articulated HGVs. If the mean rate ratio is equal to 1.0, then the rates are the same. If the ratio is not equal to 1.0, then the test tells us if the difference from 1.0 is statistically significant.

6.46 Table 13 shows that the national incident and casualty rates for LSTs are substantially lower than those of the standard fleet. The ratios in the table are less than 100% (1.0) and are statistically significant. **For the public access location comparison, LST incidents are occurring at a rate of 33% of the GB articulated HGV fleet.**

Table 13: Summary comparison of LST public road collision and casualty three year rolling average rates (2014-16) vs. GB articulated HGVs (2013-15)

Injury incidents Public access locations	LST Rate per billion vkm	GB Artic HGV Rate per billion vkm	Ratio LST/GB-HGV
Collisions	**54**	**165**	**33%**
Casualties	**72**	**237**	**30%**

Sources: LST from trial data. GB from STATS19 and TRA3105 – all 2013-2015 – all figures rounded. Both ratios shown to be statistically significant at the 5% confidence level.

6-5 Our approach to analysis of safety in urban operations

6.47 There is a valid question over whether urban LST operations, where LSTs would be expected to perform most high angle turns, could pose a threat to vulnerable road users such as pedestrians, cyclists and powered two-wheeler users, as well as to other drivers. The analytical question is whether such an effect might be 'hidden' by the dominance of motorway / trunk road operations in the national average calculations given above.

6.48 To carry out an urban analysis we need to estimate the number of urban incidents and the urban/rural distance travelled ratio, for the standard trailer and LST populations. The source data or estimate process for each element of this data is given here, before the results are presented. We also need a consistent definition of urban across all the data.

6.49 Here, we have laid out the various preparation steps and data discussions. The actual comparison of LST urban incident rates to those of standard trailers, is in section 6.6.

Consistent definition of urban

GB urban areas are defined by the ONS based on the national census data

6.50 The key background data for the GB articulated HGV fleet is that used in all government transport data. It is derived from the latest national census in which geographic areas are defined by the Office for National Statistics (ONS) as being urban or rural by the population living in the area.[28]

6.51 The STATS19 injury incident data and the national traffic flow data published by DfT are both broken down by road type and urban/rural and so the urban portion of each dataset is directly available.

6.52 The LST injury incidents have each been examined and classified as urban/rural directly by viewing the incident locations on maps, but also by locating the incident in STATS19 (where it is included) to obtain the 'official' classification for each one.

6.53 It is important to understand that when an individual incident location or section of road is classified as urban, **this does not mean 'town centre'**. A straight section of dual carriageway that was part of the trunk network, would still be classified as urban where it by-passed a town, as it might still fall in an urban geographic area as defined by the ONS. However, it is a useful approach because it can be applied consistently across all the elements of the analysis and it is a nationally recognised definition.

For the LST analysis, we use a definition of urban (excluding motorways)

6.54 For the analysis here, our primary interest is in the use of LSTs off the Motorway or trunking network. Removing the motorway data from the urban definition is easy for all datasets. However, removing the 'trunk network' is more difficult as not all the datasets include that as a 'flag'. We have therefore applied a filter to all the datasets which divides them into:

- Urban (excluding motorways) = ONS urban, not including motorways
- Rural or motorway = ONS rural, plus all motorways

6.55 This includes all dual carriageway A-roads that pass through ONS urban geographic areas classified as 'Urban'.

6.56 **Where the terms 'urban' and 'rural' are used without further definition, they can be taken to carry the meaning noted above**.

[28] The ONS defines an area as Urban or Rural based on the population living in that area according to the most recent national census (currently 2011). The Classification defines areas as rural if they are outside settlements with more than 10,000 resident population. For details see https://www.gov.uk/government/collections/rural-urban-classification

Source data for urban operations comparison

The source for the GB articulated HGV fleet is DfT published data

6.57 For the general GB articulated HGV fleet, traffic census data[29] published by DfT includes a breakdown by road type in ONS rural or urban locations.

6.58 A similar approach is adopted for the STATS19 data – which is reported using the same classifications of roads and ONS urban/rural locations.

6.59 In each case, we have re-assigned the data to give the breakdown using our definition noted earlier, so that motorway traffic and incidents are separated from the urban data.

The source for LST urban injury incidents is the trial data

6.60 The detailed data for the injury incidents noted in Table 9 have been analysed and the incidents classified in Table 14 under the same tailored definition of urban / rural or motorway described above.

Table 14: Number of personal injury collisions for LST trial population (whole trial to end 2016) – urban/rural split

Number of collisions in each location type	Public and private	Public only
N_{LR}, Rural or motorway	15	15
All motorways	*12*	*12*
Rural (excluding motorways)	*3*	*3*
N_{LU}, Urban (excluding motorways)	8	3
Total	23	18

The source for LST urban/rural distance split

6.61 The trial data submissions do not contain detailed data on LST journeys by road type nor for urban or rural environments. Therefore we do not have data on the actual proportion of LST journeys/distance that occurred in ONS urban/rural areas or the road type data to determine how much took place on motorways.

6.62 As has been noted earlier, the trial requirements do not demand that operators track the trailers using GPS; about 60-70% of the LSTs in the latest year (2016) would have associated GPS data. For earlier trial years this figure would be much lower.

6.63 Where the LSTs are GPS tracked, the terms of the trial do not require the operators to make that data available to DfT as at the time the trial was launched in 2011, it was judged that this would have restricted participation to just the larger operators.

6.64 Therefore LST urban/rural split could be determined immediately from trial data.

6.65 The 2015 report outlined a proposal to 'model' the routes followed by the LSTs, based on the start and end postcodes, to estimate the actual percentage of LST distance that was travelled on urban (excluding motorways) roads. The rationale for using modelling rather than a sample of actual GPS can be found in Annex 3.

6.66 The model has been created and tested during 2016 and the first results have been used in the analysis here.

[29] DfT road transport statistics - table TRA3105

We have estimated that 8.0% of LSTs distance travelled in 2016 took place on roads we could classify as urban (excluding motorways)

6.67 We have calculated 'modelled' routes for **all** LST journeys in 2016, based on a set of parameters including route distance and speed.

6.68 Where available, the majority of the route is carried out on the nationally defined Strategic Route Network (SRN) operated by Highways England or the Primary Route Network (PRN) – that is, the major roads designated by local authorities for travel between key locations (defined by DfT).[30]

6.69 The routes are expressed as a series of road links from the Ordnance Survey (OS) national road network, allowing us to associated each link with its characteristics including road type. The OS network link coordinates were then compared to the ONS Urban geographic areas to determine the ONS urban/rural status of the link. We could then calculate the distance travelled in urban areas (excluding motorways) as a proportion of the total distance travelled on each route.

6.70 The results are summarised in Table 15 below, alongside the comparison values for the standard articulated fleet in GB (as in Table 12 above).

Table 15: Urban (excluding motorways)/ Non-urban split of Distance and Percentage of Vkm in Urban areas for LST fleet (2016) compared with the GB Articulated HGV fleet, annual averages

Urban/ Non-urban vehicle km split	LSTs (2016) million vkm from route modelling estimate	LSTs (Whole trial period to end 2016) estimated million vkm	GB Artic HGVs billion vkm annual average 2013-2015	GB Artic HGVs billion vkm whole trial period to end 2015
Rural or motorway	**123.64**	**291**	12.9	**51**
All motorways	**-**	**-**	*8.1*	***31.7***
Rural (excluding motorways)	**-**	**-**	*4.9*	***19.3***
Urban (excluding motorways)	**10.76**	**25.5**	0.8	**3.2**
Total	**134.40**	**319**	13.7	**54.2**
% Urban and not on a motorway	**8.0%**		5.8%	**5.9%**

Sources: LST from trial data and LST route modelling. GB from TRA3105 to 2015 (2016 not yet published).

6.71 In Table 15, note that:

- The LST 'whole trial' column is generated by applying the 8.0% urban (excluding motorways) from the route modelling carried out for 2016, to the entire 319 million vkm of the LSTs since the trial began.
- The GB articulated HGV fleet data is shown in two forms because we need to use the data over different time periods to fit the available LST data.
  - The first figure over the years from 2013-15 was used for the National incident rate calculation shown earlier, where we now have sufficient data on both collisions and vehicle km for the LSTs to do a 3-year rolling average.

[30] See Guidance on road classification and the primary route network – DfT January 2012 https://www.geoplace.co.uk/documents/10181/87438/Guidance+on+Road+Classification+and+the+Primary+Route+Network/b7144810-af9a-41a1-a4cf-0f9c6de015d4

- The second is the based on the entire data for 2012-2016 – the whole trial period – and is used for the urban operations the urban operations analysis where we do not have sufficient LST injury incidents to drive a 3-year rolling average.

Modelled routes – validation and sensitivity

6.72 We have carried out some model validation by checking the modelled routes against those proposed by industry leading HGV routing software and also against a small sample of actual GPS data provided by an operator. We have also carried out some sensitivity testing which suggests that our estimate is very unlikely to be so grossly inaccurate as to invalidate the conclusions drawn later in this analysis. Again, more discussion of this can be found in Annex 3.

6.73 Our conclusions were that the modelled routing is sufficiently accurate to be used for this initial calculation of the proportion of LST operations that took place in urban areas (excluding motorways).

6.74 Further validation against actual GPS route data would be required if the modelled routes were to be used as a more direct indication of where LSTs had actually operated.

6.75 To summarise, we estimate **that LSTs on the trial in 2016, ran on roads in urban areas (excluding motorways) for 8.0% of their total operating distance, compared to an average of 5.9% for the GB articulated HGV fleet (2012-2015 data).** This value of 8.0% is taken forward into the comparison of urban incident rates in the next section of the report.

What does the LST operations result tell us about the LST fleet?

6.76 This result may be 'counter-intuitive', since the general assumption to date has been that compared to the national fleet, the LST operations would be even more skewed towards motorway / trunking routes than the general GB articulated fleet. However, we note that the allocation process was only designed to encourage a diverse mix of operators, not to produce a fleet that accurately modelled the nature of the national trailer fleet.

6.77 The largest LST fleets on the trial mostly belong to retailers and parcels companies who use them to delivery to sites and depots at the edges of towns – locations that would fall into the ONS urban classification, even if they are not in town centres. Such operations might therefore be over-represented compared to the national trailer fleet.

6.78 It will be important to consider this issue of the trial vs national operational mix when interpreting the trial results and, later, scaling them up to any national impact assessment. There are two issues:

- The extent to which operators who have self-selected to join the trial, and their operations, represent any future projection of LST operations outside trial conditions
- The way this particular sample of operators is choosing to use the trailers, which may itself only represent a particular segment of their fleet operations.

6-6 Statistical comparison of injury incident rates: Urban

6.79 In this section we present our analysis of urban incident rates (excluding motorways), using the various data elements prepared in the previous section.

6.80 The number of safety incidents involving LSTs in urban locations (excluding motorways) is very low, so as with the national statistical analysis presented earlier, it is important to test whether differences in accident rates observed between the LST fleet and the GB fleet of articulated HGVs (which includes LSTs) are 'real', or are just the result of natural variation ('noise' in the data). We do this using both a classical 'Poisson Test' and a Bayesian comparison. The details of this approach were given in some detail in the 2015 Annual Report

6.81 When we presented this analysis in the 2015 Annual report the tests were statistically inconclusive, but indicated that with the addition of 1-2 more years of trial data, they might be expected to become so. As we show later, the addition of the 2016 data has been sufficient to give statistically robust results.

Injury incident analysis – urban – classical statistics

At the end of 2016, based on the three confirmed urban injury incidents, we can state that the trial LSTs were operated with a lower rate of injury incidents in public, urban (excluding motorways) locations, than the average for GB articulated HGVs (95% confidence level).

6.82 There have now been sufficient personal injury incidents involving an LST in urban operations on public roads to determine a statistically meaningful assessment of the relative safety of LSTs compared to the background GB articulated HGV fleet (which includes LSTs) for urban operations.

6.83 Using the STATS19 equivalent case, which only considers incidents that are on the public highway, there have been three LST incidents to date in urban locations. We can be confident that this number is robust due to the level of detail provided by operators for safety incidents. However, as noted in section 6.5, there remains some uncertainty in incident rate (incidents per billion vehicle km) because of the uncertainty in urban vehicle kilometres.

6.84 The results in Table 16 summarise some incident rate calculations for different assumptions about the proportion of LST vehicle km driven on urban (excluding motorway) roads.

6.85 Using the estimates of:

- 8.0% urban operations (excluding motorways) for LSTs, from the route modelling described earlier (paragraph 6.61 onwards), compared with
- 5.9% urban operations (excluding motorways) for the general background fleet

6.86 Then our best estimate for the value of M, the ratio of these two percentages, is approximately 1.36. In other words, the LSTs drove on urban roads (excluding motorways) approximately 36% more than the average for the GB articulated HGV fleet.

6.87 The sensitivity analysis results in Table 16 show the effect of different M values:

- M=0.5, which would be the case if LSTs drove on urban roads 50% less than the average for the GB fleet
- M=1.0, which would be the case if LSTs drove the same amount on urban roads as the average for the GB fleet
- M=1.5, which would be the case if LSTs drove on urban roads 50% more than the average for the GB fleet

6.88 In each case, we calculate a key indicator - the 'mean rate ratio'. This is the ratio of LST urban (excluding motorways) collision rate to the background (GB articulated HGV fleet) urban collision rate. So, a mean rate ratio >1.0 would imply that the LST collision rate is higher, a value <1.0 implies that the LST collision rate is lower.

6.89 We then test whether we can be confident that any apparent difference between the two collision rates is significant (and not just 'noise' in the data). We use the same Poisson test as we did earlier for the national analysis.

6.90 If we assume the urban operations form 8.0% of all LST distance travelled (i.e. our best estimate value of M=1.36, from the route modelling) then the mean rate ratio is 0.20 with a 95% confidence limit range of 0.04-0.60. (Table 16 – third column)

6.91 If we assume that LSTs drive the same proportion of their vehicle kms on urban roads (excluding motorways) as does the background GB HGV articulated fleet, i.e. the value of M is 1.0 rather than 1.36, the mean rate ratio becomes 0.28 with a 95% confidence limit range of 0.06-0.81. (Table 16 – second column).

6.92 Similarly, for the M=1.5 case (fourth column), the mean rate ratio becomes 0.19 with a 95% confidence limit range of 0.04-0.54.

6.93 In all these cases the analysis shows a mean rate ratio less than 1 across the confidence interval range so we can state with a high degree of confidence that the LST incident rate is lower than the background population.

6.94 The only case where the mean rate ratio is not sufficiently smaller than 1.0 to be statistically significant (i.e. we cannot say that the LST incident rate is lower than the background population) is the M=0.5 case (Table 16 – first column). The mean rate ratio becomes 0.56 with a 95% confidence limit range of 0.11-1.63.

6.95 We note that this very conservative case would only occur if the modelled routing was very significantly **over estimating the proportion of distance travelled on urban roads** - the sensitivity analysis carried out on the route modelling suggests that this is very unlikely to be the case. As noted above, this could be explored further by additional validation of the routing model using GPS data from a suitable range of actual routes driven.

6.96 As the trial proceeds the additional data may allow us to state with confidence, even with this extreme assumption, that the trial LSTs are operating with a lower rate of injury incidents in public, urban locations (excluding motorways), than the average for GB articulated HGVs.

6.97 **We can conclude that there is strong evidence for the LST injury incident rates in urban areas being less than the urban average for all GB articulated HGVs, even if the modelled routes are over estimating the proportion of distance travelled on urban non-motorway routes**.

6.98 We can also see that the statistically significant mean rate ratios found for urban operations of 0.28-0.19 (for M=1 – 1.5) are no higher than the national mean rate ratio (0.33) noted earlier in paragraph 6.46 (page 44).

6.99 **We can conclude that the use of national averages to compare LST incident rates to the general national fleet, are not masking an underlying problem of higher injury rates in urban areas.** However, we will continue to monitor and report the national average incident rates and the urban incident rates separately as we acknowledge that the risk of injury events in urban operations will remain an area of concern for the trial.

Table 16: Urban operations injury incident rate analysis

Injury incident rate ratio significance test results **based on three confirmed LST urban injury incidents (public locations only**), varying the M parameter to change the assumed LST urban (excluding motorways) vehicle kilometres

	M = 0.5 Assuming Trial LSTs drove on urban roads **50% less than** the average for GB semi-trailers	**M = 1.0** Assuming trial LSTs drove on urban roads **the same amount** as the average for GB semi-trailers	**M = 1.36** Assuming trial LSTs drove on urban roads **36% more than** the average for GB semi-trailers	**M = 1.5** Assuming Trial LSTs drove on urban roads **50% more than** the average for GB semi-trailers
GB Articulated HGV fleet average collision rate **- Urban (excluding motorways) (2012-2015)**				
No. of collisions	< ---------- 1833 ---------->			
Billion vehicle km	< ---------- 3.2 ---------->			
Mean collision rate per billion vehicle km	< ---------- 573 ---------->			
Trial LSTs - Urban (excluding motorways) (Trial to end 2016)				
No. of collisions	< ---------- 3 ---------->			
Billion vehicle km (all)	<---------- 0.319 ---------->			
Urban (excluding motorways) km %	3.0%	5.9%	8.0%	8.9%
Billion vehicle km – Urban	0.0094	0.019	0.026	0.028
Mean collision rate per billion vehicle km	319	159	117	106
LST vs GB Articulated HGV fleet average (Urban – Non-motorway)				
Mean rate ratio	0.56	0.28	0.20	0.19
95% confidence limit of mean rate ratio	0.11 – 1.63	0.06 – 0.81	0.04 – 0.60	0.04-0.54
p value that mean rate ratio equals 1.0.	**0.43**	**0.01**	**<0.01**	**<0.01**
Statistical interpretation	Not significant at the 5% level. Insufficient evidence to reject null hypothesis that the rates are the same	Significant at the 5% level. Sufficient evidence to accept alternative hypothesis that the rates are different	Significant at the 5% level. Sufficient evidence to accept alternative hypothesis that the rates are different	Significant at the 5% level. Sufficient evidence to accept alternative hypothesis that the rates are different

Injury incident analysis – urban – Bayesian statistics

6.100 As with the national figures, we have sought to confirm our conclusions from the classical statistical analysis, but using Bayesian statistics to re-examine the data.

6.101 Applied to this problem, the Bayesian analysis results determine the probability that the LST injury incident rate is higher or lower than that for the background population. This is different from the classical Poisson Test described above, which just gives a 'pass/fail' indication at a given confidence level. In simple terms, the Bayesian analysis gives an insight into how far away from, or 'inside' a robust statistical test the result falls.

Analysis of the LST urban injury rate using a Bayesian approach strongly supports our conclusion that the LSTs are being operated on the trial with a lower injury incident rate than the average for GB articulated HGVs.

6.102 As with the classical test above, the results are sensitive to the assumed value of M so the results are shown for the same range of M as in earlier tables.

6.103 The results in Table 17 show that

- If the value of M is 1.0 – meaning the LSTs drive the same proportion of their vehicle km on urban roads (excluding motorways) as the background population – there is a greater than 99% chance that the LST urban (excluding motorways) incident rate is less than the background rate for all articulated HGVs.
- If the value of M is nearer to 1.36, as estimated by the route modelling described earlier, then then it is almost certain that the LST urban (excluding motorways) incident rate is less than the background rate.
- Even if the value of M is as low as 0.5 – meaning that the urban (excluding motorways) vehicle km proportion for LSTs is half that of the background population – there is still an 85% chance that the LST incident rate is less than the background rate.

Table 17: LST Urban injury incident rate - Bayesian Analysis

Bayesian Analysis Summary of urban incidents STATS19 Equivalent Case (3 injury events)	Median Collision Rate Ratio	The probability that the LST (injury) incident rate on urban roads is:	
		HIGHER	LOWER
	=LST/RST rates & (HDI*)	than the background rate for all large GB articulated HGVs.	
To end 2015 with M=1.0	0.31 (0.07-1.0)	2%	98%
To end 2016			
M=0.5	0.59 (0.18-1.6)	15%	85%
M=1.0 (same urban % as background fleet)	0.29 (0.09-0.80)	0.3%	99.7%
M=1.36 (result from route modelling)	0.22 (0.07-0.60)	0%	100%

6-7 Safety impact outcomes expressed as 1 in 'n' journeys

6.104 For communication with the general, non-technical reader, it is useful to summarise the key incident impact results in terms of "1 event in every x km" to convey a sense of the scale of the incidents being observed with LSTs, compared to existing semi-trailers in common use in the country. In Table 18 we present a summary of the safety incident data using this format.

6.105 The information in Table 18 relates only to incidents involving an LST, operating in a public location and where the fact that the trailer was an LST has been determined to be relevant to the event occurring or to the outcome.

6.106 The data is presented at the national level, to be consistent with other published results. The urban operations (excluding motorways) analysis has concluded that these national results do not appear to be concealing an underlying problem of LST operations in urban areas.

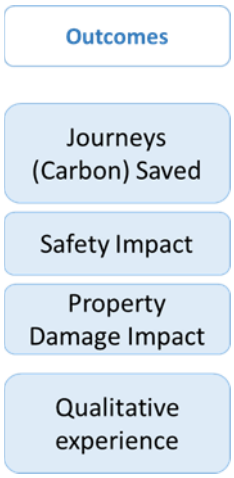
Table 18: Summary of LST-related injury incident outcomes compared to those for all GB Articulated HGVs

Summary of LST-related injury incidents and outcomes after 319 million km travelled (26 million km 'urban'), compared to those for all GB Articulated HGVs (>7.5T)				
Collisions in all public locations* 2012-15 and resulting casualties		**GB Artic HGVs 1 in every …**	**LST Involved 1 in every …**	**Judged LST Related 1 in every …**
All Incidents	All locations	**6** million km	**18** million km	**106** million km
	Urban only	**1.7** million km	8.5 million km	No incidents
By incident severity (worst injury)				
Fatality	All locations	**116** million km	**No Incidents**	**No Incidents**
Serious	All locations	**33** million km	**46** million km	**No Incidents**
Slight	All locations	**5** million km	**20** million km	**106** million km

Notes to be included with table:

- **'**All public locations' covers all public roads and also private land where there is public access.
- 'Urban' here defined as all roads, not including motorways, in ONS defined urban areas
- GB Articulated HGVs: Based on DfT National data for all articulated HGVs > 7.5T. 2012-2015 (TRA3105) = 54.2bn km of which 3.2bn urban non-motorway. Injury incidents from STATS19 2012-15: Total collisions = 9,046 (1,833 Urban), Total casualties = 469 fatalities, 1,638 serious and 10,808 slight. See Table 11.
- LST Involved: 18 events (3 urban). Any injury event in which an LST was involved, even if the trailer being an LST was not relevant – data from latest annual report table - Table 9. Non-injury (damage only) incidents are covered separately.
- LST Related: 3 events (0 urban). Events involving an LST where the fact that the trailer was an LST rather than a standard length was considered to be at least part of the cause. ***Not used in headline figures for trial injury rates.***
- These figures are national / urban averages. The latest annual report includes analysis that concludes that the comparisons between LST incident rates shown here are all statistically robust at a 95% confidence level

7 TRIAL OUTCOMES 3: PROPERTY DAMAGE IMPACT



7.1 As reported last year, with the increasing statistical confidence in the distance saved and safety analysis results, we have been looking in more detail at the issue of property damage incidents.

7.2 This section reports on three separate analyses relating to 'damage' incidents

1. **The basic trial data** – looking at the events reported in the incident logs submitted by all operators
2. **Damage incidents vs measured 'kick-out'** – a study recommended in last year's annual report, matching the VCA measured tail-swing ('kick-out') for different LST designs to the incidents reported in the trial data.
3. **Operator 'In-house' damage incident comparison** – an extension of the feasibility work reported last year to explore a sample of cases where the LST damage incident rate might be higher than that for standard trailers and what might influence any such difference

7-1 Damage incidents from trial incident logs

7.3 In earlier Annual Reports we presented multiple breakdown charts of all non-injury events, including any in depots and some where there was no resulting damage.

7.4 Our focus now is on events that:

- resulted in some damage
- were located on the public highway (or in a publicly accessible area)
- were assessed as being related to the fact the trailer was an LST.

7.5 Table 19 shows a summary of the breakdown of the 733 where some damage was recorded (either to the vehicle or public/private property). Of these, only 234 occurred in a public location (as noted earlier – paragraph 4.45).

7.6 Each event is classified by the operator with their judgement of whether it was judged to be 'LST Related', using the options shown. The operator judgements are checked by Risk Solutions and, where necessary, amended with their permission. Where there is limited narrative information, for any event where the impact was at the rear of the trailer, we prudently assign it as 'LST Related = Yes'.

7.7 If we conservatively count all the events noted as 'Yes – partly' or 'unclear' as LST related, we have 115 events of interest in 319 million km travelled over 2.6 million legs. There is no national database against which this can be compared, to see whether it is better or worse than standard length trailers. **The LST performance equates to:**

- **1 reported damage only event for every 2.8 million km travelled by the LSTs**
- **1 reported damage only event for every 23,000 journey legs operated by LSTs.**

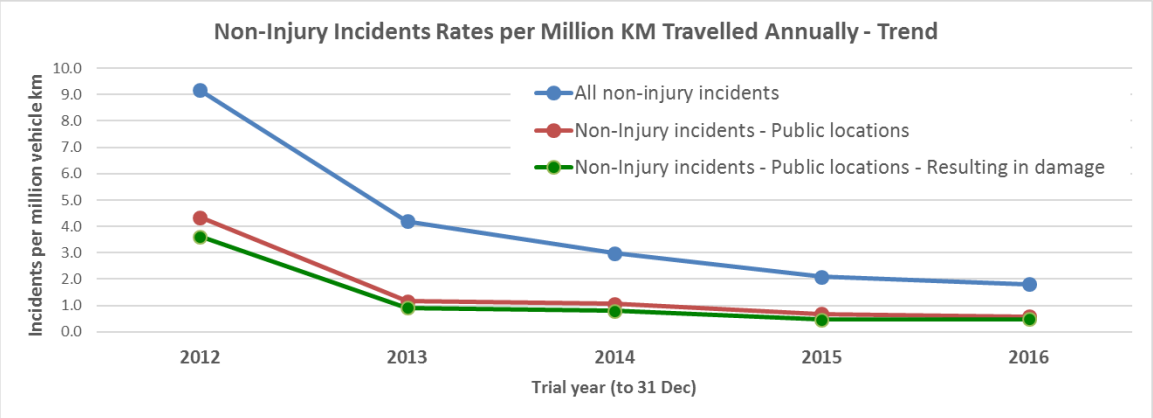
Table 19: LST non-injury incidents by location

LST Non-Injury incidents recorded as resulting in damage 2012-2015	Was incident 'LST Related' ?				
Filter levels: PUBLIC/PRIVATE > Location > Manoeuvre before incident	Yes	Yes - Partly	Unclear	No	Totals
PUBLIC ROAD / LOCATION	**55**	**21**	**39**	**119**	**234**
00 On main carriageway - not in restricted lane	**54**	**20**	**39**	**114**	**227**
01 Reversing	1	1	3	4	9
03 Waiting to go ahead but held up	1		1	4	6
04 Slowing or stopping			1	8	9
05 Moving off	1	1	1	7	10
06 U turn	2		2	1	5
07 Turning left	35	7	12	11	65
08 Waiting to turn left				1	1
09 Turning right	12	11	12	17	52
10 Waiting to turn right			1		1
11 Changing lane to left			1	7	8
12 Changing lane to right				3	3
13 Overtaking moving vehicle on its offside			1	1	2
15 Overtaking on nearside				1	1
16 Going ahead left hand bend			1	2	3
18 Going ahead other	2		3	47	52
04 Cycle lane (on main carriageway)	1				1
06 On lay-by or hard shoulder				2	2
07 Entering lay-by or hard shoulder				3	3
08 Leaving lay-by or hard shoulder		1			1
PRIVATE LAND	**144**	**74**	**78**	**203**	**499**
10 Company Property / Depot	**111**	**46**	**39**	**140**	**336**
11 Other Private Property (not on road)	**33**	**28**	**39**	**63**	**163**
TOTAL	**199**	**95**	**117**	**322**	**733**

Non-injury (damage only) incident rates – trend over time

7.8 Figure 22 shows a time trend of the full set of non-injury incidents. The key observation at this stage of the trial is that the rate of non-injury events, normalised by distance to remove the effect of the fleet growth, reduced from the start of the trial until the end of 2013 and has remain broadly steady ever since.

Figure 22: Annual Non-injury incidents by trial - Trend



Source: LST Trial data

7.9 Some operators have commented that they have also detected a reduction in all incidents once a group of drivers in a depot have 'settled in', with the pattern being repeated, albeit with fewer events, each time trailers are introduced at a new location. This may be the case, since for those early periods of the trial, there was only a small group of operators and they would all have been 'new' at the same time. In the later periods, any evidence of the same effect being seen in those joining the trial would be masked in the data by the fact they were going through their learning period in smaller numbers at any one time, while the overall dataset would reflect the growing set of operators who had 'settled in'.

7-2 The effect of increased tail-swing on damage incidents

The issue of tail-swing ('kick-out') and damage

7.10 Some observers of the trial have raised concerns about the increased 'kick-out' of the rear of these trailer compared to standard 13.6m trailers and the associated potential for safety risk to vulnerable road users. The potential impact on roadside furniture is also of particular interest to asset owners such as local authorities.

7.11 The feasibility studies and impact assessment conducted by DfT before the trial started concluded that they would not expect to see any material increase in injuries arising from use of the LSTs on the trial. The evidence presented in Section 6 is consistent with this.

7.12 The impact assessment did note that there might be some increase in damage-only incidents arising from the use of longer trailers.

The VCA model reports as a data source

7.13 The current trial of longer semi-trailers (LSTs) allows participating operators to operate LSTs on the roads in Great Britain under Vehicle Special Orders (VSOs). These orders are issued on the basis that operators submit data as required for trial monitoring, and that the trailer models are approved by the VCA. The VCA requirements are that the longer trailers must adhere to the length limits for the trial (either 14.55m or 15.65m) as well as a number of other dimension criteria including demonstrating that they are able to perform a turning manoeuvre according to a given specification. The VCA tests each model constructed by manufacturers and issues a model report for each chassis design.

7.14 DfT commissioned an analysis of the evidence to date on the relationship between LST 'kick-out' metrics and all incidents. The analysis is dominated by the damage events since they significantly outnumber the injury events.

7.15 **Note that this is a study of the effect of different kick-out measurements within the LST fleet, not a comparison with other semi-trailers.** There is no comparable dataset covering damage incidents for non-LSTs.

7.16 The results of our analysis are summarised here. A fuller version of the tasks, statistical analyses and results is provided in Annex 4.

Our approach

7.17 For this study we considered the historical evidence for LST damage and injury incident rates. Where possible, we have linked each incident to individual LST kick-out measurements which we have extracted from VCA model report data.

7.18 Risk Solutions worked with VCA to collate and cleanse LST design data on steering mechanism, steering angle and measured 'kick-out' and we have linked these data to the main LST trial dataset to support the analysis reported here.

7.19 An initial analysis of numbers of legs and incident rate per leg by trailer 'kick-out' length was inconclusive. To support a more refined analysis of the data we constructed a dataset that included leg type characteristics, LST steering type and incident data. We undertook statistical analysis of this refined dataset data to examine evidence for correlations between trailer and incident type characteristics, and to test for the statistical significance of any relationship between other trailer design features and the rate of incidents resulting in injury or damage. Regression analysis and chi-squared tests were employed using the 'R' statistical analysis package (See Annex 4).

7.20 We have paid particular attention to incidents where the trailer was on the public highway, was turning, and where the incident was judged to be possibly LST related.

Summary of findings

We found the following statistically significant findings at the 95% level.

The analysis has found no simple relationship between the measured trailer kick-out and the overall rate of injury and damage incidents.

7.21 Statistical analysis of all incidents on all route types found no correlation between measured kick-out of the trailer and the rate of incidents.

7.22 Our analysis did show that incidents were more prevalent on 'delivery' (e.g. to/from a retail or industrial site) rather than 'trunking' (e.g. supplier to distribution centre) routes, which is consistent with other analysis already performed during the trial. This may be expected as Trunking operations typically involve a large proportion of their journey on major dual carriageways, and they often start and end at specially designed distribution centres.

7.23 By focusing on delivery legs only we might expect routes to involve more built up areas or tighter turns. However, even here we found only a very weak correlation between measured trailer kick-out and incident rates for delivery incidents; the effect is so small that it is not judged to be material.

The probability of a relevant incident occurring on a Delivery leg on a public road is lower by a statistically significant amount if the steering system is Self-tracking

Published studies (Cebon 2002[31]) indicate similar results, although the trailer designs in that study had dual steer axles.

There is a reduction in incident frequency as turn angle limit of the axle design increases

There is a weak correlation between the turn angle limit of the axle design and incident frequency, but the effect disappears if only incidents on public roads are included in the analysis. This suggests that it may be to do with manoeuvring in depots, where some very tight turns might be attempted, rather than an issue of concern in public road operations.

Leg distance was not found to be significant in any of the analyses.

7.24 This seems to confirm our presumption that this type of incident (turn related) is more associated with the start and ends of journeys rather than the overall number of miles driven.

Discussion and conclusions

7.25 Our analysis could find no statistically significant correlation between kick-out and incident frequency.

7.26 The most plausible explanation of this lack of correlation is that behavioural factors and organisation operating policies are a bigger influence on incident rates than any effect arising from the difference in kick-out.

7.27 A high proportion of operators said they provide special training to LST drivers (see Figure 12) and well trained or experienced drivers may be more cautious when driving an LST. They may take account of the benefits of the steering axle and take a different line into corners such that the actual kick-out is reduced.

[31] ' Comparative performance of semi-trailer steering systems' in 7th International Symposium on Heavy Vehicle Weights and Dimensions, Delft, NL, June 16-20, 2002

7.28 If this is the case, it emphasises the importance of understanding how much the trial conditions are affecting driver behaviour and how much that can be replicated in any post-trial situation.

7.29 If, risk from 'kick-out' remains a concern, it might be valuable for DfT to explore with manufacturers and operators, two areas related to the design of LSTs:

1. **How are the different designs used in practice?** This might provide an operational explanation as to why the kick-out measured in the test is not strongly related to what happens in real on-road experience, even in delivery operations.
2. **What are the different determinants of the designs produced?** LSTs on the trial exhibit a wide range of kick-out measurements. What determines the choice of steering mechanism and the geometry that results in the final kick-out? Are there sound operational reasons for these choices?

Recommendation 2016-4: **Understanding the underlying basis for LST design variation**	Ref paragraph 7.29
DfT / VCA should consider working with the industry, including manufacturers, to better understand (1) reasons why kick-out measurements are not strongly related to real world experiences, and (2) the justification for the variety of LST designs with different kick-out measurements.	

7-3 Comparison of LST damage incidents to other trailers in targeted samples of operator in-house data

7.30 As reported last year, we have been carrying out a special analysis of incident data recorded in the in-house databases of a small sample of LST operators.

7.31 The benefit of this approach is that it overcomes the problem of there being no national 'damage incident' database (comparable to STATS19 for injury incidents) against which to compare the trial data on LST damage events.

7.32 The purpose of the study was to see whether we could calculate relative damage incident rates of LSTs and standard length articulated trailers within the fleet operated by a single operator.

7.33 Our original aim as to see whether it was feasible to produce results:

- on a **common** basis for the LSTs and standard length HGV articulated trailers within one fleet
- on a **comparable** basis for LSTs and standard length HGV articulated trailers between the fleets of different operators.

7.34 We believe we have extracted data that meets the first of these aims for seven operators.

7.35 We believe any comparison of results between different operators should be regarded with great caution, due to the significant differences in the nature and quality of the different operators' datasets. **The aim was to use this analysis as a basis for exploring, where this is the case, why. The study was not intended to produce numerical results that could be applied to the entire LST fleet as the sample is too small and too selective.**

7.36 During 2016 we have revisited the analysis of the four datasets reported last year, added three more and conducted a more thorough analysis. This is reported below. The analysis focused on incidents in public locations – we have not studied incidents in depots here.

7.37 In addition, some very limited data on the extent of damage to trailers was provided and this is also discussed below.

Limitations of the data and analysis

7.38 The limitations of this approach are significant. Accordingly, the results need to be interpreted with some caution. The key limitations are listed below.

The sample only covers a small number of operators

7.39 In 2015 we reported results from four operators. During 2016 we have added three more operators bringing the total to seven out of more than 160 operators on the trial. The sample size is limited by resources and data availability as noted below.

The sample only covers a limited time range

7.40 The data only covers incidents in two consecutive years for each operator, rather than the whole trial.

The statistical significance of some of the results is limited

7.41 This is a limitation of size of the datasets for each operator and the small number of incidents experienced in the time period being studied. For some cases, the natural variability in the data (the change in incident rates for an operator between the two years for which we have data) are sometimes greater than the difference between the LST and standard length HGV articulated trailers incidents rates in any one year.

The sample of operators was intentionally skewed towards those most likely to be operating 'delivery' rather than 'trunking' routes

7.42 We have intentionally looked for operators where any underlying issue of damage to roadside assets or other objects might be most likely to occur.

The sample was limited to operators with good in-house data collection and reporting systems

7.43 The analysis requires records,

- of all incidents resulting in damage to the trailer (and by inference, perhaps damage to an object that was hit)
- for all their trailers (not just LSTs) collected on the same basis
- in computer readable form.

The sample size is limited by the time and resources available

7.44 This work is more labour intensive than the general trial data collection, both for Risk Solutions and the operators. The operator has to produce the incident data, often from systems designed for maintenance management, not incident monitoring and also produce matching total trailer-fleet distance for the relevant period. This requirement goes beyond their original operator undertaking and it therefore done as a matter of goodwill by the operators.

The sample cannot be guaranteed to be comparing the LST operations with exactly similar operations in the operator fleet

7.45 Working with each operator, we have sought to ensure that the data for standard length HGV articulated trailers is filtered to cover a set of trailers and operations which is representative of the operations on which their LSTs are being used. The very diverse nature of the work carried out even within one fleet means that this alignment is unlikely to be perfect.

7.46 Our approach in deciding which standard length trailer data to include in the comparison has been to make a choice that would make the results more, rather than less, conservative where possible.

The standard length trailer data source quality is variable and not comparable between operators or in relation to the more standardised sources such as STATS19.

7.47 This means that, the results from each operator in the sample can only be viewed as a single comparison between the LSTs and the other trailers in that fleet of that one operator. Since the data from other operators in the sample may have been collected under very different conditions and for different purposes, any direct comparison between the results of operators could be highly misleading.

7.48 Further in reviewing the overall results emerging from the trial, the results from this special analysis should not be held to be 'on the same level' as those based on more robust data sources, principally the injury incident results. Specifically, this refers to the fact that for injury events:

- the LST incidents are analysed in some detail, often with requests for further narrative from the operators, while
- the background GB HGV articulate fleet injury data comes from STATS19, the police database for which the data is collected in a standardised format against a well-defined set of specifications.

Implications of these limitations when interpreting the results

7.49 These limitations mean that we cannot use the data quantitatively to directly scale-up results for the sample of operators to the national situation. Neither can we be sure that the comparisons between incident rates are meaningful – even where they are statistically significant. However, it does provide us with a method of identifying operations where incident rates may be higher or lower for the LST fleet compared to the standard length HGV articulated fleet with respect to damage only incidents and focus further qualitative research to explore why.

Description of the operators

7.50 The selection of operators, as noted above, intentionally focused on operators who do more than simple motorway trunking between very large distribution centres. Analysis of LST fleet damage incident data shows that incidents were more prevalent on 'delivery' (e.g. to/from a retail or industrial site) rather than 'trunking' (e.g. supplier to distribution centre) routes. The hypothesis is that these may involve more travel in urban areas or tighter turns where the geometry of the LST trailer is likely to have a bigger impact as explained in Section 7-2. Drivers may also be less familiar with these routes.

- Operators A and B mainly operate trunking routes between their own depots or those of their suppliers, but those depots include some in outer-urban areas, not just large motorway-located industrial sites[32].
- Operators C, D and F are largely delivering goods from depot to retail sites.
- Operator E is unusual, and was selected intentionally, they deliver to industrial sites but a significant number of these they may only visit a few times in a year.
- Operator G operates between industrial sites, including in outer-urban areas, mostly with locations familiar to drivers.

Analysis and results

7.51 Table 20 summarises the results from in-house data for seven operators on the trial. These results include only incidents which:

- occurred on the public highway - not in depots or loading yards.
- resulted in damage to the trailer – and by implication, may have resulted in damage to either infrastructure assets, natural assets (e.g. a tree) or another vehicle.

7.52 We have generally taken a prudent approach to both the LST and standard HGV incidents in deciding whether to include them in the dataset:

- where the location was in doubt, we have included the incident
- where the damage was to the tractor unit, not the trailer, we have still included it in case the manoeuvre being performed placed the tractor unit in a different position because of the length of the trailer.

[32] The information about the nature and variety of sites visited by these operators come in part from the operator data received as part of their regular leg data, including the number of unique postcodes included in their 2016 dataset and, in some cases, from examination of the location of those delivery points using GIS mapping of those postcodes.

Table 20: Comparison of LST vs standard length damage public highway incident rates based on a sample of 'in house' data for seven operators

(Note in this table RST refers to 'Regular Semi-Trailers', i.e. standard length HGV articulated trailers)

Op	Nature of operation	Year	Regular semi-trailers PDI - Public Location Damage Incident mkm - million km			Long semi-trailers			LST vs RST Incident Rate Ratio Range (95% confidence)	Poisson Test for Statistical Signficance of inc rate ratio
	A general description of the type of operations based on predominant leg type of the LSTs		PLDI	mkm	Inc / mkm	PLDI	mkm	Inc / mkm		
A	In-house fleet - both RST and LST operating trunking routes between depots, including DCs in outer urban areas	2014	446	181	2.5	8	4.8	1.7	Insufficient evidence of rate difference (29% - 134%)	0.340
		2015	565	185	3.1	14	5.1	2.8	Insufficient evidence of rate difference (49% - 152%)	0.820
B	Operations between goods suppliers (industrial locations) and distribution centres	2014	71	44	1.6	1	3.9	0.3	16% (0.4% - 91%)	0.033
		2015	200	35	5.7	25	5.2	4.8	Insufficient evidence of rate difference (53% - 128%)	0.482
C	Largely deliveries from distribution centre to retail sites	2014	248	89	2.8	38	9.1	4.2	150% (104% - 211%)	0.032
		2015	266	81	3.3	59	13.9	4.2	Insufficient evidence of rate difference (96% - 172%)	0.093
D	Largely deliveries from distribution centre to retail sites	2014	375	130	2.9	17	3.1	5.4	188% (110% - 309%)	0.023
		2015	164	123	1.3	7	3.0	2.4	Insufficient evidence of rate difference (70% - 375%)	0.219
E	Specialist delivery to mix of distribution centres and industrial equipment dealers - significant proportion of deliveries are to infrequently visited locations.	2015	27	8.4	3.2	16	1.5	10.7	332% (167% - 638%)	0.001
		2016	9	8.3	1.1	11	1.3	8.7	800% (301% - 2185%)	0.000
F	Largely deliveries from distribution centre to retail sites	2015	972	201	4.8	2	0.8	2.5	Insufficient evidence of rate difference (7% - 196%)	0.576
		2016	867	222	3.9	1	0.6	1.6	Insufficient evidence of rate difference (1% - 234%)	0.626
G	Largely deliveries between industrial type locations including outer-urban areas	2015	82	46	1.8	12	5.5	2.2	Insufficient evidence of rate difference (60% - 223%)	0.626
		2016	74	45	1.7	10	6.4	1.6	Insufficient evidence of rate difference (43% - 183%)	1.000

Only a few of the comparisons of LST to standard length trailer incident rates are statistically significant

7.53 The final two columns of Table 20 contain the comparison of the LST damage incident rate to the standard length trailer damage incident rate. The last column contains the results of a statistical test of the comparison of the LST and standard length trailers incident rates using the same method as was applied to the injury incidents earlier in this report[33].

7.54 As explained in earlier sections of this report, the test tells us whether the apparent difference between the LST and standard length trailer incident rates is in fact 'real', rather than being a difference that could arise just out of chance or natural variation in the underlying data. The test result value in the right hand column can be read as follows:

- <=0.05 There is a 95% chance that the rate ratio for this operator is not 1 – i.e. there is a real difference between the LST and standard length trailer incident rates
- >0.05 The data does provide sufficient evidence prove that the LST and standard length trailer incident rate are not the same

7.55 In the table, a green shaded result in the last column indicates a 'passed' test. Where this is the case, the actual comparison of rates (to the left) is highlighted in green if the LSTs rate is lower than the standard length trailer rate and red if the LSTs rate is higher.

7.56 Whereas in the 2015 Annual Report, we presented the 'rate ratio' in all cases, we now only state the ratio where the statistical analysis shows it to be significant at the 95% confidence level commonly applied in statistical analysis. Where this is not the case, the result is shown as "Insufficient evidence of rate difference".

Interpretation – incident frequency comparison

7.57 Given the limitations of the data described earlier and the limited number of results that are statistically significant, we need to interpret the results carefully. This careful interpretation and the limitations of the analysis must be properly reflected in any reporting or use of these results outside the context of this report.

For a group of three of the operators, there is insufficient evidence to say that there is any difference between the LST and standard length trailer incident rates

7.58 For operators A, F and G, the results are not statistically significant. We cannot say with confidence that the difference in rate ratio calculated is real.

For two operators, delivering from DCs to retail sites, the LST incident rate was HIGHER than that for standard length trailers in one year

7.59 For operators C and D, in 2014, we can be 95% confident that the LST incident rate is higher than that for the standard length trailers in the same fleet. Both operators are delivering goods from DCs to retail sites.

7.60 We had a joint meeting with them following the analysis of their data and they confirmed that our conclusion was probably correct. They carried out their own analysis arriving at somewhat different numbers, but the same conclusion.

7.61 Operator C noted that they had observed some similar effects with damage incident rates between their dual and single deck trailers and operator D agreed. Where drivers operated mainly single deck units, but then picked up a dual deck in the middle of a

[33] The comparison of the two incident rates is subjected to a Poisson Test using the 'R' statistical package. The result is a value which indicates whether the two incident rates are, in fact, different at a 95% confidence level.

series of runs, the operator had concluded that they sometimes failed to make the relevant compensations in their driving style. This might be referred to as their '**equipment awareness**' at any point in their journey. They also expressed the view that the effect was amplified if the route involved an initial extensive stretch of motorway (where no adaptation of driving style was required) before the driver moved onto trunk or non-trunk A roads.

7.62 Both operators noted that a range of visual cues were now being adopted or considered, for both dual-deck and LSTs, including warnings on driver paperwork, and painting the front of trailers in different colours (as a visual cue from the cab). They were discussing the possibility of using any in-cab telematics or job display screens as another option for delivering such a reminder.

For one operating between suppliers and DCs, the LSTs rate was LOWER than that for RSTs in one year

7.63 For operator B, in 2014, we can be 95% confident that the LSTs incident rate was lower than that for the RSTs in the same fleet. Operator B mainly operates trunking routes between their own depots or those of their suppliers, but those depots include some in outer-urban areas, not just large motorway-located industrial sites. LSTs and standard length trailers operate the same routes, giving us additional confidence in the rate comparison.

For one specialist operator the LSTs clearly had more incidents than the standard length trailers in the same fleet in both sample years

7.64 Operator E is a much smaller fleet than the others in the sample and was included specifically because we were looking for a type of operation where we might expect to see the greatest difference between their LST and standard length trailer operations due to the nature of those operations. Specifically:

- They have a relatively small cohort of drivers who operate both LSTs and standard length trailers, with 25% of their time/distance in LSTs.
- They deliver specialist goods to a range of large and small industrial suppliers. While for busier sites they will have a delivery at least weekly or more often, the analysis of their journey leg data shows they have a large number of sites that they may only visit a few times a year.

7.65 Examination of incident location data shows that the incidents are not necessarily occurring at the actual delivery point site itself, but at points all along the route. This suggests that the general familiarity of the route may be the issue, not necessarily a problem of accessing unsuitable delivery sites.

7.66 This suggests that the cause may be the combined effect of equipment awareness (they are pulling an LST) and limited route familiarity, both of which are an inherent characteristic of the work of Operator E.

7.67 We have discussed the nature of the operation and the difference in LST and standard length trailer incident rates with the operator and they believe that in general, our conclusion is correct and reflects their experience.

Comparison of incident rates within operator fleets: summary

7.68 This analysis was based on a small number of cases and there are too few statistically significant results to support systematic comparison. Conducting the sort of in-depth analysis performed here on all 160+ operators on the trial would be untenable, but it may be that an amended data gathering framework could include a small template that would enable operators to enter the basic data for their whole fleet incident count and distance

(but not the individual events) and so generate am incident rate ratio similar to that used here.

7.69 The discussions we have had with operators' around their experience of operating mixed single and dual decked trailers and LST/standard length trailers, is worth exploring further. DfT and the industry should consider how risks arising from drivers switching between different types of trailer can be managed, especially where this is combined with infrequent use of trailers and unfamiliar routes.

7.70 At the same time, we need to see whether any further influences on incident rate emerge from any expanded discussion of this topic with operators.

Recommendation 2016-5: **Increasing data on the relative rate of LST damage incidents to those of all trailers in the fleet of each operator**	Ref paragraph 7.66
DFT should consider working with the industry and/or amending the data framework, to assess how many operators experience a difference in damage only incident rates between their LSTs and standard length trailers. **This should include work to better understand the underlying causes, including but not limited to, the impact of route familiarity and equipment awareness, especially on non-trunking operations, on the ability of drivers to operate LSTs without an increased risk of collisions resulting in property damage** **This recommendation is subject to DfT determining whether the value of this additional data justifies the additional reporting requirement on operators**	

Interpretation – incident severity – extent of damage to property

7.71 Only one of the three new operator data samples submitted during 2016 contained any associated data on the extent of the damage to the trailer. As with the single sample reported in 2015, this was data from their maintenance department repair logs, or values from an insurance claim made by or against the company.

7.72 The new information has not led to any significant change to the data we hold on incident severity so the conclusions are similar to those in last year's annual report.

Where data was provided, a clear majority of the incidents result in very minor damage to the vehicle, as measured by the repair costs

7.73 The data was very sparse, but did highlight that for both LSTs and standard length trailers , in a clear majority of the incidents recorded the damage to the trailer was very minor (e.g. a scratch, a broken bulb lens cover, a lost mud-flap) as opposed to major events in which the trailer required substantial repair to the chassis or upper structure.

7.74 We looked at this to see whether there was any evidence that LST incidents cost more to repair. The data provided was not in a form that would easily permit a numerical comparison of the repair costs of the LSTs vs standard length trailers, but we conducted a qualitative review of the two sets of data on repair costs or the description of the damage per incident. This provided no evidence of any difference between the distribution of repair costs for LST incidents and standard length trailer incidents.

7.75 We have no information on any costs for repair or replacement of third party assets. There is no comprehensive database of damage caused to local infrastructure, kerbside furniture, or other road vehicles by incidents, the information being dispersed between highways authorities, local authorities, insurers and other parties.

7.76 While the damage to the trailer is not a direct measure of the damage done to the object that was hit, it does give some indication that many of the damage events reported here will not have resulted in major impact on either infrastructure assets or private property.

7.77 Risk Solutions and DfT are now in contact with the Local Government Association (LGA) transport policy department. The LGA is looking at the possibility of a survey of local authorities to explore their awareness of the trial and to identify any examples of an LA adopting special HGV restrictions specifically in response to problems of LSTs operating on their roads.

7.78 We believe this is an area that the trial needs to focus on more in future, because obtaining accurate data is so challenging. To do this, we would need to liaise with the industry and perhaps organisations such as Local Authorities (via the LGA) to gather evidence from a range of sources to seek further insights into the extent of any additional damage being caused from the use of LSTs in place of standard trailers.

7.79 We are therefore making the recommendation below, subject to DfT determining the cost-benefit of such a change to the data requirement.

Recommendation 2016-6: **Increasing data on the nature and severity of damage incidents involving LSTs**	Ref paragraph 7.78
If DfT wish to assess the impact of damage only incidents in more detail, then operator in-house incident severity for both LSTs and ideally standard length trailers would need to be gathered as part of the standard trial submissions. **To achieve this we would recommend that the incident log template be revised to incorporate including at least narrative evidence of the severity of damage to the trailer and any objects hit in the collision and, potentially, a simple damage impact ranking.** **This recommendation is subject to DfT determining whether the value of this additional data justifies the additional reporting requirement on operators**	

8 WIDER IMPACTS - LOOKING AHEAD

Scaling up from trial conditions.

Wider Impacts

Applicability of results to general UK semi-trailer fleet

8.1 The emerging outcomes from the operation of LSTs on the trial are confirming positive results in terms of savings, without any apparent increase in safety risk.

8.2 The issue of incidents that do not result in injury but do cause damage to the trailer and potentially to infrastructure or private assets, needs further work. We need to better understand the operational conditions under which LSTs might be involved in more damage events than other trailers, but also to get an idea of the severity of any such damage. Recommendations in this area were made in Section 7 (see paragraph 7.78)

8.3 In the next phase of work, we also recommend that DfT should include a task to analyse the impact of LSTs in reducing emissions, both on the trial and as part of any projected wider adoption.

8.4 These results can only reflect the position within the trial fleet and under trial conditions. We believe that during 2017-19, DfT should plan to conduct initial 'scaling up' analysis – applying the data gathered so far on the trial to a theoretical scenario where LSTs were widely available at some point in the future and start work to consider what might be required for satisfactory operation of LSTs beyond a trial.

Recommendation 2016-7: **Preliminary assessment of 'future impact' of LSTs – scaling up and emissions assessment**	Ref paragraph 8.1 - 8.4
DfT should consider including an initial 'scaling up' analysis in their 2017-19 plans for the trial evaluation, to begin assessing the potential future impact of LSTs. This would include work to translate the current distance/journey saving results into measures of reduced emissions/air pollution.	

8.5 Scaling up the trial results to assess the impact of a national adoption of LSTs will need to consider:

- Evidence of the likely take-up of LSTs by different operator types, based on the nature of their work and the extent of their control over that workload. An estimate of future take up was made during the pre-trial feasibility studies, based on a survey of operators in 2011, but those responses pre-date any actual operational experience of LSTs. The QSF2 process, which we expect to complete by mid-2017, will provide an up to date expression of trial operators' views of potential future take up, based on their experience of the trailers to date
- The data from the operators on the trial will then need applying correctly to the profile of similar operators nationally to get estimates of likely take up and impact across the country.
- The relative cost and benefits of LSTs to different types of business, particularly smaller companies, which then informs, the 'Small and Medium Business Assessment (SaMBA) in any policy impact assessment.

8.6 By creating a scaling-up 'model' at this point in the trial, we can:

- Assess whether the data being captured on the trial is likely to be sufficient to support a balanced and robust impact assessment. If not, by identifying any gaps we can consider how they might be resolved as part of future years' data gathering.

- Open up evidence based conversations that will need to develop between DfT, the haulage industry and other interested parties such as Local Authorities and civil society groups regarding what guidance or regulation might be required to maintain the positive results seen on the trial under post-trial conditions.

Recommendation 2016-8: **Preliminary exploration of possible post-trial requirements or guidance for operating LSTs**	Ref paragraph 8.4 - 8.6
DfT should consider conducting evidence based conversations between DfT, the haulage industry and other interested parties such as Local Authorities and civil society groups, regarding what guidance or regulation might be required to maintain the positive results seen on the trial under post-trial conditions.	

8.7 **By making these recommendations, Risk Solutions is not stating that the trial data is now 'complete' and we are not making a recommendation at this point that LSTs be made part of standard equipment.** The recommendations are simply suggesting the exploratory work could now be started, based on the evidence gathered so far.

Changes to trial size and data collection

8.8 The most significant change in 2017 is DfT's expansion of the trial to permit up to 1000 additional LSTs, to meet continuing demand for the trailers from operators. At the same time, the trial duration will be extended by 5 years to enable the investment in trailers.

8.9 In the consultation on the possible extension of the trial, and in other comments during 2016, DfT have suggested that they might consider re-balancing the data framework. The suggestion was that they might reduce the level of detail collected on individual journey data, where we feel to have a good understanding of the operational patterns, while focusing more on incident reporting, both for injury data and property damage.

8.10 At the same time, there have been calls from some observers of the trial for DfT to increase the detailed data collected on actual LST routing, based on GPS data.

8.11 We have set out implications of these actual/potential changes in the comments below.

We need to review the trial management processes to ensure they remain fit for purpose with the additional trailers and operators

8.12 We believe the current arrangements for managing the data management process and operator support can be adjusted to manage this change – they will need some minor enhancements but not major revision.

8.13 The key change for the current evaluator role is the likely addition of as many as 50 new operators needing monitoring and support.

8.14 DfT/VCA may wish to consider whether the current process for testing, VSOs and other technical liaison with the operators will need strengthening to deal with the expansion.

DfT will need to clarify their plans for future data collection

8.15 DfT have already noted publicly that they are considering a revision to the trial data gathering framework to focus less on utilisation and more on incident analysis.

8.16 On 25 April 2017, DfT issued the following statement, through Risk Solutions, to all current trial participants:

1. The data collection framework for the LST trial remains unchanged for 2017-P2 (Operations May-Aug 2017).

2. The same data framework will apply to all existing trial participants AND those joining the trial for the first time under the 2017 trial extension, and must be completed as per the terms of the operator undertaking.
3. DfT are reviewing the framework in the context of the emerging findings and other requests for outputs from the trial and hope to be able to announce any change to the data collection process in time for implementation at the start of data period 2017-P3 (1st Sep- 31st Dec 2017) or at the latest, for 2018-P1 (i.e. operations from 1st Jan 2018)

Current plan for transition to new data framework

8.17 Risk Solutions have been consulted on the options for a revision to the framework and outlines have been discussed for reducing the requirement down from leg-by-leg data collection to a summary format, but with an increased focus on incident data collection. No decision has yet been made on the final design.

8.18 At the time of writing the plan is for the new data collection framework to be used from 1 January 2018 onward.

8.19 The data being collected in 2017-P3 (Sep-Dec 2017) will be in the existing data format.

Any revised data framework would need to be designed to take into account future DfT decisions on GPS tracking requirements for LSTs

8.20 We are aware that DfT have been asked to consider the merits of extending the requirements for the additional 1000 LSTs to include GPS tracking and, implicitly, a requirement that the GPS data be available as part of the trial evaluation data. The request is based on a concern that the modelling of the LST routing based on start and end postcodes does not provide sufficient knowledge of the actual paths being used by the trailers.

8.21 One option DfT are considering, alongside a requirement for GPS tracking on all LSTs (or just new ones), is the possibility of obtaining a substantial sample of LST GPS data to be used in an enhanced validation and upgrade of the existing routing model.

8.22 Another option is to obtain a sample of GPS data from one or more of the GPS providers covering a wider range of the LST fleet. A tentative discussion with providers suggests that this might be possible from the databases held by just one or two of the leading suppliers of HGV telematics systems.

8.23 If GPS data were available for all LSTs, or just the new allocations, then the data framework could be designed to maximise the use of this information, reducing the burden of manual collection by operators. Specifically, GPS data,

- could probably be used to replace a major part of the existing journey log
- could allow for new analysis, for example providing exact geo-location of incidents.

8.24 Annex 3 includes some additional information on the resource implications of making GPS data more available not only for the industry, but also for the analysis of such data to support the evaluation.

8.25 Alternatively, if real LST related GPS data could be obtained for a substantial sample of routes then this could be used to either validate the existing route modelling work reported here or improve the modelling until such validation was achieved. The validated model could then be applied to ALL the LST postcode>postcode routes in the 2016 and 2017 data with increased confidence.

8.26 At this stage, we have not made a specific recommendation regarding the approach to be taken to obtaining and using raw GPS data to further refine the analysis presented here. We have presented a number of options to DfT, any of which would be theoretically possible, representing different scales of data and resulting challenge/cost.

8.27 We see the broad choice being between:

1. Complete GPS data collection from the whole LST fleet in future, requiring a mixture of data collection from trailers with existing tracking and a requirement to backfit the remainder of the fleet
2. An ongoing large scale collection of GPS data from either the new (2017 allocation) operators / trailers, creating a future flow of data from a part of the fleet that can be used to test/validate any future modelled routes
3. A 'snapshot' (repeatable) of GPS data from existing tracked LSTs, to be used to test/validate any future use of modelled routes, possibly with the same being obtained directly from one or two of the largest tracking providers, rather than from individual operators.

8.28 From the perspective of simply expanding on the work presented in this report, the next logical step would be to validate the existing routing model (or any improved version) using a substantial sample of data, from Option (2) or (3) above, Option (3) being likely to be the most economic approach.

8.29 While Option 1 would provide a comprehensive dataset, it would only do so for future years, it would require a significant increase in the data requirement for operators, as well as significant resources to host and process the data. We also foresee limitations on the use of such data as commercial operators would be very resistant to having any results published that displayed their individual routing.

9 CONCLUSIONS AND RECOMMENDATIONS

Trial inputs and activities

9.1 The original target fleet of 1800 LSTs is now on the road or on VSOs

9.2 **The original planned LST fleet of 1800 trailers was on the road or on VSO at the end of 2016.** At the time of writing, we believe the entire fleet is now on the road.

9.3 There is a good mix of trailer designs, including single/dual deck, flatbed and skeletals.

9.4 There is one design carrying bespoke 50-foot ISO containers on a road-rail operation

Data submission process and compliance management are working well

9.5 The operators' raw data remains confidential between the operator and Risk Solutions

9.6 The contact and relationship management system introduced in 2015 is working well.

9.7 A clear majority of operators are submitting journey data of good quality and on time.

9.8 Where operators fail to submit data, are persistently late, or are not establishing a robust data collection process, there is an effective process of follow up by Risk Solutions in conjunction with DfT.

9.9 During 2016 we had one case where DfT issued a notice to an operator giving a deadline for missing data to be provided, after which their VSO would be suspended, requiring them to remove the trailers from the road. This was only the second time in the trial that a case was escalated to this final stage. As with the earlier case, the operator produced draft data before the deadline.

A significant percentage of the LST fleet can be tracked using GPS data

9.10 Survey responses from 92 of the 160+ current participants show that 39% of them can track their LSTs using GPS, but this represents 70% of LSTs operated by those who have responded to the survey so far, or around 60% of the whole LST fleet. (Figure 9).

9.11 This conclusion needs to be treated with some caution as it only reflects the 92 operators who had responded by the time the analysis was performed. We note that, the companies who have been slow to respond to the survey might well be dominated by smaller or less well equipped companies who might therefore also not have GPS tracking. If so, the overall level of GPS tracking across the trial may be somewhat lower than the 70% found in the sample to date.

Qualitative feedback continues to be positive for a clear majority of participants

9.12 Most operators reported no problems incorporating LSTs into their existing operations, most with some self-imposed special measures.

9.13 Feedback from LST users (managers, drivers, loading staff etc.) continues to be generally positive.

9.14 We have made one recommendation relating to engagement as the trial expands.

Recommendation 2016-1: **Industry Engagement**	Ref paragraph 3.26
We recommend that DfT liaise with FTA, RHA and other stakeholders to arrange a further LST Trial industry forum, ideally during 2017, to communicate with the operators and retain participant engagement, as the trial enters its sixth year and the trial community is extended.	

Trial outcomes 1: Distance/journeys saved

LSTs are operated at high levels of utilisation

9.15 LSTs had travelled over 300 million km by the end of 2016 and as expected, the annual distance added with almost 1800 trailers on the road is now > 100 million km.

9.16 More than half of the distance covered by LSTs is between 'industrial' sites expected to have lower public movement or limited public access.

9.17 We estimate that around 30% of all distance covered by LSTs includes a leg to or from a retail site, taking into account the analysis of empty return legs

9.18 Empty running of LSTs is only 2/3 that for regular semi-trailers in the same period.

9.19 LSTs have been 100% full for 34% of their distance travelled, with part of the additional length of the LSTs in use for around 54% of all distance.

Since the start of the trial, the use of LSTs has removed between 15 and 18 million vehicle kilometres of freight traffic from the roads of Great Britain, equating to 125-150,000 journeys saved.

9.20 Over the whole fleet and across the trial we have calculated that the average % distance saving is 5.3%, which **equates to 1 in every 19 journeys**.

9.21 The most efficient LST operations are saving up to 1 in every 9 journeys.

9.22 There are a small number of cases where little or no saving from LSTs is being reported.

9.23 The results of an ongoing qualitative survey process are being used to initiate conversations with operators who appear to be getting lower levels of benefit to explore the range of reasons why this is the case.

Individual company LST utilisation results have been checked with operators, who confirm that they are consistent with their understanding of performance

9.24 These results have been checked as part of the QSF2 process in which individual operators were presented with a summary of their own LST performance. In the responses received to date, 94% of the operators agreed that our figures reflected their understanding of the performance of the LSTs in their operation.

9.25 We have made one recommendation relating to the analysis of distance/journeys saved.

Recommendation 2016-2 **Understanding low efficiency use of LSTs**	Ref paragraphs 5.23-5.27
Once the QSF2 analysis is completed, the scope of work for 2017-18 should include further enquiry with operators whose results suggest limited benefits from using LSTs to better understand the range of factors involved.	

Trial outcomes 2: Safety impact

Incident data summary

There have been no fatal accidents involving LSTs

9.26 There have been no fatal accidents involving LSTs in 319 million km of operation.

9.27 Since the start of the trial there have been 23 injury incidents (28 casualties) involving an LST of which 18 incidents (23 casualties) were on the public highway or other locations accessible to the public.

9.28 Since the last annual report, there have been seven further injury incidents involving LSTs in public locations, resulting in three serious and four slight injuries.

9.29 Of these seven incidents, two have been identified as being of special interest for because they exhibit key characteristics of concern, such as urban locations, injuries to vulnerable road users or unusual scenarios. It is one of the latter that has led to the recommendation below.

Recommendation 2016-3: **Technical appraisal of LST 'course correction at speed'**	Ref paras 6.26-6.35
DfT / VCA should consider the questions raised in this report, relating to the likely response of an LST using a self-steering / command steered axle to a sudden course correction 'at speed' (e.g. 50 mph).	

Injury incidents comparison to other semi-trailers - NATIONAL

When measured across all road types, the LSTs on the trial are being operated as safely if not more safely per km, than the trailers they replace

9.30 This analysis is based on all 23 injury incidents involving LSTs in public locations, regardless of whether the collision was judged to have been related to the trailer being an LST.

9.31 We have statistically significant results indicating that the LSTs on the trial are being operated as safely if not more safely than the trailers they replace, when considered across all road types.

9.32 Nationally, they been involved in around 70% fewer personal injury collisions and casualties, compared to the average for GB articulated HGV Injury incidents operating over the same distance.

9.33 This result is statistically robust at a 95% confidence level

Injury incidents comparison to other semi-trailers – URBAN

When measured on operations in urban roads (excluding motorways), the LSTs on the trial are being operated as safely, if not more safely, per km, than the trailers they replace

9.34 To address the concern that characteristics of LSTs may mean that they present additional risks when operated in urban locations, we carried out an analysis focusing on LST related incidents in urban locations (excluding motorways).

9.35 This analysis is based on all injury incidents involving LSTs in public locations, even where the collision was judged to have been related to the trailer being an LST.

9.36 This analysis uses route modelling to estimate that LSTs on the trial in 2016, ran on roads in urban areas (excluding motorway) for 8.0% of their total operating distance, compared to an average of 5.9% for the GB articulated HGV fleet as a whole.

9.37 **Based on 8.0% urban operation the LSTs on the trial are being operated as safely, if not more safely, than the trailers they replace, when considering running only on roads in ONS defined urban areas (excluding motorways).**

9.38 This result is statistically robust at a 95% confidence level

9.39 This conclusion remains statistically valid for all cases where the proportion of LST operation on urban roads (excluding motorways) is assumed to be the same as or greater than that for the wider GB semi-trailer fleet.

There is an additional safety benefit of around 5% reduction in collisions in delivering a fixed quantity of cargo using LSTs rather than standard 13.6m trailers due to the reduction in the number of journeys

9.40 The general comparison between LSTs and other trailers is done on a simple 'per km' basis, reflecting the approach in all national road statistics

9.41 When we consider the risk arising from delivering the same quantity of goods using LSTs rather than standard length trailers, the work is carried out in fewer journeys. Put simply, to deliver the same goods using LSTs requires, on average, 1 in 19 fewer journeys/km of operation.

9.42 This is equivalent to a 5% reduction in collisions, or at the average incident rate for large articulated HGVs (dominated by standard length trailers) around 2-3 collisions and 3-4 casualties saved, independent of any difference between the LST and standard trailer incident rates noted above.

Trial outcomes 3: Property damage

9.43 The trial data includes 161 damage only incidents in which the fact the trailer was an LST was noted as being or possibly being part of the cause. This equates to one in every 2.8 million km. To address the concern that design characteristics of the LST trailers, may result in a higher risk of incidents, we analysed this data in a number of ways.

Our analysis found no simple relationship between LST kick-out and the overall rate of injury and damage incidents on either trunking or 'delivery' routes.

9.44 There is no comparable dataset covering damage incidents non-LSTs. The new study reported in Section 7 explored whether we could find any statistical relationship between LST incident rates, and trailer characteristics, within the LST fleet. Particularly we looked for any relationship between the different kick-out (tail-swing) measurements and incident rates.

9.45 Within the LST dataset, we found little or no statistically significant difference between the incident rates of trailers with different kick-out measurements operating on the trial.

9.46 The only statistically significant correlations found where:

- Trunking routes resulted in fewer incidents than delivery (retail or industrial) routes
- LSTs fitted with Command-steer axles (about 20% of the fleet) had fewer incidents per km than those fitted with the more common Self-steer mechanism, in the limited scenario of incidents relating to turning manoeuvres and where the incident clearly involved the trailer (i.e. judged LST related)

9.47 The analysis in Section 7 (paragraph 7.29) recommends that DfT might want to consider studying the rationale behind the adoption of different trailer designs, including the geometry and axle choice. This might provide some insights to inform design guidance in any future expansion of the trial or general roll-out of LSTs.

Recommendation 2016-4: **Understanding the underlying basis for LST design variation**	Ref paragraph 7.29
DfT / VCA should consider working with the industry, including manufacturers, to better understand (1) reasons why kick-out measurements are not strongly related to real world experiences, and (2) the justification for the variety of LST designs with different kick-out measurements.	

A small study suggests that increased risk of property damage collisions compared with standard trailers in the same operator's fleet, may occur in some situations. The sample is too small to generalise to the whole LST fleet. We recommend further work in this area, with a particular focus on issues of driver's awareness when operating LSTs (and other less 'standard' trailer types) and route familiarity / frequency.

9.48 This study compared LSTs with other trailers using in-house incident data for a sample of operators who could provide data for the two different fleets that had been collected on a comparable basis. The study has been extended from four operators, reported last year, to seven. The sample is small because this form of data collection and analysis remains very resource intensive.

9.49 The analysis was designed to allow us to identify cases where incident rates differed between the LST and standard fleets, and discuss with the operators why this might be so. The operators were therefore selected on the basis that we suspected from the nature of their LST operations, would be at higher risk of incidents.

9.50 Because of the small sample, and the choice of operators based on a prior assessment of their likely incident risk, these results cannot be scaled up to the whole fleet.

9.51 In the sample study, data from two operators running mainly to/from retail sites appear to have experienced a higher incident rate for their LSTs than their regular fleet, as did one operator delivering specialist equipment to industrial sites.

9.52 Another operator, also moving suppliers' goods from their sites to large depots had experienced lower incident rates with their LSTs.

9.53 The operators involved in the sample study observed that as with dual deck and other tall trailers, LST damage incidents may arise from lack of driver awareness when changing between trailer types. This may especially be the case if the route involved an initial extensive stretch of motorway (where no adaptation of driving style was required) before the driver moved onto trunk or non-trunk A roads. Unfamiliarity with the route may also be a factor.

9.54 The issue of damage-only incidents remains a key area of interest for the trial. We have put forward two recommendations in this area.

Recommendation 2016-5: **Increasing data on the relative rate of LST damage incidents to those of all trailers in the fleet of each operator**	Ref paragraph 7.66
DFT should consider working with the industry and/or amending the data framework, to assess how many operators experience a difference in damage only incident rates between their LSTs and standard length trailers. **This should include work to better understand the underlying causes, including but not limited to, the impact of route familiarity and equipment awareness, especially on non-trunking operations, on the ability of drivers to operate LSTs without an increased risk of collisions resulting in property damage** **This recommendation is subject to DfT determining whether the value of this additional data justifies the additional reporting requirement on operators**	

Recommendation 2016-6: **Increasing data on the nature and severity of damage incidents involving LSTs**	Ref paragraph 7.78
If DfT wish to assess the impact of damage only incidents in more detail, then operator in-house incident severity for both LSTs and ideally standard length trailers would need to be gathered as part of the standard trial submissions. **To achieve this we would recommend that the incident log template be revised to incorporate including at least narrative evidence of the severity of damage to the trailer and any objects hit in the collision and, potentially, a simple damage impact ranking.** **This recommendation is subject to DfT determining whether the value of this additional data justifies the additional reporting requirement on operators.**	

Wider Impact

9.55 These results can only reflect the position within the trial fleet and under trial conditions. We believe that during 2017-19, DfT should plan to conduct initial 'scaling up' analysis – applying the data gathered so far on the trial to a theoretical scenario where LSTs were widely available at some point in the future.

Recommendation 2016-7: **Preliminary assessment of 'future impact' of LSTs – scaling up and emissions assessment**	Ref paragraph 8.1 - 8.4
DfT should consider including an initial 'scaling up' analysis in their 2017-19 plans for the trial evaluation, to begin assessing the potential future impact of LSTs. This would include work to translate the current distance/journey saving results into measures of reduced emissions / air pollution.	

Recommendation 2016-8: **Preliminary exploration of possible post-trial requirements or guidance for operating LSTs**	Ref paragraph 8.4 - 8.6
DfT should consider conducting evidence based conversations between DfT, the haulage industry and other interested parties such as Local Authorities and civil society groups, regarding what guidance or regulation might be required to maintain the positive results seen on the trial under post-trial conditions.	

9.56 **As stated earlier, by making these last two recommendations, Risk Solutions is not stating that the trial data is now 'complete' and we are <u>not</u> making a recommendation at this point that LSTs be made part of standard equipment.** The recommendations are simply suggesting the exploratory work could now be started, based on the evidence gathered so far.

Trial extension, the data framework revision and GPS data

9.57 We note that in view of the 2017 extension to the trial, and the DfT statement regarding a possible revision to the data framework later in 2017, we may wish to bring forward further recommendations in this area in due course

9.58 In regard to the fitting of GPS to LSTs or a requirement for operators to make GPS data available. We have presented a range of options to DfT to support their decision making process

9.59 From the perspective of simply expanding on the work presented in this report, the next logical step would be to validate the existing routing model (or any improved version) using a substantial sample of data, is likely to be the most economic approach.

9.60 While Option 1, requiring all operators to fit GPS to LST trailers and supply the data to the trial, would provide a comprehensive dataset which would open up many analytical possibilities. It would only do so for future years. It would require a significant increase in the data requirement for operators, as well as significant resources to host and process the data. We also foresee limitations on the use of such data as commercial operators would be very resistant to having any results published that displayed their individual routing.

ANNEX 1: 2015 ANNUAL REPORT RECOMMENDATIONS

The table below lists the recommendations made in Section 8 of the previous LST Trial Annual Report, along with the action taken in each case.

Area of work recommended	Progress
The work by VCA to link the design parameters of individual LST designs into the master trial dataset needs to be completed to enable analysis of operational and incident patterns in relation to key design measures such as tail-swing	Analysis completed and reported here
As the trial progresses, Risk Solutions and DfT will be challenging non-compliance earlier, especially for operators who have already been on the trial for several periods, in order to reduce the resource being taken up with missing/late cases	Process was adjusted during 2016 with addition of an earlier DfT intervention step for cases of repeated missing/late data
For a robust, statistically significant result on the relative safety of LSTs in urban operations, we recommend the trial data collection continue until at least the end of 2017 and that further work be carried out to study LST urban operations	Analysis completed based on incidents to end 2016 and LST urban distance (excluding motorways) estimated using route modelling
Further analysis of the issue of damage-only incidents should be carried out to verify (or otherwise) the results of the sample study of in-house data	Analysis completed for a further 3 operators and original 4 operator data revisited. Reported here
DfT to consider further work in each of the priority analysis areas (below) and to assess the potential value to the evaluation, in relation to the resources required	
Further qualitative survey to gain insight into current experience, extent of GPS tracking, response to individual journeys saved results and potential future LST take up.	QSF2 launched. Responses from 92 of the 160 operators reported here. Work continues to obtain remaining responses during 2017. The potential future take-up results a will be reported once we have the full set of submissions
Model the LST routes, leading to an improved estimate of the proportion of total LST distance travelled on urban routes (or local roads) and (optionally) other analysis linked to road network asset information and options for route visualisation	Analysis completed and reported here
Initial carbon saving and scaling up (to impact of a national LST roll-out) based on data to end 2016	Not necessarily planned for this report. Both tasks included in outline workplans for 2017-19

ANNEX 2: EVALUATION PERFORMANCE SUMMARY

The table below summarises the evaluation to date in terms of the elements of the evaluation programme logic model. The principles of good evaluation require that we test each stage of model to ensure it is delivering what is needed for the later stages.

Inputs | Activities & Processes | Outputs | Outcomes | Wider Impacts

PLM Element	Evaluation indicators	
Policy Inputs (DfT)	• Continued investment of time and resources by internal DfT freight policy team, VCA and funding of data evaluation.	✔
VSOs (VCA)	• Live VSO system managed by VCA. Good communication between DfT / VCA / Risk Solutions to update data or correct mismatched records.	✔
LST Designs (Manufacturers)	• 14 manufacturers involved in LST production. • More than 50 unique LST models tested and documented by VCA.	✔
Investment (Hauliers)	• To be confirmed. Initial approach made to contacts in SMMT to discuss the best approach to estimating this value.	?
Eval'n Framework	• Evaluation framework first published in 2013 Annual Report still in use.	✔
Applications and Allocations	• 295 individual applications for LST allocations across all allocation rounds • 163 companies carried allocation forward to trailer order and VSO.	✔
LSTs in Operation	• 1511 LSTs on the road and submitting data at end Dec 2015. 1760 now on road or on VSO with more coming on the road this summer • 98% of the original aspiration of 1800 – fleet judged to be 'complete'.	✔
Data Gathering & Submission	• Total data submitted each period currently around 250,000 legs. • For full fleet of 1760 LSTs, we expect 300,000+ legs per period.	✔
Participation Engagement	• Many operators now submit the data without significant problems, having established a robust process, while some continue to struggle to get consistency. There is no apparent relationship to company size. • More than 2300 individual email/phone/other contacts with operators logged by Risk Solutions in 2015 and a further 300 with DfT.	✔
Data Framework and Process	• Core framework stable since start of the trial. • Current version of data collection tool in use since 2013.	✔
Participation Range	• Satisfactory mix of size and operation type.	✔
Master Data (Quality/Timeliness)	• Quality checking now stable and producing few if any invalid data records. Master data produced within 1 week of the end of a submission period.	✔
LST Ops Data	• Now collecting almost 800,000 journey records a year.	✔
LST Incident Data	• Now 1-200 events reported annually – additional sample of damage data • Good data on the few injury events.	✔
Qualitative Data	• Majority of experiences very positive – very few poor experiences.	✔
Journeys (Carbon) Saved	• 1 in 19 average across fleet. Best cases 1 in 9. • Work still required to explore data of lower efficiency cases.	✔
Safety Impact	• Nationally – 70% lower than standard fleet. • Urban operations (excluding motorways) – substantially lower than standard fleet	✔
Applicability to general UK fleet	• Beyond current scope of work – 'scaling up' analysis using the trial data will be required for any post-trial policy impact assessment.	-

ANNEX 3: LST ROUTE MODELLING

As outlined in the main report, we have used route modelling, based on the start and end postcode for each LST leg, to generate estimates of the proportion of LST distance travelled on different road types. This annex summarises,

- The rationale for using route modelling rather than GPS data
- The rationale for creating a bespoke routing model rather than an existing HGV routing provider or service
- The route modelling approach, noting the main model parameters.

The results presented in the main report are based on analysis using the first robust version of this routing model, for which a sample of routes has been checked against the online version of a leading industry HGV routing service and a small sample of actual routes provided operators. Further validation of the model and improvement of the routing choices could be carried out if a larger set of sample GPS data was to be made available.

Why have we used modelling rather than actual GPS data?

The primary reason for seeking data on the routes take by LSTs on the trial was the need to assess the rate of injury incidents on urban roads, as opposed just the national view which might be dominated by motorway driving where the injury rate is low compared to the distances travelled.

An 'urban operations' incident analysis requires both an urban incident count and a related distance travelled in urban areas for both the LST fleet and, for comparison, the full GB fleet of articulated HGVs.

('Urban areas' are defined by the Office for National Statistics (ONS) based on existing geographic boundaries and a criteria of >10,000 population for a settlement / area to be defined as urban. This definition is the baseline for all DfT published transport data)

The missing element of data is the distance travelled by the LSTs on roads through ONS urban areas, since the original trial terms and conditions did not require operators to collect or submit GPS data. (At the time the trial was being designed, tracking of individual trailers, as opposed to tractor units, was not as common as it is now and it was judged that to demand it would have limited participation by smaller operators).

In 2015 we reviewed options for estimating the LST 'urban operations' distance and discussed them with both DfT and some specialist GPS/Routing providers.

The final decision to model the routes was made after comparing three main options:

Option 1: **Sampling of the part of the fleet** that was already fitted with trailer GPS (or could be tracked by association with their tractor GPS data)

Option 2: **Back-fitting the entire fleet** (or those not currently fitted) with trailer GPS

Option 3: **Modelling the 'likely' routing of LSTs** using the origin and destination data already provided in the trial data submissions (with an increased requirement for full postcode data from 2016)

Option 1) had the disadvantage that we would only get data from the most technically advanced fleets, which would bias the dataset towards larger operators. It would also be complex, given that data is usually held not by the operators, but by the telematics companies.

Option 2) was judged not only to be the most expensive (for the installation costs and the ongoing data service costs from the telematics providers, or arranging data downloads from static GPS datalogging units) and possibly hard to justify for the additional benefit the data would provide.

This option would also involve either

all trailers being fitted with a single system,

OR

merging data from these additional systems and any existing operator fitted systems into a single data source.

This option would also take a significant amount of time to set up (perhaps 1 year) before data became available.

Options 1 and 2 would also carry additional resource requirements to collect, store and process large quantities of GPS data.

Option 3) was deemed to be the approach that would most effectively provide some insight into the balance of road types used by LSTs,

- at a reasonable cost
- in a reasonable timescale
- without undue additional burden on the industry to fit equipment and provide data that was not covered in the original commitment they signed when joining the trial.

The approach would require more comprehensive completion of start/end postcode data for all LST journeys by all operators, but this data was already being provided by a large proportion of the participants.

The approach could be applied to all operators regardless of size

In addition, this approach could, if required, be applied to historic trial data (pre-2016) where postcode information was available or at least would be possible without delay for all data gathered during 2016.

Rationale for using a bespoke model rather existing HGV routing software

We consulted with three GPS / Mapping providers and had detailed discussions with each around what service they could provide. We found several constraints:

- The general providers of HGV routing services to the industry have systems and business models designed to provide a response to multiple individual routing requests issued through established hardware and data systems. In order to provide a service for bulk processing of routes based on postcode inputs they would need to create a special data input process, for which they would charge development fees.
- The most promising provider, who thought they could process the data, was then unable to provide the service other than through their standard business model of £x per trailer, per month and were unable to offer us a price for bulk processing of a single dataset.
- These providers would have only given us a GPS ‘string of pearls’ for the suggested route. We would still have had to process that data and map it to both road type and ONS urban/rural locations, or pay the provider to do so.

The scale of costs quoted by the one provider who was willing to undertake the work was comparable to our estimates for developing a routing model tailored to our

requirements and linked to the Ordnance Survey (OS) map data to provide access to all the detail of the roads assets.

In addition to these constraints, we already had access to an in-house software platform used for work we undertake for Highways England, which could be used to characterise the necessary OS road network data, with the new routing algorithm simple being added as a new module to the system.

The modelling – summary of method

The routing calculations were performed using Risk Solutions own MapSnap™ platform. This includes tools to characterise any 'link + node' road network for vehicle routing purposes, and identify road links within urban areas by comparison with the ONS 'urban area' geographic shape definitions.

The tool is then able to process a list of routes (with start and end points), and for each, create the details of a route that is likely to be taken by a vehicle, with options to select either the quickest, or shortest route.

For this piece of work, we needed to:

- Work using the OS ITN[34] which required a new import process.
- Tailor the routing to use only HGV compliant road links
- Integrate a new process to classify links according to the special definition of urban (excluding motorways) described in the main body of this report.
- Create bespoke route data exports, including the proportion of their length in urban areas for further analysis.

In the absence of a large validation GPS dataset from operators a set of carefully chosen modelling parameters and assumptions have been used to ensure that the routes chosen are representative of the routing choices likely to be made by fleet operators, driven by the demands of access, fuel efficiency and journey time predictability.

The routing assumptions we used include:

- Routes chosen for journeys take account of HGV height restrictions.
- Routes are biased towards using major trunk roads where these are available (motorways and principal A roads), avoiding the shortest direct route and subsequent unlikely use of minor roads (urban and rural). That is 'once on a trunk road, stay on a trunk road' until you near your destination.
- Routes are based on shortest time, not shortest distance, avoiding using minor roads with slow average speeds.
- There is no variation in the journeys between the same locations, reflecting operators preferred routing, but not taking into account driver or planner variations in route choice due to traffic conditions, time of day etc.

The parameters used in the routing algorithm can be adjusted to improve the representation of LST routes taken if required and if additional validation data can be obtained showing actual routes taken by LSTs on the trial.

The Ordnance Survey Integrated Transport Network (OS ITN) definition provided the road network topology, which includes routing restrictions for HGVs.

[34] At the time the model was being created, the ITN was the most up to date road network data source available from OS. The more recent OS 'MasterMap Road Highways Network" was only released after the import module based on the ITN had been completed. A future version of the model could include a revised import module to use MasterMap

We used the UK government's (ONS) definition of urban areas, but then grouped all journey distance on motorways with the rural data, as they would not include the key urban features of junctions and sharp angle turns that were of concern in this study.

The routing process produces output data, which are used to calculate the proportional distance and time spent in rural areas; distance travelled, time taken, proportion of distance and time in urban areas.

Model checking

The overall average variance between our modelled route distances and the operators' values was found to be only 2%.

The lengths of the model's route suggestions were compared to the operator reported distance (from their trial data). The operators reported distances were also checked with a simple crow flies distance, to check they are viable.

We also visually compared the routes chosen by the modelling with actual routes reported by a small sample of operators, and a larger sample of routes generated using the Pie3D HGV mapping tool.[35]

As a result of these checks we concluded that the routes are a reasonably good representation of real routes taken by LSTs, as least in terms of the general pathway and road types chosen. The requirement at this stage is that the modelled routes be sufficiently good for the purpose of the calculations presented in the main body of this report

There is no claim being made that these are the ACTUAL routes taken for each LST journey, nor that this model could be used to propose routing for actual LST operations.

Results and sensitivity testing

The model estimates that 8.0% of the distance travelled in 2016 by LSTs on the trial, compared with the published figures of 5.9% (3 yr average) for the whole GB articulated HGV fleet

We tested the robustness of our result, primarily seeking to consider if the modelled routing might be systematically over-estimating the extent of urban operations for LSTs.

Overestimating the value is the key concern since for a fixed number of urban injury incidents, this would then underestimate the urban injury incident rate. For the model to be systematically overestimating the distances travelled by LSTs in urban areas, LSTs would need to be routed in our modelling for a greater distance on roads in urban areas and less distance on the trunk road network, particularly motorways. This would most likely happen in a scenario where the routes chosen by our algorithm were more direct, across country, and through cities and towns, rather than around them on the trunk road network. For this to be the case, the distances covered by the modelled routes would be significantly different to the distances declared by operators.

But, our comparison of the modelled route distances with operators declared route distances, showed that in ¾ of cases the distances are within 10%. The extent of urban operations in these routes only varied slightly from all modelled routes (lower by 0.6%). Therefore we are confident that in the majority of cases the modelled routes are representative of real routes.

[35] Available at http://truckanddriver.co.uk/free-truck-route-planner/. We did discuss the option of passing our entire 35,000 routes through such a tool in bulk and had discussions with several providers. However, none of them were set up technically or commercially to process routes in bulk in this way. In addition, the results would have been in GPS (WGS84 – String or pearls) format, would still only have been one possible route the trailer might have taken and we would still have needed to map the GPS data across to the OS ITN links.

We conclude that, the LSTs selected for the trial travel more often into urban centres than the general HGV fleet, and/or the mechanism used to estimate urban distances in the published figures for the GB GHV fleet is slightly different from the definition of urban used in our work.

For completeness, we have also considered whether our process could be under-estimating the extent of LST urban operations (i.e. a result >8.0%), although if this were the case the effect would be to further reduce the urban operations injury rate for a fixed number of injury incidents.

The only feature of our modelling that might potentially lead to this is if our routes are favouring using SRN/PRN more than operators might do. Our model tends to favour using these trunk roads where available, based on our choices of average speeds on different road types.

To consider this possibility we have done some visual comparison of routes where our distance was significantly different to that declared by the operator. We found cases where our routes were longer, using more trunk road distance, and avoiding urban areas – these routes reduce the overall distance travelled in urban areas. And other cases where our route was shorter, taking non-trunk roads, and passing through towns, increasing the overall distance travelled in urban areas. From the routes inspected there was a balance of these opposing cases, demonstrating that we could not find a systematic bias related to urban routing.

It may be that in a future version of our routing, we could build in a more refined set of routing criteria to select the 'most economically sensible route' that trades off small time savings against fuel use and preferences for larger roads where available.

Our current view is that the under/overestimating variances balance out, as indicated by the overall average variance between our distance that the operator values, being only 2%. We can see no evidence that a change of routing criteria would change this so substantially that it would change the result that the trial LSTs appear to be operating around 8% of their distance on Urban (non-motorway) roads.

ANNEX 4: LST SWING OUT METRICS VS INCIDENT RATES

Introduction

The current trial of longer semi-trailers (LSTs) allows participating operators to operate LSTs on the roads in Great Britain under Vehicle Special Orders (VSOs). These orders are issued on the basis that operators are trial participants and submit data as required for trial monitoring, and also that the trailer models used have been subject to the VCA approval process.

Manufacturers are free to construct longer trailers that adhere to the length limits for the trial (either 14.55m or 15.65m) as well as a number of other dimension criteria. They must also demonstrate that they are able to perform a turning manoeuvre according to VCA specifications, as laid out in the trial requirements. The VCA tests individual models as constructed by manufacturers and issues a 'model report for each chassis design. Each VSO, issued to the operator and retained in pdf copy by VCA, also records the model of the trailer.

The DfT feasibility studies conducted by DfT before the trial started did not indicate that the increased length of the trailers would result in an increase in the injury incident rate. However, the objectives of the trial include analysis not only of injury incidents but also any impact on other road users or local infrastructure from the operation of LSTs. Some observers of the trial have raised particular concern about the increased 'kick-out' of the rear of these trailer compared to standard 13.6m trailers.

The purpose of this special topic analysis is to assess the evidence to date for a relationship between LST kick-out metrics and safety risk.

The VCA has kept records of the model tests, but neither DfT nor VCA has been in a position to transfer the records to an accessible electronic format. The first step in this Special Topic Analysis project was for Risk Solutions to work with VCA to collate and cleanse the model report data, and to link the model report data to as many of the 'on the road' LSTs as possible. This then supported analysis of the trial data against trailer model characteristics.

This project note describes:

- the trailer model report data available
- how this data has been linked to the main trial data
- analysis of the key characteristics of the trailer fleet made possible through this linkage, and
- the results from a preliminary analysis of the potential impacts of key design features on trailer safety risk performance.

Linking model characteristics with trailer and journey data

Model Report Data Available

Risk Solutions was provided by VCA with a list of trailer models. This information covers 48 individual trailer models, produced by 12 different manufacturers, and includes some of the key physical features that characterise each model. For each model we have the following data, the relevance of which is described below:

1. Manufacturer
2. Length (in metres)
3. Steering type (self-tracking or command steer)
4. Number of steering axles

5. Kick-out (in millimetres)
6. Steering angle limit.

Steering Type and Number of Steering Axles

Typically, each longer trailer has at least one steering axle that helps the longer back end of the trailer negotiate turns. These axles can be self-tracking, effectively turning based on the movement of the trailers itself, and not attached to the tractor unit. Alternatively, the steering axles can have a command steer (passive) configuration, where the axles are effectively connected, either mechanically, hydraulically or electrically, to the behaviour of the turning angle of the fifth wheel and the bedplate.

Kick-out and the turn-out test that is used to measure it

The standard requirements for vehicle manoeuvrability are contained in EU Regulation 1230/2012, which does not contain a standard requirement for measuring kick-out for semi-trailers (type O vehicles). Indeed, trailers are deemed to qualify under the standard regulations based on a wheelbase calculation only. The kick-out measurement is only applied to type N (commercial) and M (passenger) vehicles.

For the LST trial, DfT required all designs to have their kick-out measured by the 'drive in' test normally applied to M_2 and M_3 buses, broadly on the basis that an articulated M_3 bus, with a maximum length of 18.75m (the same as the longest LSTs) would be a meaningful benchmark.

The test, illustrated in Figure 23 is performed as follows:

Drive-in test method

The vehicle shall be stationary, a vertical plane tangential to the side of the vehicle and facing outwards from the circle shall be established by marking a line on the ground.

The vehicle shall be moved from a straight line approach into the circular area described in Figure 1 with its front wheels turned such as the front outermost point follows the contour of the outer circle (see Figure 2a of Appendix 3 to this Annex).

Source: EU Regulation 1230/2012 Part B, Para 8.1.2

Figure: Op Cit.Appendix 3, Figure 2b "Drive in test for M_2, M_3 vehicles

The kick-out is the value of Umax shown in the figure as measured during the test.

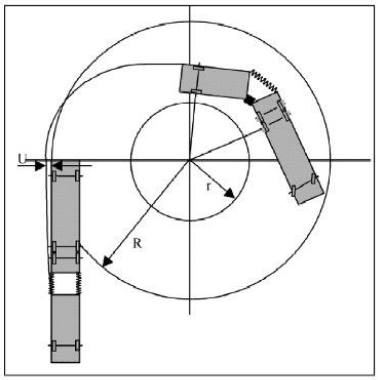


Figure 2b:
rear swing-out (articulated vehicles)
R = 12,5 m
r = 5,3 m
U_{max} ≤ 60 cm

Figure 23: Drive-in Test

Steering Angle Limit

The steering angle limit refers to the maximum turn angle of the axle fitted to the trailer.

Connecting Model Report Data and Trial Data

One of the elements of information we require from operators is the model report number for their trailer – this is provided to them on the VSO issued by VCA. With this we can connect each trailer's data to the model characteristics. The data is not very 'clean' in this area, especially in relation to the early trial VSOs. Not all operators provide this information, not all model numbers were provided accurately (and we had

no way of verifying this data element) and historically not all VSOs had the correct model provided on them.

We carried out an initial analysis to identify how much of the data we had could be matched with a VCA model report number. We found that of the 1,775 trailers in our database 824 had not been provided with a recognised VCA model report. However, for these trailers we were able to provide VCA with an accurate VIN and VSO from which VCA were able to identify the correct VCA model report number for these trailers. Over a number of iterations, working closely with the VCA team, we have identified as far as possible an accurate model against each trailer VIN. This has resulted in a database of 1,761 trailers matched against a valid model type.

We have used this connection to explore the overall characteristics of the LST fleet, and whether any of the model design features correlate with the way that trailers are used and have performed during the trial.

However, it should be noted that not all the VCA model type data is complete. We have complete data for 98% of the fleet in terms of trailer numbers, and for 88% of the journey legs. This disparity arises because some of the earliest trailers on the road (which have therefore racked up the greatest number of journey legs) are those for which we have only a National Small Series Type Approval (NSSTA) number rather than the underlying VCA model number. To date VCA have not been able to make the connection from one to the other.

Real World Use of Trailers in the Trial and Impact on Analysis

The results here would include any incidents where in the real world the trailer was being turned through a greater angle than used in the test and hence the kick-out would be greater than measured in the test. The results are nonetheless comparable, since the data potentially includes such real world turning patterns for all trailer designs.

The final real world effect inherent in this data is the choice of routes on which operators are using LSTs. We note that the clear majority of operators have specifically stated that they are only operating LSTs on selected routes (which they have assessed as suitable). These results reflect the outcomes of these route choices, not any theoretical scenario where LSTs are operated on routes with a greater number of very high-angle turns.

Fleet characteristics

The fleet of LSTs for which we have ‘connected’ trial data can be broken down according to manufacturer, number of trailers, journey legs operated and characteristics from the VCA model reports.

These charts provide context for the analysis and discussion that follows in Section 4.

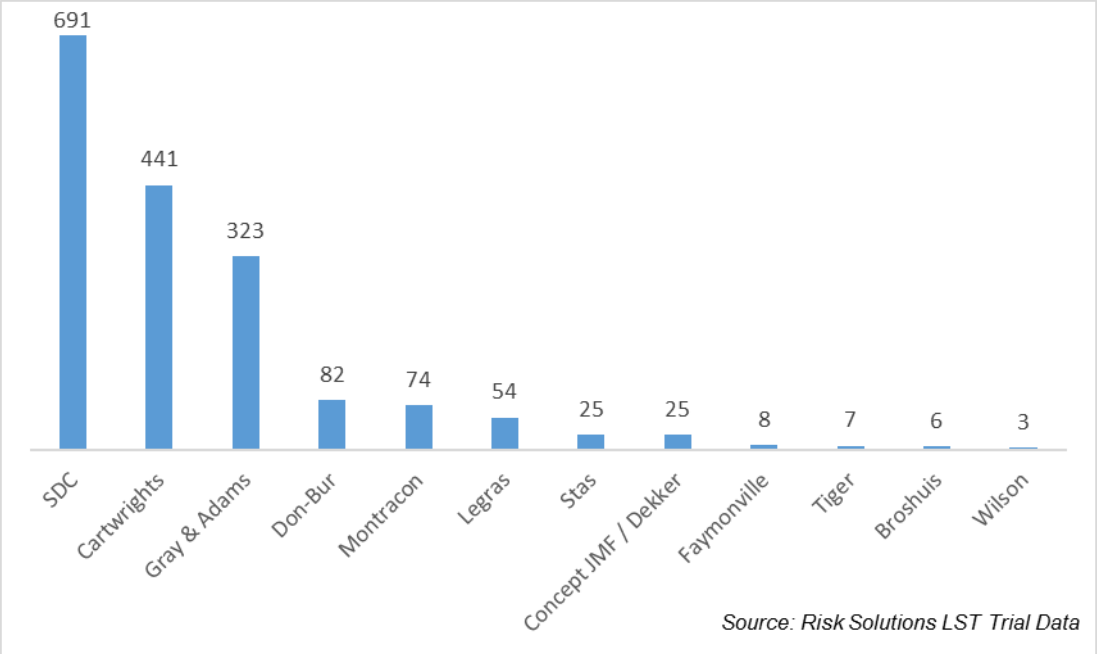


Figure 24: Number of Trailers in LST Fleet by Manufacturer

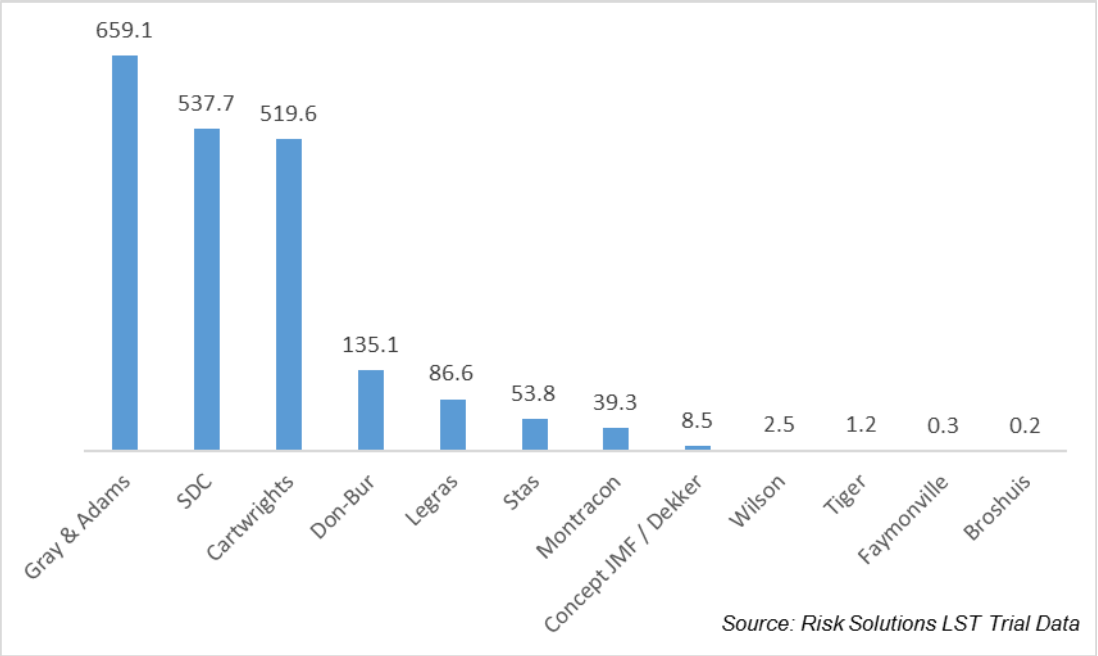


Figure 25: Thousands of Journey Legs by Manufacturer

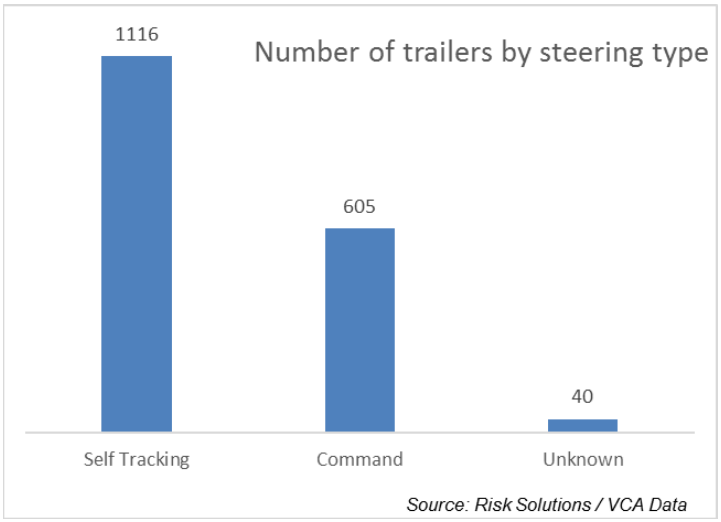


Figure 26: Number of Trailers in LST Fleet by Axle Steering Type

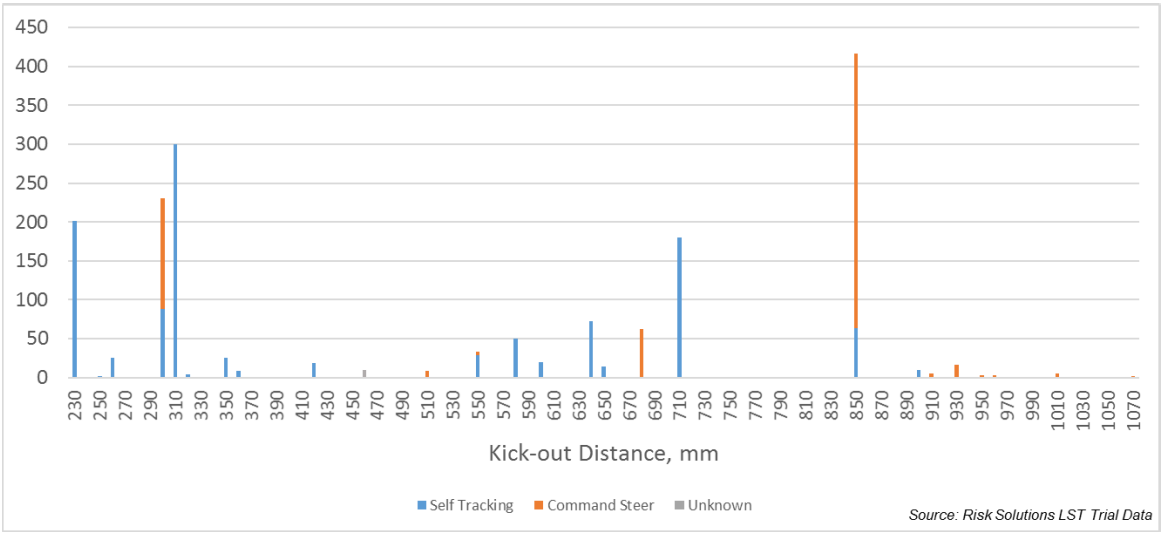


Figure 27: Number of Trailers in LST Fleet by Kick-out Distance andSteering Type

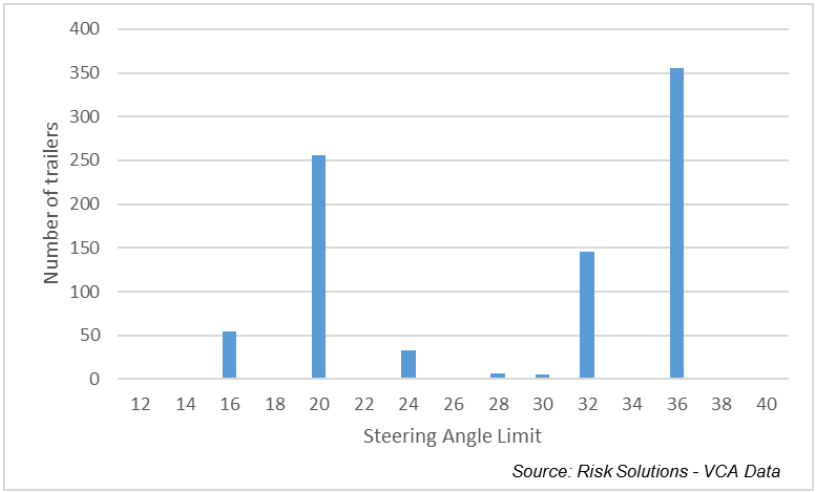


Figure 28: Number of Trailers in LST Fleet by Steering Angle Limit

Analysis of trailer and journey characteristics against incident statistics

We have conducted an analysis of incidents against trailer and journey characteristics. The purpose of this analysis was to explore some possible hypotheses. The underlying assumption of many observers of the trial, is that incidents that are related to the nature of the LST (i.e. its longer length and/or steering system) are related to the way the trailer negotiates turns, so that characteristics such as steering angle, kick out and steering type may be correlated with incidents associated with a turn manoeuvre. For some industry observers, it has been 'taken as read' that an increased kick-out would lead to an increase in damage, if not injury, incidents.

There are other possible variables which may be correlated with the likelihood of these incidents, such as the leg type (a proxy for whether the journey is more likely to be mainly on motorways and A roads or mainly on smaller urban or semi-urban routes), the length of the trailer, the length of the journey and so on.

Initially, we produced simple charts, such as Figure 29, looking at combinations of these variables, to see if there was any obvious correlation that could be seen 'by eye'.

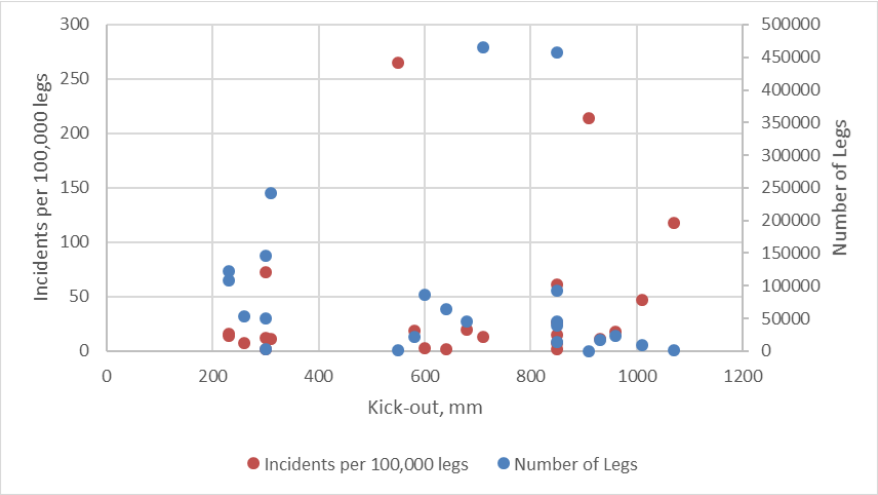


Figure 29: Raw LST injury and damage incident data vs. by kick-out

This was inconclusive due to the spread of results and the presence of what appeared to be outlier cases. We therefore moved on to a progressive statistical analysis of the data as described below.

Data preparation

We prepared a dataset that combined LST journey leg trial data with incident data and linked this to the VCA model report data for the trailer performing the journey leg. To support a robust statistical analysis, we had to create fewer categories for some of the data than are captured in the overall trial data.

Leg Type

We initially categorised leg type as follows:

- 'Trunking' incorporates leg types:
  - 3) SUPPLIER TO DIST CENTRE
  - 4) DC TO DC
  - 7) PALLETISED TRUNKING
- 'Delivery' incorporates leg types:
  - 5) To/from RETAIL SITE

  - 6) To/from INDUSTRIAL SITE
- 'Unknown' incorporates leg type:
  - 1) EMPTY FROM DEPOT TO JOB
  - 2) EMPTY BETWEEN JOBS
  - 8) EMPTY BACK TO DEPOT
  - 9) OTHER LEG TYPE

Steering Type

We also categorised the steering type as follows:

- 'Self Tracking' – 1 SELF-STEER
- 'Command' – 1 COMMAND (Passive), 2 COMMAND (Passive)

Incident Data

We associated each leg with a series of incident flags, indicating whether an incident meeting certain criteria occurred on that journey leg. Journey legs already contain an incident yes/no flag and to this we added the following flags:

- **Damage or injury incident flag** – indicates an incident resulting in damage or injury (some incidents result in neither).
- **Turn manoeuvre flag** – indicates that the incident was associated with or occurred during a turn manoeuvre: either making a left, right or U-turn or preparing to turn.
- **LST-related flag** – indicates that the operator judged the incident to be wholly, partly or maybe related to the fact that the trailer was an LST. These judgements are then checked by Risk Solutions and, where appropriate, amended. For example, we take the prudent view that any turning incident where the rear of the trailer hit an object maybe LST related.
- **Incident relevant flag** – indicates that all three of the previous incident flags are set to 'Yes' – these are the incidents for which we would anticipate the highest correlation between the likelihood of an incident and the characteristics of the trailer itself, while excluding events where there was no damage or injury.
- **Public / private flag** – indicates whether the incident occurred on a public road or in a private location, such as a depot or client site.

Analysis and refinement

Once we had constructed the dataset with all the links established, we analysed the data using a the 'R' statistical package, to examine whether or not there is evidence that incidents are correlated to particular trailer characteristics.

After our initial analysis we divided the Leg Type 'Unknown' category into 'Empty', incorporating all the empty leg types, and 'Unknown' which contains anything else previously in that category apart from the empty legs.

Our initial analysis included incidents on all road types, but we then looked specifically at those on public roads only, as these are most likely to be of relevance for policy making.

A detailed description of the various logistic regression analyses we conducted to explore the implications of the data is provided in the Appendix to this note.

Our conclusions are given in the final section of the document.

Conclusions

The probability of a journey leg suffering an incident that (i) resulted in damage or injury, (ii) was LST related, and (iii) occurred during a turn manoeuvre is reduced by a statistically significant amount if the journey is classified as Trunking rather than a Delivery, and/or if the steering system is Self Tracking rather than Command.

The conclusion that incidents occur more often on delivery legs is as one might expect, given the nature of Trunking operations, having a large proportion of their journey on major dual carriageways and often starting and ending at specially designed distribution centres at either end.

The conclusion that there is a basic relationship with the steering system is interesting and we can point to some published studies (Cebon 2002[36]) that would indicate the same result, although the trailer designs in that particular study had dual steer axles.

There is also a reduction in incident probability as turn angle limit increases, although the coefficient value is small so the effect is quite weak, and disappears if only incidents on public roads are included in the analysis.

This is a much less significant effect than those noted above and the fact that it only really seems to affect the results if the off-public road results are included, suggests that it may be to do with manoeuvring in depots, where some very tight turns might be attempted, if the axle permitted it, rather than an issue of concern in public road operations.

Leg distance was not found to be significant in any of the analyses

This would confirm our presumption that this type of incident (turn related) is more associated with the start and ends of journeys rather than the overall number of miles driven.

Kick-out does not appear to be a statistically significant variable in our initial analysis.

This reinforced the impression from our 'by eye' examination of the results, that there is no simple relationship between measured kick-out and collisions.

We then explored Delivery legs only on the basis that these have a higher probability of an incident occurring, and we might expect routes to involve more urban areas or tighter turns. We looked for evidence of a kick-out effect. The aim here was to check that the trunking legs were not masking an underlying issue on delivery legs. However even with this more focused analysis there was no statistically significant impact of kick-out, although the probability of a relevant incident occurring on a Delivery leg on a public road is still reduced by a statistically significant amount if the steering system is Self Tracking.

No other parameters are statistically significant at the 5% level.

[36] ' Comparative performance of semi-trailer steering systems' in 7th International Symposium on Heavy Vehicle Weights and Dimensions, Delft, NL, June 16-20, 2002

Logistic regressions of incident statistics

This section is provided in support of the main findings reported above and presumes that the reader has the necessary background in statistics to be familiar with the terminology and methods used. As with other statistical analysis we have conducted for the LST trial, we expect DfT will wish to have this reviewed by an in-house statistician.

Run 0: Initial Exploratory Analysis

The LST journey legs database contains information that can form the basis of a logistic regression analysis. The aim of this analysis is to fit a statistical best-fit model that relates the probability of a journey leg being involved in an incident against a number of predictor variables. The form of a logistic regression model is follows:

$$log_e\left(\frac{\pi}{1-\pi}\right) = a_0 + a_1X_1 + a_2X_2 + \cdots$$

where π is the probability that a given journey leg suffers an incident for a particular set of X value predictors. These predictors can be continuous (e.g. trailer kick-out distance in mm) or categorical (e.g. leg type, steering type). The function $\pi/(1-\pi)$ represents the 'odds' of being involved in an incident, so for example if the probability of an incident is 0.1 then the odds = 0.1/0.9 = 1/9 (or 'nine to one against').

The initial prepared database contained 25 variables. 12 of these are potentially relevant to the analysis:

LegTypeCategory	**A categorical variable set to either "Delivery" or "Trunking" if known**
LegDistanceKM	The leg distance in km (set to 'missing' if less than 0.001 km as otherwise e.g. zero km would be treated as a valid observation in the analysis)
TrailerLength	A categorical variable set to either "14.6m" or "15.65m" if known
KickOutmm	The kick out distance in mm recorded for the trailer if known; set to 'missing' otherwise
SteeringCategory	A categorical variable set to either "Command" or "Self Tracking" if known
NewAngleLimit	The steering angle limit recorded for the trailer if known; set to 'missing' otherwise
NoOfSteeringAxles	A categorical variable set to either "1 axle" or "2 axles"
IncidentRelevantFlag	Set to "Yes" if an incident occurred on the leg that (i) resulted in damage or injury, (ii) was LST related, and (iii) occurred during a turn manoeuvre (i.e. all three of the following flags are set to "Yes")
DamageOrInjuryIncidentFlag	Set to "Yes" if an incident occurred on the leg that resulted in damage or injury for any reason
TurnManouevreFlag	Set to "Yes" if an incident occurred on the leg during a turn manoeuvre
LSTRelatedFlag	Set to "Yes" if an incident occurred on the leg that has been assessed as LST related
LegIncidentFlag	Set to "Yes" if any kind of incident occurred on the leg

There are 2,314,001 legs recorded in the trial database covering all LST trial operations from 2012 to 2016-P2. Approximately 60% of these have complete data records (i.e. no 'missing' values) for all of the key variables listed above (noting that 'Empty' legs would fail this test).

We are mostly interested in the incidents where the Incident Relevant flag is set to "Yes", so this has been the focus of this analysis. There are 131 such cases, so the raw probability that any leg selected at random has experienced an incident of this type is 131/2314001 = 5.66×10^{-5} or approximately 1 leg in every 17,664. The first thing to check is whether our categorical variables are possible incident predictors. We do this using a Chi-squared test, to see whether the distribution of "Yes" and "No" values for the Incident Relevant flag is independent of the predictor variable. The results are summarised in the table below.

Leg Counts	Trailer Length		Chi squared test result
Incident Relevant Flag	14.6m	15.65m	p = 0.284 Incident occurrence and trailer length are **independent**
No	332,834 (legs)	1,799,177	
Yes	16	115	
	Leg Type Category		Chi squared test result
Incident Relevant Flag	Delivery	Trunking	p = 6×10^{-10} Incident occurrence and leg type category are **not independent**
No	718,044	902,022	
Yes	78	27	
	Steering Category		Chi squared test result
Incident Relevant Flag	Command	Self Tracking	p = 2×10^{-9} Incident occurrence and steering category are **not independent**
No	710,037	1,333,081	
Yes	76	50	
	Steering Axles		Chi squared test result
Incident Relevant Flag	One axle	Two axles	p = 5×10^{-4} Incident occurrence and no. of steering axles are **not independent**
No	1,994,535	49,055	
Yes	117	9	

These results indicate that all the categorical variables apart from Trailer Length are worth including in the logistic regression analysis (in addition to the numeric variables for turn angle limit, trailer kick out and leg distance).

The analysis was done with the R statistical package, using the 'glm' (general linear model) package. We used the following initial form of the model:

```
glm(IncidentRelevantFlag ~ LegTypeCategory + SteeringCategory + NoOfSteeringAxles + NewAngleLimit + KickOutmm + LegDistanceKM, data=Legs, family=binomial())
```

The resulting model fit coefficients (refer to the logistic regression equation above) are shown overleaf.

The parameters marked with *** are highly statistically significant and the parameters marked with * are significant at greater than the 5% level. The other parameter estimates are not statistically significant, so there is insufficient evidence to reject the 'null hypothesis' that they are equal to zero.

	Estimate	Std. Error	p value
a_0 (Intercept)	-6.191	0.8772	1.69×10^{-12} ***
a_1 LegTypeCategory - Trunking	-1.737	0.2993	6.54×10^{-9} ***
a_2 SteeringCategory - Self Tracking	-1.693	0.2950	9.51×10^{-9} ***
a_3 NoOfSteeringAxles - Two	-9.266	315.1	0.9765
a_4 NewAngleLimit	-4.997×10^{-2}	2.257×10^{-2}	0.0268 *
a_5 KickOutmm	-4.709×10^{-4}	5.37×10^{-4}	0.3809
a_6 LegDistanceKM	-1.369×10^{-3}	1.145×10^{-3}	0.2320

The negative sign of the significant coefficients indicates that (for example) the chance of having this type of incident on a leg is **reduced** if the leg type category is “Trunking” or the steering category is “Self Tracking”.

The initial model was also refined using stepwise regression, which adds / subtracts variables from the model until the best overall fit is reached. This also confirmed the above results because the final form of the model did not include the variables for number of steering axles, kick-out or leg distance. The coefficients for this ‘reduced’ form of the model are shown below.

	Estimate	Std. Error	p value
a_0 (Intercept)	-6.803	0.728	$< 2 \times 10^{-16}$ ***
a_1 LegTypeCategory - Trunking	-1.747	0.277	3.05×10^{-10} ***
a_2 SteeringCategory - Self Tracking	-1.563	0.271	8.28×10^{-9} ***
a_3 NewAngleLimit	-0.047	0.022	0.0345 *

Following this initial exploration of the data, we conducted a number of runs of the model tailored to look for statistically significant effects within sub-sets of the data.

Run 1: Focus on Leg Type and Steering Category

Leg Type

The original analysis had two possible leg type categories:

Trunking – Leg Types 3, 4 or 7 Delivery – Leg Types 5, 6

Everything else was set to ‘missing’ so it was excluded from the regression analysis.

In this next stage of analysis we have created three leg type categories:

Trunking – Leg Types 3, 4 or 7 Delivery – Leg Types 5, 6

Empty – Leg Types 1, 2, 8

Again, everything else is set to ‘missing’.

If we look at the leg frequency table for this new categorisation we see the following:

	Leg Type Category		
Incident Relevant Flag	Delivery	Trunking	Empty
No	718,044	902,022	632,576
Yes	78	27	19
Percentage "Yes"	0.011%	0.0030%	0.0030%

The proportion of legs suffering an incident is identical to 2 significant figures for "Trunking" and "Empty", suggesting that Empty legs and Trunking legs have a similar risk level, about 3.6 times lower than Delivery legs.

If we repeat the logistic regression analysis using the new Leg Type Category variable, we find the following regression coefficients:

	3.122 **Esti** **e**	**Std. Error**	**p value**
a_0 (Intercept)	-6.777	0.8357	5.05×10^{-16} ***
a_1 LegTypeCategory - Empty	-1.492	0.2880	2.23×10^{-7} ***
a_2 LegTypeCategory - Trunking	-1.771	0.2954	2.01×10^{-9} ***
a_3 SteeringCategory - Self Tracking	-1.580	0.2823	2.20×10^{-8} ***
a_4 NoOfSteeringAxles - Two	-9.391	246.7	0.9696
a_5 NewAngleLimit	-3.693×10^{-2}	2.195×10^{-2}	0.0924 *
a_6 KickOutmm	-3.368×10^{-4}	4.876×10^{-4}	0.4897
a_7 LegDistanceKM	-6.841×10^{-4}	1.057×10^{-3}	0.5174

The results are very similar to the original analysis. LegTypeCategory and SteeringCategory are highly statistically significant, and the negative sign shows that the probability of a leg suffering an incident reduces if the leg type is "Empty" or "Trunking"[37] and/or if the steering category is "Self Tracking". Because the regression coefficients are very similar for LegTypeCategory – Empty and LegTypeCategory – Trunking, we can conclude that they both contribute a similar amount of risk, confirming the results from the frequency table. We could speculate that the majority of the Empty legs are in fact taking place over the same routes as the Trunking legs.

Run 2: Analysis for Public Road Incidents Only

In this additional analysis, we have restricted the incidents to **those occurring on public roads only**.

We have used the same three leg type categories as the previous analysis:

Trunking – Leg Types 3, 4 or 7

Delivery – Leg Types 5, 6

Empty – Leg Types 1, 2, 8

And again, other leg types were set to 'missing'.

[37] Remember that each leg can either be Delivery, Empty or Trunking. The regression analysis uses two dummy variables X_1 and X_2 (that take the value 0 or 1) with regression coefficients a_1 and a_2. $[X_1,X_2] = [0,0]$ corresponds to Delivery; [1,0] corresponds to Empty; [0,1] corresponds to Trunking.

If we look at the leg frequency table for this new categorisation we see the following:

	Leg Type Category		
Incident Relevant Flag - public roads only	Delivery	Trunking	Empty
No	718,086	902,051	632,586
Yes	36	8	9
Percentage "Yes"	0.0050%	0.0009%	0.0014%

This suggests that Delivery legs have a higher level of risk than Trunking legs, and that Empty legs are somewhere between the two (perhaps reflecting a mixture of route types).

If we repeat the logistic regression analysis using the new Leg Type Category variable for incidents on public roads only, we find the following regression coefficients:

	3.176 **Esti** e	**Std. Error**	**p value**
a_0 (Intercept)	-10.82	1.615	2.05×10^{-11} ***
a_1 LegTypeCategory - Empty	-1.288	0.3798	0.00070 ***
a_2 LegTypeCategory - Trunking	-2.142	0.4659	4.27×10^{-6} ***
a_3 SteeringCategory - Self Tracking	-0.6047	0.4876	0.2149
a_4 NoOfSteeringAxles - Two	-9.955	404.8	0.9804
a_5 NewAngleLimit	0.0672	0.0456	0.1408
a_6 KickOutmm	-0.00083	0.00073	0.2520
a_7 LegDistanceKM	0.00017	0.0015	0.9104

The only variable that is statistically significant is the LegTypeCategory, and the negative sign shows that the probability of a leg suffering an incident reduces if the leg type is "Empty" or "Trunking."[38] The magnitudes of the regression coefficients tell us that a LegTypeCategory of Trunking is the lowest risk, confirming the results from the frequency table. Steering Category and Trailer Kick-out are **not** significant predictors for the probability of a turn related incident occurring on public roads; there is insufficient evidence to reject the hypothesis that their effect is zero.

Run 3: Effect of kick-out on Self Steered trailers

Run 3-1: Effect of Kick-out on Self Steered trailers, Incidents on all Road Types

Figure 4 has shown that Trailer kick-out is strongly influenced by Steering Category, with the Self Steered trailers showing a much wider range of kick-out values but with Command Steered trailers having generally much higher kick-outs. Including Steering Category as one of the regression variables is therefore potentially masking the effect of kick-out on incident probability within a particular Steering Category.

[38] Remember that each leg can either be Delivery, Empty or Trunking. The regression analysis uses two dummy variables X_1 and X_2 (that take the value 0 or 1) with regression coefficients a_1 and a_2. $[X_1,X_2] = [0,0]$ corresponds to Delivery; [1,0] corresponds to Empty; [0,1] corresponds to Trunking.

We have therefore repeated the regression for just the Self Steered trailers, using the following R model:

glm(IncidentRelevantFlag ~ LegTypeCategory2 + NoOfSteeringAxles + NewAngleLimit + KickOutmm + LegDistanceKM)

The regression results are as follows:

	3.212 Estimate	Std. Error	p value
a_0 (Intercept)	-8.994	1.338	1.80×10^{-11} ***
a_1 LegTypeCategory - Empty	-1.696	0.4509	1.69×10^{-4} ***
a_2 LegTypeCategory - Trunking	-2.277	0.5435	2.78×10^{-5} ***
a_3 NoOfSteeringAxles - Two	-9.012	493.5	0.985
a_4 NewAngleLimit	0.0300	0.049	0.543
a_4 KickOutmm	-0.00198	0.00071	0.005 **
a_6 LegDistanceKM	-0.00183	0.0018	0.316

The results are similar to the above, with a leg type category of Empty or Trunking being highly significant for reduced incident probability. Trailer Kick-out is now also significant with a p value of only 0.005, however the coefficient value is almost zero (-0.00198) so the effect is very small.

Run 3-2: Effect of Kick-out on Self Steered trailers, for Incidents on Public Roads only

Using the same R model structure as before, but restricting the incidents to those occurring on public roads only, we have repeated the regression.

glm(IncidentRelevantFlag ~ LegTypeCategory2 + NoOfSteeringAxles + NewAngleLimit + KickOutmm + LegDistanceKM)

The regression results are as follows:

	3.244 Estimate	Std. Error	p value
a_0 (Intercept)	-10.64	2.122	5.32×10^{-7} ***
a_1 LegTypeCategory - Empty	-2.265	0.7493	0.0025 ***
a_2 LegTypeCategory - Trunking	-3.324	1.041	0.0014 ***
a_3 NoOfSteeringAxles - Two	-8.749	497.0	0.986
a_4 NewAngleLimit	0.0833	0.0793	0.293
a_4 KickOutmm	-0.0027	0.00099	0.006 **
a_6 LegDistanceKM	-0.00035	0.0023	0.877

The results show little change in the key parameters, with a leg type category of Empty or Trunking being highly significant for reduced incident probability. Trailer Kick-out is now also significant with a p value of only 0.006. The sign of the Kick-out coefficient is negative, which is somewhat counterintuitive, however the coefficient value is almost zero (-0.0027) so the effect is very small and is possibly just due to “noise” in the data.

Missing data

The R output below show the number of legs with missing data for each of the key categorical and continuous variables used in this analysis.

LegTypeCategory		LegTypeCategory2		SteeringCategory		TrailerLength	
Delivery	718122	Delivery	718122	Command	710113	14.6m	332850
Trunking	902049	Empty	632595	Self Tracking	1333131	15.65m	1799292
		Trunking	902049				
Missing	693830	Missing	61235	Missing	270757	Missing	181859
% Missing	30.0%	% Missing	2.6%	% Missing	11.7%	% Missing	7.9%

NoOfSteeringAxles		LegDistanceKM		NewAngleLimit		KickOutmm	
One	994652	Continuous Variable		Continuous Variable		Continuous Variable	
Two	49064						
Missing	270285	Missing	27623	Missing	357651	Missing	270548
% Missing	11.7%	% Missing	11.9%	% Missing	15.4%	% Missing	11.7%

GLOSSARY

CIF	Company information form - the MS Excel workbook developed to capture background information about the operator's company and standard operations prior to the trial.
DfT	Department for Transport
Double deck/ dual deck	A specialised trailer with two floors covering all or part of its internal length to allow for more cargo to be loaded.
DSF	Data submission form - the MS Excel workbook developed to allow operators to submit all trial data in the required format for analysis.
Flatbed	A flat trailer with no enclosure or doors. Can be loaded/unloaded from the sides or above, and does not require elevated access for forklifts.
FMCG	Fast Moving Consumer Goods - products that are sold quickly and at relatively low cost. Examples include non-durable goods such as soft drinks, toiletries, over-the-counter drugs, processed foods and many other consumables.
FTA	Freight Transport Association
ISO	Containers meeting the international specification for intermodal transport.
Leg	A single journey from A to B.
LST	Longer Semi-Trailer - a trailer exceeding the standard length of 13.6m, towed by a tractor unit (as opposed to standard length trailers).
LST Related	
MOA	Mode of appearance - the physical form of the load, for example standard pallets, loose/ bulk, livestock.
Model Report	A document specifying the conformance criteria for a specific model to be licensed for use on the road, created by the VCA after testing new vehicle types.
PLM	Programme logic model - a diagrammatic representation of the structure of a process for the purposes of evaluation.
QSF	Qualitative survey form - the MS Excel workbook developed to capture qualitative information from operators about their trial experience.
RHA	Road Haulage Association
RST	Regular Semi-Trailer – i.e. up to a maximum length of 13.6m (not requiring a VSO) – sometimes use to refer to a GB standard length HGV trailer.
Skeletal	A skeletal trailer composed of a simple chassis for the mounting of an intermodal trailer.
VCA	The Vehicle Certification Agency is an Executive Agency of the United Kingdom Department for Transport and the United Kingdom's national approval authority for new road vehicles, agricultural tractors and off-road vehicles.
VIN	Vehicle Identification Number - a unique 17 digit identifier required on all vehicles, stamped on the chassis on manufacture.
VSO	Vehicle Special Order - a certificate provided by the VCA to allow vehicles that do not conform to standard legislation in terms of dimensions to operate on roads in Great Britain under specially licensed conditions.