Alternative methods for the management of night-time freight noise in London

M J Ainge
P G Abbott
C Treleven
P A Morgan
P M Nelson
G R Watts
R E Stait
Alternative methods for the management of night-time freight noise in London

by M J Ainge, P G Abbott, C Treleven, P A Morgan, P M Nelson, G R Watts and R E Stait

PPR 286
SC 0661 007 30166

PUBLISHED PROJECT REPORT
PUBLISHED PROJECT REPORT PPR 286

ALTERNATIVE METHODS FOR THE MANAGEMENT OF NIGHT-TIME FREIGHT NOISE IN LONDON

Version: Final Report

by M J Ainge, P G Abbott, C Treleven, P A Morgan, P M Nelson, G R Watts and R E Stait (TRL Limited)

Prepared for: Project Record: SC 0661 007 30166
Client: TfL Street Management. Surface Strategy & Business Development, Freight Unit
[Ian Wainwright]

Copyright TRL Limited September 2007

This report has been prepared for TfL Street Management. The views expressed are those of the author(s) and not necessarily those of TfL Street Management.

Published project reports are written primarily for the customer rather than for a general audience and are published with the customer’s approval.
This report has been produced by TRL Limited, under/as part of a Contract placed by TfL Street Management. Any views expressed are not necessarily those of TfL Street Management.

TRL is committed to optimising energy efficiency, reducing waste and promoting recycling and re-use. In support of these environmental goals, this report has been printed on recycled paper, comprising 100% post-consumer waste, manufactured using a TCF (totally chlorine free) process.
# CONTENTS

Executive summary i

Glossary of abbreviations and acronyms ix

Glossary of units and symbols (including relevant definitions) xi

1 Introduction 1

1.1 Background to the project 1

2 Overview of freight traffic in London 3

PHASE 1: POTENTIAL AMENDMENTS TO THE LLCS 5

3 The London Lorry Control Scheme (LLCS) and Exempt Road Network (ERN) 7

3.1 Overview of the London Lorry Control Scheme 7
3.2 Overview of the ERN 7
3.3 The permit system for travel off the ERN 8

4 Reasons for making changes to the LLCS and ERN 11

4.1 Why Consider Changes to the LLCS? 11
4.2 Assessing potential changes to the LLCS 11
4.3 Effects on daytime noise levels, congestion and other benefits 12
4.4 Conclusion 13

5 Potential options for changes to the LLCS 15

5.1 Should the LLCS remain unchanged? 15
5.2 How could the LLCS be changed 15
5.3 Potential changes through the introduction of new technologies 15
5.4 Potential changes through the use of low-noise surfaces on the ERN 19
5.5 Potential changes through improved enforcement 19
5.6 Potential major revisions to the LLCS 23

6 The favoured approach 31

6.1 Which policies were rejected? 31
6.2 The approach for Phase 2 31

PHASE 2: DEVELOPMENT OF AN IN-SERVICE TEST 33

7 Review of existing practices for controlling the operation of goods vehicles 35

7.1 General limitations controlling the operation of goods vehicles 35
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.2</td>
<td>Review of in-service testing methods and associated legislation for the control of vehicle noise</td>
<td>35</td>
</tr>
<tr>
<td>7.3</td>
<td>Summary</td>
<td>40</td>
</tr>
<tr>
<td>8</td>
<td>Roadside noise measurements of large goods vehicles</td>
<td>41</td>
</tr>
<tr>
<td>8.1</td>
<td>Selection of measurement sites</td>
<td>41</td>
</tr>
<tr>
<td>8.2</td>
<td>Details of the measurements</td>
<td>41</td>
</tr>
<tr>
<td>8.3</td>
<td>Results from the monitoring</td>
<td>42</td>
</tr>
<tr>
<td>9</td>
<td>Test track noise measurements of large goods vehicles</td>
<td>47</td>
</tr>
<tr>
<td>9.1</td>
<td>Selection of vehicles</td>
<td>48</td>
</tr>
<tr>
<td>9.2</td>
<td>Selection of test procedures</td>
<td>48</td>
</tr>
<tr>
<td>9.3</td>
<td>Results of the test programme</td>
<td>49</td>
</tr>
<tr>
<td>10</td>
<td>Proposals for an in-service test for the LLCS</td>
<td>55</td>
</tr>
<tr>
<td>10.1</td>
<td>Rationale and recommendations</td>
<td>55</td>
</tr>
<tr>
<td>10.2</td>
<td>Applying the in-service test in practice</td>
<td>59</td>
</tr>
<tr>
<td>11</td>
<td>Costs and benefits of in-service testing</td>
<td>65</td>
</tr>
<tr>
<td>11.1</td>
<td>Methodology</td>
<td>65</td>
</tr>
<tr>
<td>11.2</td>
<td>Conclusions on costs and benefits</td>
<td>66</td>
</tr>
<tr>
<td>12</td>
<td>The need for prediction and routing tools</td>
<td>71</td>
</tr>
<tr>
<td>13</td>
<td>Prediction of disturbance due to vehicles travelling off the ERN</td>
<td>73</td>
</tr>
<tr>
<td>13.1</td>
<td>The calculation procedure</td>
<td>73</td>
</tr>
<tr>
<td>13.2</td>
<td>Calculations for different traffic flow scenarios</td>
<td>73</td>
</tr>
<tr>
<td>14</td>
<td>Requirements for detailed application of the calculation procedure</td>
<td>85</td>
</tr>
<tr>
<td>14.1</td>
<td>The principle of a sleep disturbance map based noise prediction</td>
<td>85</td>
</tr>
<tr>
<td>14.2</td>
<td>Information required to generate sleep disturbance maps</td>
<td>85</td>
</tr>
<tr>
<td>14.3</td>
<td>Information required to generate increased accuracy disturbance maps</td>
<td>87</td>
</tr>
<tr>
<td>14.4</td>
<td>Factors for consideration in designating routes</td>
<td>88</td>
</tr>
<tr>
<td>15</td>
<td>Summary, conclusions and recommendations</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>Acknowledgements</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>References</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>Appendix A. Summary of goods transport driving restrictions in European Countries (excluding the UK)</td>
<td>103</td>
</tr>
<tr>
<td>Appendix</td>
<td>Description</td>
<td>Page</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------</td>
</tr>
<tr>
<td>B</td>
<td>The Dutch PIEK programme</td>
<td>117</td>
</tr>
<tr>
<td>C</td>
<td>Brief review of factors affecting night-time LGV noise disturbance</td>
<td>119</td>
</tr>
<tr>
<td>D</td>
<td>Changes in exposure due to improved traffic management and the subsequent changes in night-time disturbance</td>
<td>125</td>
</tr>
<tr>
<td>E</td>
<td>The potential effects on noise and other impacts of different vehicle technologies</td>
<td>129</td>
</tr>
<tr>
<td>F</td>
<td>Administrative issues associated with changes to noise tests</td>
<td>133</td>
</tr>
<tr>
<td>G</td>
<td>Results from the roadside noise measurements</td>
<td>135</td>
</tr>
<tr>
<td>H</td>
<td>Description of vehicle noise tests</td>
<td>141</td>
</tr>
<tr>
<td>I</td>
<td>Test track results</td>
<td>147</td>
</tr>
<tr>
<td>J</td>
<td>Cost-benefit analysis</td>
<td>151</td>
</tr>
<tr>
<td>K</td>
<td>Potential noise benefits of example limit values</td>
<td>159</td>
</tr>
<tr>
<td>L</td>
<td>The calculation procedure for the prediction of disturbance due to vehicles travelling off the ERN</td>
<td>161</td>
</tr>
</tbody>
</table>
Executive summary

TRL Limited has been commissioned by Transport for London (TfL) to undertake a review of the noise impacts from the London Lorry Control Scheme (LLCS). This is a scheme that limits the use of large goods vehicles over 18 tonnes within London, and is administered by London Councils (formerly the Association of London Government). The work on the project has been split into three phases. This report addresses the work in all three phases as follows.

PHASE 1: Potential amendments to the LLCS

Phase 1 begins with an overview of the LLCS, the Exempt Road Network (ERN) and the factors affecting night-time large goods vehicle (LGV) noise disturbance\(^1\). The impact of changes in night-time exposure and disturbance as a result of different types of traffic management schemes are included.

Phase 1 of the project has also addressed whether amendments could be made to the LLCS that would significantly improve the environmental benefits achieved by the LLCS, particularly with regard to noise, as well as reducing the costs to operators and enforcement authorities. It appears that several options are available that would meet these aims.

An important issue for this phase of the project concerned the reasons why changes to the LLCS might be desirable, twenty years after its implementation. Amongst these are:

(i) The LLCS now affects a steadily decreasing proportion of night time deliveries in London, because of the increasing proportion of deliveries that are being made by goods vehicles less than 18 tonnes which are currently exempt from the restrictions imposed by the LLCS.

(ii) The availability of technology that can substantially reduce the noise and other emissions from vehicles, and increase compliance. The LLCS could be amended to provide an incentive to operators to employ this technology.

(iii) The views of hauliers that the LLCS is leading to increased mileages for their vehicles.

(iv) The implementation of Congestion Charging and the proposed Low Emission Zones.

Phase 1 of the report also considers evidence on the noise emissions of natural gas vehicles. These vehicles have been the subject of discussions by London Councils’ Transport and Environment Committee (TEC) particularly regarding their noise emission characteristics when compared with conventional diesel powered vehicles.

Proposals are set out for possible ways of redefining the ERN itself, in order to address the issues of disturbance. Possible ways of assessing the eligibility of vehicles for travelling off the ERN are considered.

A major consideration is the size limit for vehicles that are covered by the LLCS. The report considers the possibility of including goods vehicles of less than 18 tonnes. The Table on the following page shows the rates of growth of total mileage (UK) by light vans and other goods vehicles.

---

\(^1\) Large Goods Vehicles (LGV) are defined, according to current taxation classes, as large rigid vehicles and articulated goods vehicles with two or more axles, all > 3.5 tonnes.
Given the above considerations, and other issues considered in the report a series of options for potential changes to the LLCS have been identified. These would clearly require the agreement and cooperation of all relevant stakeholder groups. Some options would involve only small changes, e.g.:

(i) The overall size of the Exempt Network could be increased by resurfacing some roads with a lower noise surface. The replacement programme could be phased in according to existing road maintenance schedules but the additional cost might be up to £50,000 more per kilometre than for existing surfaces.

(ii) Introducing more vigorous enforcement of the LLCS, including firmer action against repeat offenders.

Several options would involve more extensive changes to the LLCS. These changes could involve providing greater freedom to make night-time deliveries for goods vehicles that:

- Meet a more stringent noise threshold than that set by a regulated noise test. For example, a vehicle would have to pass a noise test that has been specifically designed for vehicle operations in-service.
- Are fitted with intelligent speed limiter systems (‘ISA’);
- Are fitted with low noise tyres;
- Are fitted with other low noise equipment (e.g. directional reversing alarm, quiet tail lift etc.

Following discussions with TfL regarding the outcome of the work completed in Phase 1, it was concluded that the way forward should be to concentrate on identifying and prohibiting the operation of noisy goods vehicles within the LLCS rather than major modifications to the ERN itself.

**PHASE 2: Development of an in-service noise test**

Phase 2 of the project has focussed on developing the proposals recommended in Phase 1 for the development and application of an in-service noise test. It begins with a review of available in-service monitoring and testing procedures. The conclusions of this review are that very few procedures exist that are applicable to goods vehicles. Controls on LGV noise relate almost exclusively to the placing of restrictions upon the operation of goods vehicles on the main road networks within Europe. These generally restrict the movement of goods vehicles at weekends and public holidays.

Following on from the review, a programme of roadside noise measurements has been undertaken to define the “typical” noise range for specific vehicle categories operating on the network. Additionally, it was intended that the roadside measurements would be used to examine the effects of road surface type and condition on vehicle noise levels and to identify typical noises from these vehicles that are audible above general traffic noise, e.g. body rattle noise, exhaust noise and brake squeal noise. It was intended that the information

---

<table>
<thead>
<tr>
<th>Class of Vehicle</th>
<th>Percentage increase in total UK mileage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between Years 2002-2005</td>
</tr>
<tr>
<td>Light Vans (Under 3.5 tonnes)</td>
<td>+16.2%</td>
</tr>
<tr>
<td>Goods vehicles (Over 3.5 tonnes)</td>
<td>+4.6%</td>
</tr>
</tbody>
</table>
collated would then be used to inform a measurement programme aimed at defining an appropriate in-service noise test (described below).

The roads included in the study were classified as either ‘good’ or ‘poor’ condition. Roads in poor condition included those with obvious surface irregularities such as rutting and bumps or hollows. It was found that for both road types of road condition, the vehicles could be categorised into three acoustically distinct groups. These were

(i) Cars, car based vans and transits with single tyres on the rear axle;
(ii) 2-axle rigids with twin tyres on the rear axle;
(iii) Rigid or articulated vehicles with 3 or more axles.

It was shown that noise levels over the speed range 40 to 80 km/h were about 2 to 3 dB(A) higher on roads classified as in poor condition compared with roads in good condition. This difference was consistent across all vehicle categories.

Some vehicles produced noise levels with distinct tonal characteristics from sources such as the exhaust, vehicle body (rattles etc) and suspension and brakes. Although a frequency analysis of the noise from these vehicles confirmed significant increases in noise levels at specific frequency bands these differences did not appear to significantly influence the overall A-weighted levels. It is concluded that, since these types of noise can cause disturbance and annoyance, and are unlikely to be picked up by conventional measurement methods, it is important to consider ways of ensuring that vehicles that are permitted to operate off the ERN are checked for these noise sources. This could involve ensuring that vehicles are properly maintained and that issues such as body noise are dealt with through the guidance given in the body noise best practice manual (Department for Environment, Transport and the Regions, 2000). Maintaining roads to a good standard will also help to reduce noise impact particularly from body and suspension noise sources.

A programme of measurements on the TRL test track has been undertaken as part of Phase 2 to provide information on the feasibility of different test options and to develop the basis for a practical in-service test specifically designed for assessing and certifying vehicles for operations off the ERN. The 4 vehicles identified for use in the test track study were selected based on the analysis of the results from the roadside noise measurements. The tests included the current type approval test as well as a range of candidate in-service test methods. These methods involved both dynamic (moving vehicle) as well as tests with a stationary vehicle.

The results of this study, when combined with the results from previous studies carried out by TRL, identified two possible candidate test procedures – a test with the vehicle stationary and involving the rapid acceleration of the engine of the test vehicle, and a test with the vehicle accelerating from rest. In both cases the maximum noise during the test would be measured at a specified measurement point. As both methods appear to be suitable as an in-service test and as experience in conducting these tests is presently limited to a relatively small sample of vehicles, it is recommended that a final decision on the test method would be taken following a programme of measurements that would be needed to establish appropriate limit values for these tests. In addition to the total vehicle noise test it is also recommended that when vehicles are presented for testing, measurements of both air-brake and idle noise are also taken.

The logistics of introducing the recommended test method have been considered. This includes considerations of the test site, the frequency of testing and the prescription of limit values. However, any future plans would also need to take account of other initiatives that
might be in place (e.g. the LEZ, or PIEK\textsuperscript{2}-type programmes to tackle delivery noise) to ensure compatibility and address any potential need for amalgamation of the schemes.

An analysis of the costs and benefits of introducing the test is also provided in the report. This report considered a scenario where noise limits in the test were set at a point where a vehicle that just passed the test produced 50\% less noise disbenefits than the mean for all vehicles above 18 tonnes and concluded that:

- Such a noise limit would lead to a reduction in the value of noise damage and congestion (i.e. a financial benefit to society), over a total of 5 years of vehicle operation, of between £58,000 and £89,625 depending on the number of currently controlled hours that were opened up to operators. Note: Any relaxation of permit conditions would have to go through London Councils-Transport and Environment Committee and be agreed by the boroughs before any changes were permitted.

- The costs associated with this for operators, for the same 5 years of operation, would fall by between £4,950 and £9,450 respectively. The fall in operating costs takes account of the increase in productivity per vehicle passing the test (based on the assumption that passing the noise test entitles the vehicle to operate throughout London during some of the controlled hours) but also takes account of taking the test on an annual basis and the extra cost of obtaining vehicles to pass the test.

PHASE 3: Requirements for an upgraded electronic traffic noise map of London

Phase 3 of the work has considered the development of an upgraded electronic traffic noise map of London that could be used to examine the benefits, particularly to sleep disturbance, of different vehicle noise control options. The formulation of the model took, as a starting point, the information relating the maximum noise levels ($L_{A\text{max}}$) to the speed of vehicles of different categories operating on the network. These level-speed functions had been measured on a selected sample of roads on the LLCS network as part of Phase 2. Three categories of vehicles were considered at this stage and were the same as those established from the work undertaken for Phase 2. Using values of night time traffic flows and composition, the functions were then used to determine typical traffic noise levels which were then used to determine the percentage of the population that would be ‘Highly Sleep disturbed (%HSD)\textsuperscript{3}. Using this approach a model formulation was developed that could be used to relate traffic flows, comprising any specified number of vehicle categories each with their own noise level and speed characteristic, to a measure of overall sleep disturbance in nearby residences.

In order to demonstrate how the model can be applied in practice, several example calculations were made with different traffic flows and compositions. Scenarios examining the effects on noise levels of reducing the maximum size of vehicles permitted to operate on the road from 23:00-07:00 were examined as part of this exercise. The results of the calculations demonstrated the both the feasibility and range of application of the calculation procedure and showed that small overall noise benefits and hence reduction in %HSD were achievable using the different scenarios examined.

Overall it is concluded that the basic calculation procedure could, with the provision of appropriate data, be used as the basis for a route assessment tool. This tool, based on

\textsuperscript{2} The PIEK programme in the Netherlands is an initiative sponsored by the Dutch government which supports projects aimed at tackling noise during the whole delivery process.

population disturbance due to night-time road traffic, could be applied to assist in the issuing of LLCS permits and the choice of appropriate routes for those permits. The output from the model could be used to generate a simple form of sleep disturbance map that would identify residential areas where residents could be affected by sleep disturbance. This information could then be used to target remedial action.

Main recommendations from the study

The main recommendations that follow from this study are as follows:

1. A voluntary noise test, henceforth the ‘London in-service noise test’, should be introduced for vehicles above 18 tonnes operating in London. Consideration should be given to a test with the following features:

   - A ‘Stationary’ test of vehicle noise, including idle condition
   - A ‘Pull away from rest’ test of vehicle noise
   - A check that vehicles comply with:
     - The current EU Directive limit value for airbrake noise; and
     - The government’s best practice guide on body noise.

   This test would provide improved discrimination between noisy and quieter vehicles, and would encourage the more rapid introduction of new technologies that offer reduced noise emissions. The proposed test focuses on the noise generated by the vehicle; vibration is not measured as part of this test as it is outside the scope of this project.

2. Vehicles that pass the test should be awarded a ‘Reduced Noise Certificate’, which would be valid for one year. The Reduced Noise Certificate would allow the vehicle to be used in London during some of the current “controlled hours” (see section 3.1 for details) in addition to the current uncontrolled hours (0700-2100).

3. Any vehicle that had held a permit to operate off the Exempt Road Network prior to the introduction to the test could be given a permit, exactly as before. However, any vehicle that had never held a permit prior to the introduction of the test would be required to obtain a Reduced Noise Certificate, before a permit could be granted.

4. In order to implement the test, a further programme of measurements will be needed on a further 60-70 vehicles as a minimum. This would allow a final decision on the method, and establish noise limits for each component of the test. These 60-70 vehicles would need to span the range of vehicle types and sizes that are on sale above 18 tonnes. Vehicles should also only be included if they meet the requirements of the Low Emissions Zones.

5. Further work should be undertaken to develop the concept of a noise-based sleep disturbance map into a full modelling tool. This tool could be used alongside a route assignment model, to provide information on noise mitigation strategies. Such a model would be useful in controlling night time noise impacts from vehicles travelling off the Exempt Road Network, particularly in identifying hotspots, and in optimising traffic management options.

6. After implementation of the Low Emission Zone, consideration should be given to introducing a noise test for goods vehicles in the 3.5-18 tonne range. This would
extend the benefits of the London in-service noise test to a much larger pool of vehicles, many of which are used during the controlled hours.
# Glossary of abbreviations and acronyms

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>%HSD</td>
<td>Percentage of people Highly Sleep Disturbed</td>
</tr>
<tr>
<td>BRE</td>
<td>Building Research Establishment</td>
</tr>
<tr>
<td>CNG</td>
<td>Compressed Natural Gas</td>
</tr>
<tr>
<td>CVEU</td>
<td>Commercial Vehicle Education Unit</td>
</tr>
<tr>
<td>DfT</td>
<td>Department for Transport</td>
</tr>
<tr>
<td>ERN</td>
<td>Exempt Road network</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>FEDEMAC</td>
<td>Federation of European Movers Associations</td>
</tr>
<tr>
<td>FORS</td>
<td>Freight Operators Recognition Scheme</td>
</tr>
<tr>
<td>FTA</td>
<td>Freight Transport Association</td>
</tr>
<tr>
<td>GLA</td>
<td>Greater London Authority</td>
</tr>
<tr>
<td>GRO</td>
<td>Governor Run Out</td>
</tr>
<tr>
<td>HARMONOISE</td>
<td>Project acronym: Harmonised, Accurate and Reliable Methods for the European Directive On the Assessment and Management of Environmental NOISE</td>
</tr>
<tr>
<td>HGV</td>
<td>Heavy Goods Vehicle (this term has been replaced by LGV)</td>
</tr>
<tr>
<td>HRA</td>
<td>Hot Rolled Asphalt</td>
</tr>
<tr>
<td>ISA</td>
<td>Intelligent Speed Adapter</td>
</tr>
<tr>
<td>ISO</td>
<td>International Organisation for Standardisation</td>
</tr>
<tr>
<td>LEZ</td>
<td>Low Emission Zone</td>
</tr>
<tr>
<td>LFP</td>
<td>London Freight Plan</td>
</tr>
<tr>
<td>LGV</td>
<td>Large Goods Vehicle</td>
</tr>
<tr>
<td>LLCS</td>
<td>London Lorry Control Scheme</td>
</tr>
<tr>
<td>LPG</td>
<td>Liquefied Petroleum Gas</td>
</tr>
<tr>
<td>LRTNM</td>
<td>London Road Traffic Noise Map</td>
</tr>
<tr>
<td>MGW</td>
<td>Maximum Gross Weight</td>
</tr>
<tr>
<td>NNIS</td>
<td>National Noise Incidence Survey</td>
</tr>
<tr>
<td>PAYD</td>
<td>Pay As You Drive</td>
</tr>
<tr>
<td>PLGV</td>
<td>Private/Light Goods Vehicle</td>
</tr>
<tr>
<td>SCI</td>
<td>Structural Condition Index</td>
</tr>
<tr>
<td>SILVIA</td>
<td>Project acronym: Silenda Via. Sustainable road surfaces for traffic noise control</td>
</tr>
<tr>
<td>SMA</td>
<td>Stone Mastic Asphalt</td>
</tr>
<tr>
<td>SMMT</td>
<td>Society of Motor Manufacturers and Traders</td>
</tr>
<tr>
<td>TfL</td>
<td>Transport for London</td>
</tr>
<tr>
<td>TLRN</td>
<td>Transport for London Road Network</td>
</tr>
<tr>
<td>TRL</td>
<td>Transport Research Laboratory</td>
</tr>
</tbody>
</table>
UKPMS  United Kingdom Pavement Management System  
VOSA  Vehicle and Operator Services Agency  
WebTAG  Transport Analysis Guidance Website  
WHO  World Health Organisation
Glossary of units and symbols (including relevant definitions)

A-weighting: Human hearing is less sensitive at very low and very high frequencies. In order to account for this, weighting filters can be applied when measuring sound. A-weighting, which provides results often denoted as dB(A), conforms approximately to the human ear.

**dB**  
**Decibel:** The decibel is a unit of level which denotes the ratio between two quantities that are proportional to power; the number of decibels corresponding to the ratio of two amounts of power is 10 times the logarithm to the base 10 of this ratio.

**dB(A)**  
A-weighted decibel

**Hz**  
**Hertz:** Unit of frequency, equal to one cycle per second.

**L_{eq}**  
**Equivalent sound pressure level:** The equivalent continuous sound pressure level, $L_{eq}$, is the level that, had it been a steady level during the measurement period, would represent the amount of energy present in the measured fluctuating sound pressure level. It is a measure of the averaged energy in varying sound level.

**L_{A10,T}**  
The A-weighted sound pressure level exceeded for just 10% of the time over a period of one hour. The value of $L_{A10,T}$ (where T is a number of hours) is the arithmetic average of the values of $L_{A10}$ for each of the one-hour periods making up T.

**L_{amax}**  
The maximum A-weighted sound pressure level

**L_{den}**  
The new European primary noise indicator of annoyance from long-term exposure to noise. It is a long-term average A-weighted equivalent sound pressure level. It is derived from three other levels, $L_{day}$, $L_{evening}$ and $L_{night}$, as specified in Annex 2 of the EU Directive on the Assessment of Environmental Noise.

**L_{day}**  
The A-weighted equivalent sound pressure level for the 12-hour daytime period from 07:00 to 19:00 hours, determined over all of the day periods of a year, as specified in the EU Directive on the Assessment of Environmental Noise.

**L_{evening}**  
The A-weighted equivalent sound pressure level for the 4-hour evening period from 19:00 to 23:00 hours, determined over all of the evening periods of a year, as specified in the EU Directive on the Assessment of Environmental Noise. When used to calculate $L_{den}$, a 5 dB weighting is applied to take account of the annoyance at that time of the day.

**L_{night}**  
The A-weighted equivalent sound pressure level for the 8 hour evening period from 23:00 to 07:00 hours, determined over all of the evening periods of a year, as specified in the EU Directive on the Assessment of Environmental Noise. When used to calculate $L_{den}$, a 10 dB weighting is applied to take account of the annoyance at that time of the day.

**Sound Pressure Level:** The fluctuations in air pressure from steady atmospheric pressure, created by sound, measured in pascals (Pa)

**SPL**  
**Sound Pressure Level:** Sound pressure measured on a decibel scale, i.e. $SPL = 20 \log_{10} \left( \frac{p}{p_0} \right)$ where $p_0$ is the reference sound pressure, $20 \times 10^{-6}$ Pa

**SEL**  
**Sound Exposure Level:** The sound exposure level, SEL, of a single discrete noise event is the level which if maintained constant for a period of 1 second would contain as much A-weighted sound energy as is contained in the actual noise event. The relationship between the $L_{eq}$ value produced by an event over a period of time and the SEL for the event is given by $SEL = L_{eq,T} + 10 \log_{10} T$, where T must be in seconds.
1 Introduction

1.1 Background to the project

There are a wide number of general restrictions in place across Europe which controls the movement of goods transport. These generally restrict the movement of goods vehicles at weekends and on public holidays, although there are instances of wider night-time restrictions (see Appendix A). The reasons for the introduction of these restrictions (i.e. whether the schemes were introduced to control noise disturbance, reduce traffic congestion, etc.) is for the most part unclear.

Within the UK, the London Lorry Control Scheme (LLCS) was introduced in 1986. The LLCS controls the movement of large goods vehicles (LGVs) over 18 tonnes in London. The effects of the LLCS are to:

(i) Reduce inappropriate cross-London night time and weekend lorry movements, and
(ii) Protect residential areas from disturbance by lorries at these times.

The scheme is administered by London Councils (formerly the Association of London Government).

While the LLCS has been in operation for 20 years and has been effective, in the intervening years many aspects of transport in London have changed radically.

A potentially marked change has been the growth in goods vehicles less than 18 tonnes which are currently exempt from the controls imposed on heavier vehicles. In addition, recent consultation with the freight industry indicates that there is a belief that technical improvements in LGV design have resulted in vehicles that are now quieter than when the LLCS was introduced and consequently there are calls for this to be reflected in a relaxation of the controls imposed by the LLCS.

The scheme is of concern to operators because it imposes an administrative burden, but delivers no economic benefit to them in return.

The LLCS is one of very few regulatory controls over freight operations. As such it is considered by Transport for London (TfL) that the scheme could potentially be developed to better control noise from goods vehicles, making use, where possible, of technical advances that could help improve enforcement whilst recognising improvements in vehicle design and associated technologies. The opportunity for change is also coupled with the general desire of residents and the Boroughs for improved environmental standards.

Any change should be taken with a full understanding of the various benefits and disbenefits associated with different change options. TRL Limited has therefore been commissioned by TfL to undertake a review of the noise impacts from the LLCS and to assess possibilities for amending the LLCS by

- Taking account of improvements in vehicle design and associated technological advances in noise control;
- Making use of other options for controlling the noise impact on the road network affected by the LLCS.

It was hoped that this would lead to a range of measures that better target noise-sensitive areas and provide the benefits needed without imposing undue economic burden on the various stakeholder groups.
In order to meet the overall objectives of the project, the work has been divided into three main phases. The list below sets out the tasks which constitute each of the phases of the work:

**PHASE 1: Potential amendments to the LLCS**

Task 1
- Brief literature review of 'Factors effecting night time LGV noise disturbance';
- Simple 'assessment of environmental noise impacts'.

Task 2
- Consider and evaluate new technologies and wider issues and how they impact on noise;
- Brief overview of the impact of new technologies and that of driver training/defensive driving for reducing noise;
- Consider and evaluate the cost and other implications of implementing new technologies;
- Consider and evaluate the use of bus lanes at night to promote smoother driving with less stop-starting.

**PHASE 2: Development of an in-service noise test**

Task 3
- Literature review of current monitoring procedures;
- Literature review of in-service testing best practice;
- Literature review of the advantages and disadvantages of various methods of monitoring LGV noise;
- Measurements to characterise in-service noise.

Task 4
- Noise monitoring of night-time LGV noise.

**PHASE 3: Requirements for an upgraded electronic traffic noise map of London**

Task 5
- Determine the requirement for an upgraded electronic traffic noise map of London.
2 Overview of freight traffic in London

Before detailing the work carried out in each of the three phases of the project, it is useful to consider the volume and composition of freight traffic operating in London.

Vehicles in the UK are presently taxed within 3 main groups (direct.gov.uk, 2006):

- Private/Light Goods Vehicles (PLGV): includes cars, motorcycles and vans
- Buses and larger vehicles ≤ 3.5 tonnes
- Large Goods Vehicles (LGV): large rigid vehicles and articulated goods vehicles with two or more axles, all > 3.5 tonnes.

The focus of this document is on those vehicles which are taxed as LGVs (under previous taxation laws, these were referred to as Heavy Goods Vehicles, i.e. HGVs)

In addition to vehicles that are registered in London, we need to consider goods vehicles that deliver into London but are registered outside London. Table 2.1 and Table 2.2 provide details of LGVs that are registered in London and some of the nearby regions.

### Table 2.1: Large goods vehicles over 3.5t registered in London and the regions, 2004 (DfT, 2005)

<table>
<thead>
<tr>
<th>Area in which vehicle is registered</th>
<th>Number of large goods vehicles of 3.5 tonnes and above in area (thousands)</th>
<th>Total numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>London</td>
<td>23.1</td>
<td>23.1</td>
</tr>
<tr>
<td>South East (excluding London)</td>
<td>53.9</td>
<td></td>
</tr>
<tr>
<td>South West</td>
<td>39.6</td>
<td>237.2</td>
</tr>
<tr>
<td>East of England</td>
<td>45.6</td>
<td></td>
</tr>
<tr>
<td>East Midlands</td>
<td>43.2</td>
<td></td>
</tr>
<tr>
<td>West Midlands</td>
<td>54.9</td>
<td></td>
</tr>
</tbody>
</table>

### Table 2.2: Large goods vehicles registered in Great Britain, by gross weight, 2004 (DfT, 2005)

<table>
<thead>
<tr>
<th>Vehicle weight (tonnes)</th>
<th>Number of large goods vehicles in Great Britain (thousands)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over</td>
<td>Not Over</td>
</tr>
<tr>
<td>3.5</td>
<td>7.5</td>
</tr>
<tr>
<td>7.5</td>
<td>12</td>
</tr>
<tr>
<td>12</td>
<td>25</td>
</tr>
<tr>
<td>25</td>
<td>33</td>
</tr>
<tr>
<td>33</td>
<td>38</td>
</tr>
<tr>
<td>38</td>
<td>44</td>
</tr>
</tbody>
</table>

Total number of large goods vehicles over 3.5 tonnes 434
Several conclusions can be drawn about the number of goods vehicles above 3.5 tonnes, as follows:

1. The LLCS deters the operation of larger vehicles. However, the trend is for fewer LGVs to operate in London, and more smaller goods vehicles to be used instead. Clearly, this trend is reducing the effectiveness of the LLCS over time. By modelling the effects of replacing one LGV delivery with multiple deliveries by smaller vehicles, the effects on noise and other environmental effects can then be determined.

2. The 237,200 goods vehicles in the regions shown in Table 2.1 are within a days return drive of London. This number is almost eight times the number in London itself. Because many of these vehicles are likely to travel to London, if the LLCS encourages new technology the scheme will reduce noise from many more vehicles than just those registered in London. It also shows that the LLCS is not just a cost on ‘London’ businesses, but will lead to equal treatment of London businesses and many businesses in the regions.

3. Table 2.2 shows that the current LLCS limit of over 18 tonnes can potentially affect only around half of the vehicles above 3.5 tonnes. It clearly does not affect the 164,000 vehicles of 3.5-12 tonnes. It does affect the 175,000 from 25-44 tonnes, to the extent that their operators wish to use them in London. Some of the 95,000 vehicles in the 12-25 tonne range will be affected, i.e. those above 18 tonnes. In addition to these vehicles, further vehicles from abroad will be affected. Even these numbers are relatively small in comparison to the number of light goods vehicles in the UK, i.e. those under 3.5 tonnes.

4. We note that some large delivery firms will register all their vehicles at one location, for example their head office, no matter where the vehicles are normally used. This slightly reduces the accuracy of the DfT figures in Table 2.1 and Table 2.2, for the purposes of understanding where a particular vehicle is habitually used.

The move to smaller vehicles for deliveries is demonstrated by Table 2.3 below, which compares the growth in light goods vehicle mileage in the UK with the growth in mileage for heavier goods vehicles.

**Table 2.3 Rates of growth of van and lorry mileage in UK (DfT, 2006b)**

<table>
<thead>
<tr>
<th>Class of Vehicle</th>
<th>Percentage increase in total UK mileage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Between Years 2002-2005</td>
</tr>
<tr>
<td>Light Vans (Under 3.5 tonnes)</td>
<td>+16.2%</td>
</tr>
<tr>
<td>Large goods vehicles (Over 3.5</td>
<td>+4.6%</td>
</tr>
<tr>
<td>tonnes)</td>
<td></td>
</tr>
</tbody>
</table>

The key issue from Table 2.3 is that total annual mileage by light vans has been growing nearly four times faster than the total annual mileage by larger goods vehicles.
PHASE 1

This phase of the project addresses the following tasks within the project:

**Task 1**
- Brief literature review of 'Factors effecting night time LGV noise disturbance';
- Simple 'assessment of environmental noise impacts'.

**Task 2**
- Consider and evaluate new technologies and wider issues and how they impact on noise;
- Brief overview of the impact of new technologies and that of driver training/defensive driving for reducing noise;
- Consider and evaluate the cost and other implications of implementing new technologies;
- Consider and evaluate the use of bus lanes at night to promote smoother driving with less stop-starting.
3 The London Lorry Control Scheme (LLCS) and Exempt Road Network (ERN)

The LLCS is administered by the London Councils (formerly the Association of London Government). However, the effects of the LLCS are felt by many stakeholders. In a positive sense, the LLCS helps residents of London and visitors to enjoy a significantly better environment than otherwise would be the case. There are also costs for operators, and for the London Councils in enforcement.

3.1 Overview of the London Lorry Control Scheme

The London Lorry Control Scheme (LLCS) was implemented in January 1986 in order to:

(i) Limit the environmental and social damage and disruption caused by large goods vehicles (LGVs) travelling into London, including noise and vibration, fumes and smoke, physical damage, congestion, visual intrusion, safety, etc.\(^4\)

(ii) Maintain the economic advantages that the road freight industry brings to the capital.

The scheme is such that certain roads within the Boroughs of London, including some TfL roads, are restricted for LGVs over 18 tonnes maximum gross weight (MGW), typically on three axles or more, at night time and weekends. The hours of operation (the "controlled hours") when the restrictions apply are as follows:

- Between midnight and 07:00 and between 21:00 and midnight on Mondays to Fridays inclusive;
- Between midnight and 07:00 and between 13:00 and midnight on Saturdays;
- All day on Sundays.

Road haulage companies with essential business in the controlled road network may obtain permits or special routeing agreements to operate large goods vehicles on these roads and streets during the controlled hours, provided that they are able to satisfy certain conditions which are described more fully in the next section. Such companies include:

- London-based continuous process firms (e.g. steel stockholders) depending on night trunking of supplies or early despatch of very bulky products;
- London hauliers competing for out-of-London work;
- Suppliers of fresh produce and other perishables to the London market;
- Major distributors to a national or regional market from a depot located in London, which are not located on an excluded route;
- Firms which rely heavily on unpredictable deliveries or collections that are carried out by operators not under their control.

3.2 Overview of the ERN

The LLCS provides a limited network of roads to provide access for all goods vehicles, whether they have permits or not, within the controlled area. This network is known as the Exempt Route Network (ERN). In this way the queuing of vehicles at the boundary of the scheme, or on excluded routes, is avoided, and the relative accessibility of certain parts of

---

\(^4\) Wood (1983) provides further details on how heavy lorry traffic impinges on the environment as expressed by those who live, work, or travel in close proximity to it. This report backed a night-time and weekend ban on large goods lorries, rather than a blanket ban on such vehicles and left open the possibility of more comprehensive restrictions at a future date.
London is increased. A basic network of access to industrial and commercial areas is provided. The excluded network originally comprised all trunk roads through London, and some metropolitan roads. When initially defined in 1985 it totalled:

- 120 miles of trunk roads;
- 100 miles of access roads;
- 35 miles of roads to permit turning movements (for those drivers who might wish to turn round to avoid the controlled area).

This was slightly altered in 1999 with the de-trunking of roads within London. Two small sections of former trunk roads were deleted from the exempt network and some small changes at the suggestion of the boroughs were incorporated.

Currently the ERN has the following general characteristics:

- It includes all motorway links and most of the Transport for London Road Network (TLRN) but not all;
- It gives access to most of the major industrial sites, by including minor roads in these areas so that LGVs can access these sites without requiring permits;
- It discourages goods traffic from cross-London movement;
- It includes some roads that are principally included to allow LGVs to turn around if they enter the LLCS restricted area by mistake, for example the A4008 near Watford;
- It has been designed to choose the least environmentally damaging routes among alternatives, or concentrate traffic on the already popular one, for example on the A41 as opposed to the parallel A5;
- It includes some roads on the boundary of the scheme and those that are shared with other local authorities outside London.

### 3.3 The permit system for travel off the ERN

The permit system was introduced as part of the LLCS with the aim of allowing essential night operations to continue, while safeguarding employment and maximising environmental benefit.

Any vehicle that is less than or equal to 18 tonnes can travel off the ERN without a permit. However, transport operators who wish to use large vehicles (over 18 tonnes maximum gross weight (MGW), typically on three axles or more) on roads restricted by the LLCS during controlled hours must apply for an exemption permit. These permits are issued free of charge and to a single vehicle. Applicants receive a package containing the application form and associated information, and a map showing restricted and excluded road networks.

The following information must be provided as part of the permit application:

- The name and address of the user (i.e. the company, partnership or person carrying the goods);
- Whether or not the user intends to lease out, or loan, as business, the vehicle(s) for which permits are applied and if so whether the user will supply the driver(s), be in operational control of the vehicles, and hold the Operator's Licence for the vehicles;
- The nature of the user's business and commodities carried by the user;
- The frequency of essential vehicle operations in the control scheme area during controlled hours;
- The origins and destinations of the vehicles for which permits are applied;
• The routeing which the vehicles will take in order to minimise travel on restricted streets;
• Full details of the vehicles requested for exemption.

Guidance notes are issued with permits as described below.

3.3.1 Guidance notes and permit conditions

Guidance Note 1 briefly addresses issues such as at what times the controls apply, what vehicles are affected, how to apply for a permit and the permit conditions. The main points of Guidance Note 1 are that:

• London Councils will not issue permits for vehicles whose operation on restricted streets is not essential in the course of necessary business;
• A permit is required for each vehicle whose use is essential on restricted streets during controlled hours;
• Issue of a permit requires compliance with the permit conditions.

Guidance Note 2 expands on Permit Condition 12 which states that “The applicant shall implement driver training procedures and fleet management techniques which will have the effect of achieving significant environmental improvement”. It lists a number of practices and techniques which can be used by drivers to minimise noise and fuel consumption.

Among the other points listed as Conditions Normally Considered for Attachment to a Permit the following are specified:

• The applicant and driver will take steps to minimise that portion of the journey which takes place on restricted roads during controlled hours, unless a route is specifically agreed with the London Councils Transport and Environment Committee (Condition 5);
• “By the date specified in the Schedule, the applicant shall minimise the noise emitted by the air brake system by fitting equipment, or its equivalent, specified in the Schedule” (Condition 11). In practice improvements in vehicle technology have rendered this almost irrelevant although there may be defects due to poor maintenance.

Currently there are 56,000 permits per year being issued. This number may at first sight appear to be excessive. However, the following considerations are important:

• A single permit is only applicable to a single vehicle;
• The type of permit ranges from a temporary permit, which could be for as little as a single day, to a full permit, which is valid for 1 year;
• The permits are route specific, in relation to departure point and destination;
• The permits are free-of-charge, so operators often register whole fleets of vehicles to give them maximum flexibility on deliveries, even though many of the vehicles registered may never actually enter the LLCS.

During discussions in June 2006, the LLCS team informed the project team that the current cost of operation of the LLCS is around £0.5 million per year. This figure includes the issue of permits and the work of five enforcement officers. London Councils has set the penalty charge for operators at £500 for an infringement, which is reduced to £250 if paid within 14 days. The penalty charge for operators will increase to £550 on 1 July 2007. The penalty
charge for drivers contravening the LLCS is £100 and will increase to £120 on 1 July 2007. This is also reduced by 50% if paid within 14 days.
4 Reasons for making changes to the LLCS and ERN

Any restriction on deliveries, such as the LLCS or the other LGV restrictions in London, raise costs for businesses. A key question is whether the costs are reasonable for the environmental benefits gained. Potentially, revisions to the LLCS can now be devised that:

(i) Would deliver significantly greater environmental benefit to residents and visitors.
(ii) Are achievable at lower overall cost to businesses, with low enforcement and administration costs.

4.1 Why Consider Changes to the LLCS?

The basic design of the LLCS has not changed for 20 years and it continues to remain effective. However, in the intervening years, many aspects of transport in London have changed radically. The detailed issues that provide impetus for change to the LLCS are:

(i) Technological change in vehicles. Examples of this change have been the availability of vehicles powered by alternative fuels such as CNG and LPG and current activity around hybrid-electric vehicles of various types, and the advent of technology that can provide congestion information to drivers, and control signals directly to vehicles.
(ii) Enforcement possibilities, such as the ability to monitor vehicle movements automatically.
(iii) The desire of London’s residents, visitors and the Boroughs for higher environmental standards has increased.
(iv) Business needs in some sectors require longer operating hours to serve a 24 hour, world class city.

In addition to these positive reasons for considering change, vehicle operators have expressed specific concerns about the current form of the LLCS. The LLCS was set up to control the competing concerns relating to night-time and weekend lorry traffic. Some hauliers and businesses consider that the use of the Exempt Road Network and the complementary permit system are adding to their costs. This is through:

(i) The bureaucracy involved in obtaining permits.
(ii) Lorries being restricted to maximising the use of the Exempt Road Network, which impacts on delivery times, driver’s hours, etc.
(iii) The Freight Transport Association (FTA) and individual hauliers have raised concerns that the current Exempt Network leads to ‘excessive’ additional costs in terms of longer journeys. Condition 5 requires that maximum use should be made of the Exempt Network in accessing sites in London. Condition 5 therefore requires operators to remain on the Exempt Network until they have reached the closest point to their destination. Concerns have been that such journeys could increase vehicle mileage, fuel use, pollution and noise.

The FTA’s concerns come at a time when there are pressures for more deliveries to take place outside the peak daylight hours, for example, to avoid peak congestion or avoid paying the central London congestion charge. Deliveries outside these hours reduce the impact of LGVs on congestion, and reduce consequential environmental impacts such as pollution from congested traffic.

4.2 Assessing potential changes to the LLCS

All potential changes to the LLCS and ERN need to be tested against three considerations:
(i) What benefits will residents and visitors to London experience? These benefits are any reductions in noise, or improvements in air quality, safety or congestion. Importantly, the original aim of the LLCS in 1986 was to reduce both noise and other impacts of lorries.

(ii) What will be the change in costs for vehicle operators?

(iii) What will be the effects on the cost of enforcing and administering the scheme?

In addition, any changes to the LLCS and ERN are likely to be most successful if they:

- Are clear, and the conditions for being permitted off the ERN are simple to understand;
- Are reasonable, and hence supported by the public;
- Are demonstrably effective and easily enforceable;
- Dovetail with the LEZ, Congestion Charging Zone area and any local 7.5 tonne restrictions, as far as possible. For example, the geographical extent of the LLCS, the fines and the enforcement mechanisms are all easiest for vehicle operators to understand if they are similar to those of the LEZ. The controlled hours need to be set such that they do not work in opposition to the congestion charge. For example, they should not appear to offer only a very narrow window for deliveries between the end of the controlled hours under the Congestion Charging scheme, and the start of the controlled hours under a modified LLCS.
- Are ‘future proof’, i.e. will not require re-design or new legislation for at least ten years. This suggests that, when any new system is agreed, a schedule should be set for gradual tightening of any required thresholds in future years, e.g. after 10 years.
- Are compatible with any ongoing or proposed initiatives relating to vehicle operation at the start and end points of journeys undertaken on LLCS appointed routes, i.e. loading and unloading activities, etc. An example of this type of initiative used outside of the UK is the Dutch PIEK scheme which supports projects aimed at tackling noise during the whole delivery process; details of the scheme are provided in Appendix B of this report.

The considerations above can be used as a test of the various possibilities for changing the LLCS.

One key stakeholder has pointed out that it may be possible to favour vehicles being permitted to travel off the ERN that are quieter in use than a typical 18 tonne goods vehicle was in 1986.

### 4.3 Effects on daytime noise levels, congestion and other benefits

Many approaches to night-time noise would also reduce daytime noise levels. The point here is that most technologies that make a vehicle quieter at night would still be used during the day, and would therefore make the vehicle quieter by day. For example, a vehicle that generated a low dB noise level in a suitable representative test would be quiet in both its daytime and night time operation.

In any evaluation of the benefits of changes to the LLCS, the benefits outside of London would also have to be considered. For example, a vehicle used only occasionally for night-time deliveries in London might spend most of its time driving by day outside of the greater London area, where there could also be similar advantages.

A ‘win-win’ scenario is therefore conceivable. This would occur if a condition were derived that allowed more vehicles to operate off the ERN at night without increasing night-time noise. This would reduce the congestion caused by deliveries by day. However, great care is
needed if such a condition were to be implemented. If deliveries during the night become easier, then in economic terms this makes overall deliveries cheaper. Basic economics shows that this will act to increase the overall total number of deliveries made, thereby eroding some of the environmental benefits.

Table E.1 in Appendix E of this report, summarises some of the different vehicle technologies that might be used for reducing noise. The right-hand column of the Table shows that these technologies will also have many other positive effects on vehicles’ environmental impacts. In calculating final costs and benefits according to accepted practice, these other benefits would need to be included. When expressed in monetary terms, the effects on air quality, accidents and congestion are likely to provide large benefits.

4.4 Conclusion

LLCS permit conditions need to remain flexible enough to accommodate any future changes to vehicle technology. There is clearly scope for introducing changes to the LLCS, for example to the permit conditions, in order to encourage technologies that provide reduced levels of noise.
5 Potential options for changes to the LLCS

The LLCS provides an effective limit on night-time disturbance from LGVs in London. Its particular strengths are that, at night, it:

(i) Eliminates the movement of LGVs that have no business in London.
(ii) Controls the routing of LGVs that do have reason to be in London.

Three possibilities need to be considered. These are to:

(i) Leave the LLCS unchanged.
(ii) Make small changes to enhance the LLCS through the introduction of new technologies, the use of lower-noise surfaces or improved enforcement
(iii) Make major changes to the scheme to increase the effectiveness in protecting the night-time environment.

The remainder of this chapter considers these three possibilities.

5.1 Should the LLCS remain unchanged?

The introduction to Chapter 4 and Section 4.1 discuss reasons for changing the LLCS. The key point is that ‘revisions to the LLCS can now be devised that

(i) Would deliver significantly greater environmental benefit to residents and visitors.
(ii) Are achievable at lower overall cost to businesses’.

Therefore, there is no compelling reason to leave the LLCS unchanged.

5.2 How could the LLCS be changed

Table 5.1 and the following sections summarise some of the different aspects of the LLCS that could be changed, either through small changes or as part of a major review of the scheme, and how these changes could be brought about. The effectiveness of the LLCS/ERN could be changed radically by varying a multiple of these aspects. However, a complete understanding would require an assessment of each of these possible changes against the others, in terms of costs and benefits; such an assessment falls outside of the scope of this project and is therefore not covered in this report.

The most important issue to consider is the resulting variation in the amount of noise perceived by Londoners. Appendices C and D provide a brief review of factors affecting night-time LGV noise disturbance which must be taken into account and changes in exposure and night-time disturbance due to variations in traffic management that might arise as a consequence of some of these options

5.3 Potential changes through the introduction of new technologies

In the last three years, the technology available in vehicles has changed dramatically. In addition, the introduction of the LEZ will bring new enforcement possibilities across London.

Table E.1 in Appendix E summarises some of the different technologies that might be used, their potential to influence noise, and any additional impacts that application of the technologies might have.

Each of the technologies shown in Table E.1 could be set as a requirement for vehicles to operate off the ERN. However, care needs to be taken with regard to incentive effects. EU competition rules prevent direct subsidies that favour individual companies.
Table 5.1: Aspects of the LLCS that could be varied

<table>
<thead>
<tr>
<th>Aspect of LLCS</th>
<th>Example(s) of possible change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extent of ERN</td>
<td>More roads could be added to the ERN, or roads removed</td>
</tr>
<tr>
<td>Controlled hours</td>
<td>The controlled hours could be relaxed or tightened</td>
</tr>
<tr>
<td>Standard of technology fitted in vehicles (*)</td>
<td>Vehicles could be required to have speed or acceleration limiters, or low noise tyres</td>
</tr>
<tr>
<td>Size of vehicles</td>
<td>The LLCS could cover all vehicles above 3.5 tonnes</td>
</tr>
<tr>
<td>Noise emissions of each vehicle (*)</td>
<td>Vehicles might only be permitted to travel off the ERN if their noise emissions better the legal limit, in the type approval test, by a given number of dB</td>
</tr>
<tr>
<td>Engine exhaust emission standards; fuel types (*)</td>
<td>Permits might only be issued to vehicles with engines meeting Euro IV or V exhaust emissions criteria, hybrids, or LPG and CNG vehicles.</td>
</tr>
<tr>
<td>Driver training requirements</td>
<td>Drivers could be required to have a certificate, showing that they had been trained in low noise driving techniques</td>
</tr>
<tr>
<td>Accident record of drivers or operators</td>
<td>Permits might be suspended for any firm or driver whose accident record is worse than a set threshold</td>
</tr>
<tr>
<td>Enforcement (*)</td>
<td>Enforcement could be automated, or tightened</td>
</tr>
<tr>
<td>Vehicle replacement? Scrapping scheme (*)</td>
<td>Older commercial vehicles could be scrapped, according to the noise or engine emission standard to which they were built. The LEZ will effectively achieve this for Greater London.</td>
</tr>
</tbody>
</table>

* Issue relating to technology

Any changes to conditions for running off the ERN should be checked to see that they do not unduly encourage one form of technology, unless several suppliers could provide such technology.

The option least likely to contravene EU regulations would be to set performance standards. An example would be to open up the road network to any vehicles meeting a certain dB(A) noise limit in a test. This would not place unnecessary restrictions on manufacturers, because it does not specify any particular technology that is to be used to achieve this lower noise limit.

5.3.1 How could new technologies be brought in?

The permit conditions are a powerful feature of the LLCS. One existing permit condition requires LGVs to have air brake silencers. This condition was brought in at a time when less than 5% of LGVs had this equipment. It has encouraged this new technology.

Such permit conditions could be used to encourage the introduction of new technologies from a future date. For example:

(i) A condition could be set that permits will only be issued to hybrid or alternative fuelled vehicles (LPG, CNG or hydrogen).

(ii) A condition could be set that vehicles will only be issued with permits if either the whole vehicle or its tyres meet certain noise limits.

(iii) Vehicles could be required to have Intelligent Speed Adaptation technology, i.e. location dependent speed limiters.
(iv) Restrictions could be set on the noise from refrigeration units and other ancillary equipment on vehicles.

There are however two limitations to the effectiveness of permit conditions for the introduction of new technologies:

(i) Permits do not affect all night-time LGV movements. This is because LGVs that remain on the Exempt Network do not require a permit and also because LGVs are a decreasing proportion of all goods vehicle movements.

(ii) Firms may circumvent tighter permit conditions by deciding to change their fleets over to vehicles under 18 tonnes.

5.3.2 LPG and CNG vehicles

The present project was originally conceived as an evaluation of the possibilities offered by changes in vehicle technology, particularly the availability of LPG and CNG vehicles.

The DfT’s website has in the past cited noise reductions of up to 10 dB(A) from commercial vehicles that were powered by LPG or CNG engines. The possibility of such large reductions would clearly be of interest in any revision of the LLCS.

In addition to this, for a number of years the ‘Energy Saving Trust’ offered financial grants to operators who converted their vehicles to run on LPG or CNG. This lead to, wider availability of these vehicles in the late 1990s and at the beginning of the present decade.

TRL has recently carried out research on a limited number of CNG vehicles (Watts et al., 2005). This research compared noise emission levels from CNG vehicles with noise emission levels from corresponding diesel vehicles, for a range of operating conditions. The CNG vehicles concerned were a rigid lorry and a tractor unit. The results showed no consistent pattern.

As an example of the variable results:

(i) In the ‘pass by’ test, a CNG tractor unit produced higher noise levels than the diesel equivalent. This test involves full throttle acceleration. The tractor unit also produced higher noise levels in an additional low speed ‘pull away from rest’ test.

(ii) In the full throttle ‘pass by’ test, a CNG rigid vehicle was substantially quieter than the diesel equivalent. However, in the ‘pull away from rest’ test, it gave a higher result.

The difference in the results may in fact not even relate to the choice of a CNG engine. For the two CNG vehicles tested, it might for example have been due to differences in engine encapsulation or exhaust fitted. We would need to undertake further investigations, in order to identify possible causes.

The inconsistent results in TRL’s earlier testing of CNG vehicles might suggest that there is no particular advantage in encouraging the use of these vehicles, in order to reduce night time noise impact. A larger sample and greater examination of existing data would be required before definite conclusions can be drawn (Watts et al., 2005), however the comments made in Section 5.3.3 should be noted.

5.3.3 The availability of LPG and CNG vehicles in 2006 and beyond

It proved very difficult to obtain vehicles for the trial discussed in Section 5.3.2 above. This is an indication that there were very few such vehicles operating on the road network. We believe that the major manufacturers have now stopped producing large LPG and CNG commercial vehicles entirely. It would now therefore be difficult to conduct any further comparison of LPG and CNG vehicle types, in order to reach more definite conclusions.
Using older vehicles would not constitute a valid comparison, because the state of wear of propulsion units and body components may differ. This would lead to problems in interpreting the results.

This situation has major consequences for changes to the LLCS. If the LLCS were altered to encourage LPG or CNG vehicles, these changes might well not prove of relevance to operators.

The UK’s ‘Energy Saving Trust’ has withdrawn its subsidies for LPG and CNG commercial vehicles. One reason for this was that it was unclear whether the scheme had favoured particular manufacturers. In its place, the Energy Saving Trust has gained approval from the EU Commission for a ‘technology neutral’ subsidy programme. If implemented, this programme would encourage any vehicle whose CO₂ emissions were better than a given threshold, no matter what technology was used to achieve this.

The result is that there is now even less incentive for operators to purchase LPG or CNG vehicles. The withdrawal of subsidies for conversions is another reason why changes to the LLCS to encourage LPG and CNG vehicles are unlikely to be relevant to today’s operators.

It is unlikely that any future government support programmes will support particular types of technology. Modern incentive programmes usually encourage performance standards, and are carefully designed not to prescribe particular technologies.

5.3.4 Electric vehicles

Interestingly, the research project discussed in Section 5.3.2 (Watts et al., 2005) did show significantly lower noise levels for an electric van compared with a similar diesel van. There were reductions in noise level of between 3.2 to 6.8 dB(A), depending on the vehicle operation.

Manufacturers of electric vehicles in the UK include Modec (www.modec.co.uk; manufacturers of electric flatbed tippers and delivery vans) and Smith Electric Vehicles (www.smithelectricvehicles.com; manufacturers of three different capacity electric trucks, i.e. 4.5t GVW, 5-7t GVW and the first high performance 7.5t truck). Express, mail and logistics operator TNT will operate the first two of the 7.5t electric trucks in and around London (Smith Electric Vehicles, 2006).

A further example of an electric delivery lorry is known from the continent. The ‘Gefco’ company began running ten tonne electric delivery vehicles in France in October 2003. The parent company of Gefco states their advantages as follows (PSA, 2006):

‘The electric trucks produce no direct pollutant emissions and no CO₂. They are also silent. The trucks offer a top speed of 70 km/h and a range of up to 100 km (between 50 and 60 km in the city).’

Electric vehicles could provide very significant environmental advantages in an urban setting, in comparison to other delivery vehicles. However, the overall environmental burden associated with providing the electricity to charge the batteries needs to be considered particularly where the electricity is provided at power stations burning fossil fuels.

In order to encourage the greater use of electric vehicles, the LLCS would need to be changed in order to encourage electric vehicles. Sustained high prices for fossil fuels might provide additional support. However, to date we have found no examples of this technology for goods vehicles over 18 tonnes.

In April 2006, France announced a major national research investment into diesel electric hybrid vehicles. This offers the possibility of these vehicles being available in the medium term.
5.3.5 Hydrogen Vehicles

TfL’s hydrogen powered buses have demonstrated the potential for routine use of this technology in London. When hydrogen is used in fuel cells, it eliminates the noise from combustion that is one major noise source in traditional commercial vehicles.

The cost of a large vehicle powered by a fuel cell is between 5 and 10 times that of an equivalent diesel vehicle. The LLCS would need to offer operators very significant advantages in order to offset these purchase costs, although it is not known whether this would be possible. However, mass production of fuel cells is likely to bring down these costs significantly over a timescale of even 2 to 4 years from now.

Currently, TfL plans to increase the number of buses powered by Hydrogen fuel cells from 3 to 10. There will be 60 additional fuel cell vehicles by 2010. This is from a fleet total of 6800 in London (EDIE, 2006). The presence of these fuel cell vehicles will build public confidence in the technology, and enable routine operation of a Hydrogen fuelling infrastructure in London. These are important developments for the use of Hydrogen fuel cells by freight companies.

5.4 Potential changes through the use of low-noise surfaces on the ERN

Road surfaces are already in use in the UK that reduce traffic noise by up to 6 dB(A), compared to noise levels from traffic on newly laid Hot Rolled Asphalt (HRA) on high-speed roads. Twin-layer porous asphalt surfaces are available in Europe and used on high-speed; these produce very low levels of tyre/road noise, and absorb some of the engine and transmission noise that is incident on them.

Encouraging the use of low-noise surfaces on the Exempt Road Network would have the twin advantages of:

(i) Reducing noise from the roads that LGVs are most likely to use at night.
(ii) Reducing noise from all traffic by day

Laying these surfaces might cost around £50,000 more per kilometre than more commonly used surfaces. The improvement would be greatest on the sections of road with the highest speed limits, where the tyre/road noise is greatest. One source of funding could be the penalty charges collected from LLCS infringement.

It is noted that the Proposal 6 of the Mayor’s Ambient Noise Strategy states that “Transport for London will, and London boroughs and others should, use noise-reducing surfaces, where practicable and cost-effective, and where they do not compromise safety, particularly skidding resistance, and other criteria. This includes:

- Where possible, prioritising higher speed roads and roads with significant night traffic flows and speeds; and
- Assessing how the life cycle acoustic performance of noise-reducing surfaces may best be monitored and findings shared.”

5.5 Potential changes through improved enforcement

These measures might be implemented either individually or in combination. They would provide direct benefits to operators in that they would eliminate unfair competition from other operators who presently succeed in infringing the LLCS.
5.5.1 Increase the number of enforcement officers.
This would lead to more complete enforcement.

5.5.2 Target enforcement action against repeat offenders.
Some infringements of the LLCS are accidental, and some appear to be deliberate. Action against repeat offenders could address operators who might see the existing penalty charges as simply a business risk/cost. One approach would be to apply increased penalty charges for an infringement that occurs within a certain time period of a first infringement, e.g. one year.

5.5.3 Work with the police and VOSA.
The police and VOSA officers have powers to stop vehicles. These powers might assist LLCS enforcement, by:

(i) LLCS officers carrying out joint patrols with VOSA or police officers, who would be able to stop and warn drivers of foreign registered vehicles. From 2007, these officers will be able to impose ‘on-the-spot’ fines for some offences, although these do not include infringements of the LLCS.

(ii) LLCS officers could supply to VOSA or the police the registration numbers of vehicles that repeatedly infringe the LLCS. Drivers who commit one type of offence are statistically much more likely to be committing other offences. So the provision of information on repeat LLCS infringers would assist VOSA’s intelligence driven enforcement actions. It would also deter operators who deliberately infringe the LLCS, and would be likely to lead to some having their ‘O’ licences (operator’s licence) suspended.

It is noted that the Metropolitan Police’s Commercial Vehicle Education Unit (CVEU) is dedicated to supporting the Freight Operators Recognition Scheme (FORS) which is being developed as part of the London Freight Plan (LFP). The vision of the LFP is “The safe, reliable and efficient movement of freight and servicing trips to, from, within and, where appropriate, through London to support London’s economy, in balance with the needs of other transport users, the environment and Londoners’ quality of life”. Proposal LFP4 of the LFP is concerned with the development and roll out of the FORS. It has been suggested that membership of FORS might be a requirement of obtaining an LLCS permit. Additional details on FORS are included in Section 5.6.4.

5.5.4 Receive images from the LEZ cameras.
The imminent arrival of the LEZ opens new enforcement possibilities. The LLCS and LEZ rules could be amended to place a heavy fine on any vehicle detected by the LEZ cameras that was breaking the night-time and weekend curfew. That solution would reduce the current level of contraventions of the LLCS.

LLCS enforcement officers could be provided with images from the LEZ cameras. Data protection should not be an issue, because the registration numbers of vehicles are not the same as names and addresses of individual drivers. The LEZ camera images could provide an alternative way for enforcement officers to survey the network, which might be difficult to patrol in some places, particularly at certain times of the year.

Revenue-raising is not an aim of the scheme, just as it is not the main aim of the LEZ fines. It would be important to find an equitable use for any penalty charges collected. Possibilities would be:
• To retain the money, and use it to re-surface the ERN with road surfaces that offer the lowest possible noise levels;
• To pass the money out to the Boroughs, in order to finance specific noise reduction programmes. These would most likely include noise barriers, sound insulation in buildings and very low noise surfaces on additional Borough roads.

5.5.5 Changes to the extent of the Exempt Road Network.

The following text considers operational criteria which could be used either individually or in combination to assess whether additional roads could be added to the ERN or whether additional roads should require the use of permits. However, it is noted that most of the ERN is essentially ‘self-chosen’ since there are often no other alternative routes available.

Criteria for road-related assessment

The following criteria could potentially be used to assess acceptable routes based on characteristics that are specific to the roads themselves. Their validity could be assessed by using TfL’s asset management databases, although this falls outside the scope of the current project.

• Surface condition

The condition of the road surface (including the actual surface type) is an important factor in the noise generated by any vehicle in urban situations, especially LGVs. Visual inspection scales exist that could be applied to determine if a route could be added to the network. However, such a system would require a large amount of administrative work, as roads are continually being re-surfaced or patched, by many different companies. It should be noted that the condition of the road surfaces on the ERN will already be inspected as part of TfL’s existing maintenance programme and the data held within UKPMS.

• Speed limits

In normal operating conditions, the speed of a vehicle has a direct influence on the amount of noise emitted. By limiting the available routes to those below a set speed limit, reductions in noise levels could be achieved. However, roads with lower speed limits tend to be in populated areas, so this criterion would need to be used with caution. An alternative may be to have lower speed limits at night on routes through sensitive areas where there is no alternative. Trials at Gleisdorf in Austria have been reported where a system was installed which reduced speed limits when noise levels exceed specified limits (Bendtsen et al., 2005); Figure 5.1 and Figure 5.2 show the setup and warning signs used at the trials site; the reduction in speed also leads to improved traffic flow and thereby improved road safety.

• ‘Smooth’ routes, i.e. no traffic lights & junctions

As identified in Chapter 3, a source of complaint is often vehicles starting and stopping. By specifying routes where there are few junctions or traffic signals, smoother driving would be achieved, and probably fewer people disturbed. This would also have benefits for emissions and fuel economy. Existing or new dedicated running lanes, e.g. combined bus and LGV lanes, could employ a form of ‘greenwave’, whereby LGVs have priorities at traffic signals.
Criteria for exposure related assessment

The following criteria could be used to assess acceptable routes based on population exposure

- **No. of people exposed alongside route**

  The number of people exposed along certain roads could be calculated to determine the routes most affected by traffic noise. There are several existing methods used to determine populations exposed, for example the approaches adopted in the Highways Agency Design Manual for Road and Bridges or in the Department for Transport WebTAG (Transport Analysis Guidance Website) appraisal process. Both of these could be used with existing noise maps to determine population exposed. This process could be adopted for individual roads or to assess specific routes (see Phase 3)

Operational criteria for a “flexible” ERN

The use of operational criteria to create a “flexible” ERN could pose the most administrative work and cause the greatest confusion among those participating in the LLCS. However, these options may provide a fairer way of distributing the noise nuisance. Some could provide operators with a greater number of available route options. Examples of these criteria include the following:
• **Route rotation**

The rotation of routes (on a nightly, monthly or seasonal basis) is a possibility for distributing the noise nuisance. However, it could be difficult to administer and potentially confusing and actually increase the number of people affected by lorry noise albeit for a smaller proportion of the time. There is also often no other route available, so rotation may not be an option.

• **Routes only open to ‘quiet vehicles’**

Such a system would create a secondary ERN, on which only specific vehicles could operate. While this would still place restrictions on vehicle movement, it would provide more freedom to those who demonstrate noise reduction techniques are being used. Again, administration could be difficult and this may cause confusion among drivers, operators and the public. The use of a ‘quiet vehicle’ category is discussed in Section 5.6.1 in more detail. Charges could be based on route sensitivity. However, this would be complex to design and agree. There would be a need to communicate complex information to operators and drivers.

### 5.6 Potential major revisions to the LLCS

The four proposals set out below represent a selection of possibilities for major revisions to the LLCS. These proposals have been chosen on the basis of information contained earlier in this report and in the Appendices, the expert judgement of the Project Team and the criteria listed in Section 4.2.

#### 5.6.1 Use of vehicle noise tests

Currently, one example of each model of LGV has to have passed a vehicle noise ‘type approval’ test, before that vehicle can be sold in the EU. However, the current vehicle ‘type approval’ noise test is not an ideal measure of the noise that would be emitted by an LGV under normal operating conditions. Vehicles selected for type approval are, of course, new vehicles and only a small sample of vehicles are actually tested, the test results taken to apply for the total production. In addition rigid vehicles are tested without a body fitted and tests of tractor units are carried out without the trailer fitted.

Two ways in which noise tests could be used for vehicles in London would be:

- To select vehicles that achieve a set noise level, e.g. 4 dB(A), below the level required by the type approval test for that vehicle category\(^5\). It must be stressed that this value is only quoted here as an example; see later in this report for further information on development of limit values;

- To select vehicles that meet a given noise level in an in-service ‘London’ test that would be set by London Councils and TfL. This approach would offer the benefit of a more relevant test as it would be carried out on specific vehicles that were in-service and therefore were already equipped for freight haulage work.

Passing either or each of these tests could be set as a requirement for LGVs to be given preferential access to London. For example, LGVs that met these limits might be allowed to enter London.

---

\(^5\) The 4 dB(A) reduction is an example based on an Austrian regulation “Nachtfahverbot” (night travel prohibition) from 1990. At that time, the authorities wanted to force any night-time transit traffic, mainly between Germany and Italy over the Alps, to run much more quietly. To achieve this, Austria prohibited all commercial transit traffic during night-time, unless the vehicles complied with a noise level 4 dB(A) lower than the EU type-approval limit limit that was coming into force about the same time (84 dB(A)). (Sandberg, 2001)
operate on an extended Exempt Road Network, or to operate during some or all of the controlled hours.

These two approaches are described further below.

**Use of the present vehicle type approval test**

The current type approval test method is described in an ISO standard. The noise limit values are set in an EU Directive.

The test essentially involves the vehicle being driven at a pre-determined speed in a given gear, and accelerating over a test section. The maximum noise level at 7.5m from the centre of the vehicle is measured, and an average of the measurements from each side of the vehicle is calculated.

Other key features of the type approval test are:

- Rigid vehicles are tested with no body. Articulated vehicles are tested with no trailer;
- The surface used for the test is not representative of surfaces currently on UK roads. However, this is less of an issue for large goods vehicles (as opposed to light vehicles), because the main element of the noise measured is from the vehicle rather than the tyres;
- This test has disadvantages in that it is only representative of one particular driving style, i.e. a rapid acceleration. This driving style is not typical of the majority of urban driving techniques;
- More importantly, vehicle noise emissions under the present type approval scheme are not representative of noise emissions under typical urban driving conditions. Introducing more stringent noise limits therefore does not guarantee similar reductions in noise from vehicle operating in urban areas. (See Appendix G).

However, using the existing type approval test we could set a new, lower, limit value.

Work will be carried out in Phase 2 of this project to determine an appropriate level. The noise level would need to be achievable with modern technology, and provide a suitable ratio of benefits and costs.

Careful consideration would be needed to determine the year in which this new limit would be required. This would depend on how many vehicles already meet the limit, and whether time would be required for manufacturers to develop such vehicles.

The main advantage of using the existing type approval test is that manufacturers must already carry out the test. So the noise level in the test has already been measured for vehicles on the road, and the level will be measured routinely for each new design of vehicle that is marketed. A manufacturer would simply have to demonstrate sufficiently good performance in the test. With sufficient demand from customers who wished to have vehicles that meet the lower limit in the test, a market would be created for quieter vehicles. This would encourage all manufacturers to invest in new technology.

A disadvantage of this method is that it would still use the test that is not wholly representative of urban vehicle operating conditions. There are also issues relating to the retrospective treatment of vehicles currently in operation. These are addressed below.

The technical issues associated with the lowering of noise limits in the type approval test are described in Table 5.2.
Table 5.2: Summary of technical issues associated with a lower noise limits in the type approval test

<table>
<thead>
<tr>
<th>Technical issue</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development of achievable level</td>
<td>Through the work of the project a noise level below the existing one will be selected that would have sufficient benefit and is achievable with existing technology.</td>
</tr>
<tr>
<td>What technology can be used to achieve the lower noise level?</td>
<td>This approach does not specify a particular technology. By simply setting a new limit, this would leave manufacturers unrestrained in what technology they use to achieve the lower noise level.</td>
</tr>
<tr>
<td>Can a vehicle be checked while in-service?</td>
<td>The correlation with a simple roadside check will be considered, to determine the possibility of an annual check or roadside spot check.</td>
</tr>
</tbody>
</table>

Use of an in-service vehicle test

An entirely new vehicle noise test could be developed, which would be more representative of actual operating conditions in London. This new test would not replace the existing type approval test which would, of course, remain as a requirement for manufacturers through legislation set by the EU. Rather, it would be an additional test, specific to the vehicle permit system associated with the operation of the LLCS.

The in-service test would be devised on the basis of measurements of vehicles operating in London. As a result, a low noise level in the in-service test would be expected to offer a better degree of correlation with noise generation in real traffic than that offered by the type approval test.

Success in the in-service test would enable a manufacturer to promote a vehicle as one that can operate within London. Any bespoke ‘London’ test might provide a model for other cities.

The technical issues associated with an in-service noise test specifically designed for vehicle operations in London are described in Table 5.3.

Administrative issues for both type approval and in-service tests, for new and existing vehicles

For each proposed test method, there are a number of administrative issues that would need to be addressed. For example, some operators might wish to bring used vehicles into London, after a new test requirement has come into force. Could they do this? Some administrative issues associated with applying the test to these existing vehicles are addressed in Appendix F. A summary of the costs and benefits associated with the different vehicle noise tests is given in Table 5.4.
Table 5.3: Summary of technical issues associated with introducing a new in-service noise test

<table>
<thead>
<tr>
<th>Issue</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>The type of test and surface to be used.</td>
<td>The actual test will be developed by first examining what particular aspects of LGV operation cause the most noise and annoyance. A test will then be developed that would contain a measure of the noise generating activities. A more representative surface would also be specified, if considered necessary, although this could involve extra costs to provide test locations.</td>
</tr>
<tr>
<td>Development of an achievable level</td>
<td>Through the work of the project, a noise level will be selected that would have a benefit and is achievable with existing technology.</td>
</tr>
<tr>
<td>What technology can be used to achieve the lower noise level?</td>
<td>The technology to be used to achieve a lower noise level will not be specified or recommended. By defining a bespoke test, and setting a limit, this would leave manufacturers unrestrained in what technology they use.</td>
</tr>
<tr>
<td>Can a vehicle be checked while in-service?</td>
<td>During the development of the test, the correlation with a simple roadside check will be considered, to determine the possibility of an annual check or roadside spot check.</td>
</tr>
<tr>
<td>Can testing stations perform such a test?</td>
<td>If a test is devised that involves a drive cycle, then the suitability of current test locations would need to be considered.</td>
</tr>
<tr>
<td>Is any extra equipment required?</td>
<td>If the test developed involves more sophisticated equipment than is currently used, then the extra costs to test locations would need to be evaluated.</td>
</tr>
</tbody>
</table>

Table 5.4: Summary of the costs and benefits of different vehicle noise tests

<table>
<thead>
<tr>
<th>Costs</th>
<th><strong>Type approval test limit</strong>: There would be very small costs to vehicle operators of purchasing vehicles that were below the type approval noise limit.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The costs to manufacturers of extra on-vehicle equipment depend on how large a market is created, and how many dB(A) improvement is demanded. A cost of £500-£3000 per vehicle would be likely. The costs to bring different vehicle designs into conformity with the test limit will vary.</td>
</tr>
<tr>
<td></td>
<td><strong>In-service test</strong>: The costs of an in-service test depend on the cost of designing the test, and whether each vehicle must be tested, or just each type of vehicle.</td>
</tr>
<tr>
<td>Benefits</td>
<td>The public benefit of both test approaches could be a substantially reduced noise intrusion, by day and night.</td>
</tr>
<tr>
<td></td>
<td>The benefit to operators will depend what concessions are offered to them for vehicles that pass the test.</td>
</tr>
</tbody>
</table>
### 5.6.2 Use of ‘Intelligent Speed Adaptation’ speed limiters

The DfT provides statistics on the rates of speeding by commercial vehicles. See Reference DfT(2006a), which provides the latest statistics for 2005. This shows that:

(i) ‘On built up 30 mile/h roads, 47 per cent of rigid LGVs exceeded the speed limit’. (page 3 of (DfT, 2006a)).

(ii) Speeding rates for articulated LGVs were similar. (Table 5, page 12 of (DfT, 2006a)).

(iii) 52% of Light Goods Vehicles exceed the speed limit. (Page 11 of DfT (2006a)).

Commercial vehicles could be given preferential treatment if they are fitted with ‘Intelligent Speed Adaptation’ (ISA) equipment, i.e. a location-dependent speed limiter. This would address the major problem identified in the first row of Table D.1.

A key action for later in this project is to investigate the costs and benefits of ISA equipment for use in London. This will require information about the various types of limiter. We would also summarise the results of the ‘on road’ trials in the UK and on the continent, and look at the progress on the UK’s ‘digital map’ of speed limits.

Table 5.5 identifies three sources of information on ISA technology, and the main points from those sources.

<table>
<thead>
<tr>
<th>Report</th>
<th>Summary of relevant issues in the report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carsten (2000)</td>
<td>Table 1 on page 7 of the report predicts fuel savings of 8.5% in urban off-peak vehicle usage. Table 7 on page 15 of the report predicts reductions of 59% in fatal and serious accidents. However, noise was not such an important issue when the report was written as it is now so noise benefits are not quantified. The report also assumed that there would be no change in other aspects of vehicle design if ISA were introduced. In practice, it is likely that there would be less incentive for vehicle operators to specify the most powerful engines.</td>
</tr>
<tr>
<td>SNRA (2002)</td>
<td>This trial, using ISA in real vehicles, involved 5,000 private motorists, professional drivers and public transport drivers. More than 50,000 questionnaires were completed during the trial, which ran for three years. Two out of three of the drivers wanted to keep the ISA equipment in their vehicles at the end of the trial. The report quantifies various environmental benefits.</td>
</tr>
<tr>
<td>Maurer (2002)</td>
<td>The report describes an existing ISA system on the continent. The system reduces the prevailing speed limit on a particular 3km road dynamically, in order to keep noise levels below a threshold. The threshold varies by time of day. This system shows how speed limits can be set and lowered in order to regulate total traffic noise. ‘The maximum speed for cars and trucks is reduced corresponding to the traffic noise situation and the noise limit in effect at this time….thus permitting to abate the noise level at a rate of up to 6dBA.’ This system is analogous to the variable speed limits in operation on the M25 and M42 motorways, where speed limits change depending on congestion.</td>
</tr>
</tbody>
</table>

The benefits of ISA systems greatly outweigh the costs. This is due to the dual effect of ISA, which reduces both accidents and all the major environmental impacts of moving vehicles. The costs and benefits of ISA speed limiters are summarised in Table 5.6.
Table 5.6: Summary of the costs and benefits of ISA speed limiters

<table>
<thead>
<tr>
<th>Costs</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>There would be very small costs to vehicle operators of purchasing vehicles that have speed or acceleration limiters fitted. The telematics technology involved is less complex than mobile telephones that were already in use in the 1990s. Since 2001, insurance companies have been fitting cars with ‘Pay As You Drive’ (PAYD) insurance technology that has analogous capabilities to ISA. See Byrne (2003). At least one insurer is now giving this equipment away without charge.</td>
<td>The public benefits would involve lower noise, fewer accidents, less air pollution and lower CO₂ emissions. These benefits would occur both by day and night. Operators would pay less for accident damage, fuel use and ‘wear and tear’ on vehicles. These benefits alone would be many times the cost of the equipment. Clearly, the operators would also have the economic benefit from operating off the ERN (see Carsten (2002) in Table 5.5)</td>
</tr>
</tbody>
</table>

‘Pay As You Drive’ (PAYD) insurance systems in fact offer very similar benefits to ISA, and are slowly being fitted voluntarily by many drivers. Incentives to bring in PAYD insurance in commercial vehicles would result in similar benefits to those of ISA systems, and would also act to deter extreme driving styles.

5.6.3 Inclusion of goods vehicles below 18 tonnes

The statistics in Table C.1 show medium levels of annoyance due to ‘small goods vehicles’. However, the licensing statistics show that there are many of these vehicles, as shown in Chapter 2. The overall level of night-time traffic noise could therefore be lowered if these were included in the LLCS. Table 2.3 shows the rapid rise in mileage by vans of up to 3.5 tonnes.

Vehicles under 18 tonnes could be brought under the control of the LLCS. However, this could be accompanied by a relatively straightforward condition for allowing them to travel off the ERN. Two obvious possibilities would be that:

- They must be fitted with ISA equipment (see Section 5.6.2 above). The large number of these vehicles would also increase greatly the resulting accident and emissions savings, both by day and by night;
- They should be fitted with the quietest low-noise tyres that are available. Although this is a simple solution, it has the advantage that it can be applied to both new and existing vehicles in the scheme, and that tyres exist that have noise levels well below the permitted maximum.

The European Commission has already identified the potential noise reductions from action on tyre noise, at low cost (European Commission (2004), Section 2.3 on pages 11-13 and Figure 7 on page 10).

Current plans foresee the LEZ covering all commercial vehicles in classes N1-N3 from 2012. ‘N1’ vehicles are goods vehicles under 3.5 tonnes gross weight, i.e. light vans. ‘N2’ vehicles are goods vehicles from 3.5 tonnes up to 12 tonnes. ‘N3’ goods vehicles are those exceeding 12 tonnes. The date from which all N1 and N2 vehicles are included in the LEZ would be the obvious date for all commercial vehicles in these classes to be brought within the scope of the LLCS.

Table 5.7 summarises the costs and benefits of the inclusion of goods vehicles below 18 tonnes.
Table 5.7: Summary of the costs and benefits of the inclusion of goods vehicles below 18 tonnes

<table>
<thead>
<tr>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>There would be costs to vehicle operators who currently operate vehicles of weight below 18 tonnes during the controlled hours in London. However, these would be reduced if the condition that these lighter vehicles needed to meet in order to operate off the ERN were minor, e.g. low noise tyres, ISA equipment.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>The public benefit could be a substantially reduced noise intrusion, by day and night. The large number of goods vehicles in the weight ranges up to 18 tonnes will mean that these benefits are large. See Table 2.1 and Table 2.2.</td>
</tr>
<tr>
<td>The main benefit to operators would be the reductions in accidents, insurance premiums and fuel usage, if ISA were required.</td>
</tr>
</tbody>
</table>

5.6.4 Driver training

Driver training is already a requirement for operators seeking to operate vehicles off the ERN. However, we do not believe that this can be enforced easily or rigorously. The large number of ‘agency’ drivers used throughout the industry means that it is very difficult for London Councils, or TfL to know the standards to which drivers have been trained, in either safety, fuel efficiency or noise reduction.

TfL is addressing driver training, as part of a wider initiative known as ‘FORS’, the Freight Operators Recognition Scheme. FORS is being developed as part of the London Freight Plan (LFP). The vision of the LFP is “The safe, reliable and efficient movement of freight and servicing trips to, from, within and, where appropriate, through London to support London’s economy, in balance with the needs of other transport users, London’s environment and Londoners’ quality of life”. It is proposed that FORS will be the leading process for disseminating best practice in sustainable distribution to the freight industry servicing London and will build key partnerships with organisations across London to achieve a more consistent level of engagement with the freight industry.

The overall aim of FORS is to engage the freight industry in best practice and cost reduction through:

- Improvements in legal compliance;
- Reductions in penalty charge notices;
- Fuel efficiency improvements;
- Reduction in the costs of vehicle collisions;
- Enhanced operator safety systems;
- Better management of occupational road risks.

As such, the FORS scheme will incorporate a training element aimed at promoting best practice in the fields of fuel efficiency, occupational road risk and delivery practices. TfL has suggested that, in order to be issued with a permit, operators could be asked to join FORS. The operators would undertake to aspire and adhere to upholding the training aspects pertinent to the initiative. This approach requires close working between TfL and London Councils. In particular, discussions will be necessary to ensure incorporation of this into future conditions for issue of a permit.
6 The favoured approach

Table 5.1 demonstrated the wide range of policy approaches that could be used, in order to improve the LLCS. Table D.1 discussed the specific technologies, and what they offer. The entries in these two tables, together with the contents of Chapter 5, constitute a 'long list' of possibilities.

Given the long list of possibilities, there was a requirement for the project to narrow down to a selected, shorter list. Only with such a short list could the resources of the project be concentrated towards original work that could lead to a revised scheme or permit condition. Section 4.2 above explained some of the issues relevant to selecting a short list. In addition, the client for this project was able to provide guidance on the scale of change to the LLCS that might be feasible over a reasonable timescale.

6.1 Which policies were rejected?

Some of the policy changes in Table 5.1 and Table E.1 would have wide-ranging effects, with the majority of the benefits falling outside the area of noise. Examples of these are the vehicle scrapping programme and the fitting of Intelligent Speed Adaptation equipment. Although these would bring very wide-ranging environmental benefits, they were not considered to be sufficiently targeted to the subject of noise.

Other policies would be very localised in their effects. An example would be re-surfacing. The largest group of policy changes that could not be taken forward were those that involved national changes. Examples were subsidies or legislation to introduce low noise tyres, the use of smart card licence detectors in vehicles, or widespread introduction of alternative fuel vehicles or Euro V emissions standards. Notably however, incentives could be designed that applied to fleets of vehicles that were used in London.

6.2 The approach for Phase 2

Following discussions within the team and with the customer, it was concluded that the best way forward is the development of an in-service noise test.

Key advantages of the in-service test are that it is narrowly focussed on noise and the actual vehicles operating in London. Meeting a certain noise threshold can be used as both the basis for an incentive for operators, and subsequently for enforcement ‘in the field’. The purpose and effects of the in-service test can be readily communicated to operators, the public and policy makers.

Developing an in-service test is an opportunity to focus on aspects of noise that arise during use of vehicles in London conditions. In this sense, the in-service test can potentially be more relevant to the problem of noise than the current type-approval test. Such a test would also be of use for furthering work on night time deliveries.

Phase 2 of the report therefore concentrates on experimental versions of an in-service test. The work includes field tests, performed on models of vehicle that are used in London.
This phase of the project addresses the following tasks within the project:

**Task 3**
- Literature review of current monitoring procedures;
- Literature review of in-service testing best practice;
- Literature review of the advantages and disadvantages of various methods of monitoring LGV noise;
- Measurements to characterise in-service noise.

**Task 4**
- Noise monitoring of night-time LGV noise.
7 Review of existing practices for controlling the operation of goods vehicles

This Chapter presents a review of practices for controlling the operation of goods vehicles that are used in different EU Member States and examines international methods and legislation specifically applicable to the control of noise from vehicles.

7.1 General limitations controlling the operation of goods vehicles

As of 2006, there are currently driving restrictions of some form in place for LGVs in the following European countries: Austria, Bulgaria, Croatia, Czech Republic, France, Germany, Greece, Hungary, Luxemburg, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Switzerland and the UK (these restrictions are summarised in Appendix A). They generally restrict the movement of goods vehicles on weekends and public holidays, however there are instances of wider night-time restrictions.

While these restrictions offer benefits in terms of controlling noise nuisance from LGVs, it is not clear whether they have been introduced specifically for this purpose or for other reasons, e.g. to reduce congestion.

In some cases, short-term exemption from the restrictions can be obtained, but this is generally only under exceptional circumstances.

There are relatively few examples of studies concerned with restricting the movement of goods vehicles reported. An example of one such project was a study carried out as part of the EU HEAVEN (Healthier Environment through Abatement of Vehicle Emission and Noise) project which concluded in March 2003. A three-week ban on the operation of large goods vehicles over 3.5t was introduced on Beusselstrasse in the Moabit district of Berlin. During the ban, the volume of LGVs on the road dropped by 30%. This meant that approximately half of the drivers whose vehicles were covered by the ban complied with the regulation (NB. It is not clear how this conclusion was arrived at, and the facts cannot be established from any of the associated project reports). Noise level reductions somewhat greater than 1 dB(A) were observed during the daytime, generally in line with expectations. No details are given as to whether measurements were undertaken at night-time (SMILE, 2004).

7.2 Review of in-service testing methods and associated legislation for the control of vehicle noise

Section 5.6.1 of the report referred to the possibilities of using either the current type approval test or a specially designed in-service test to assess the suitability of vehicles for operation off the ERN. This section of the report presents a literature review which addresses in-service testing methods and legislation related both to LGV’s and other vehicle types and examines whether there is anything in current use which could be suitable for either direct use of adaptation within the LLCS. An overview of commercially available measurement systems that could potentially be used for in-service testing is also included.

For all vehicle types, the test methods identified can be considered in two distinct categories, i.e. methods for assessing whole vehicle noise and methods for assessing the noise from individual vehicle sources.

7.2.1 In-service testing of large goods vehicles

The test methods identified by the literature review rely either solely or in part on the measurement of vehicle noise whilst the vehicle is in the traffic stream, i.e. measurements that are performed under dynamic conditions.
The only whole-vehicle noise measurement method identified that is specific for LGVs is used for enforcement purposes in the United States; “in-use” noise regulations (InterState Motor Carrier Operations Standards) apply to vehicles with a Gross Vehicle Weight in excess of 10,000 lbs (approximately 4.5 tonnes) and state maximum permissible noise levels for these vehicles. The regulations are applied by “trapping” noisy vehicles driving past a microphone at the roadside and subjecting any failing vehicles to stationary tests and visual inspections. The details of the two noise measurements are presented in Table 7.1.

Table 7.1: Measurement details for United States “in-use” vehicle noise regulations

<table>
<thead>
<tr>
<th>Test parameters</th>
<th>Highway operation</th>
<th>Stationary test*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum level</td>
<td>Pre-1996 vehicles 86 dB(A), speed limit &lt; 35 mile/h**</td>
<td>88 dB(A)</td>
</tr>
<tr>
<td></td>
<td>Post-1996 vehicles 83 dB(A), speed limit &lt; 35 mile/h**</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Post-1996 vehicles 87 dB(A), speed limit &gt; 35 mile/h**</td>
<td></td>
</tr>
<tr>
<td>Operating Condition</td>
<td>Level not to be exceeded at any time or under any condition of gradient, load, acceleration of deceleration</td>
<td>Level not to be exceeded when the engine is accelerated from idle with wide open throttle to governed speed with the vehicle stationary, the transmission in neutral and the clutch engaged</td>
</tr>
<tr>
<td>Measurement position</td>
<td>At 50 feet from the middle of the lane on an open site</td>
<td>At 50 feet from the centreline of the vehicle on an open site</td>
</tr>
</tbody>
</table>

* Only applicable to vehicles fitted with engine speed governors

** [39 FR 38215, Oct 29 1974, revised 51 FR 852, Jan 8 1986];

The other “in-use” measurement method identified for LGVs has been developed in Australia and addresses the specific issue of noisy engine brakes (National Road Transport Commission, 2003). The method allows the identification of offensive engine brakes on large goods vehicles within the traffic stream based on the measurement of noise levels as the vehicles pass by.

Engine brake noise is considered to be a particular problem in Australia and a draft Regulatory Impact Statement (RIS) addressing the problem was issued in 2006 (National Transport Commission and NSW Roads and Traffic Authority, 2006). This has identified the preferred option for tackling engine brake noise as being the combination of an in-service standard (using the above test method) and the establishment of a mechanism for prohibiting audible engine brake noise in specific areas. Consultation on the RIS was expected to be completed by August 2006 with the final proposal to be submitted to the Australian Transport Council by December 2006.

### 7.2.2 In-service testing of different vehicle types

Proposals for in-service test procedures for whole-vehicle noise from diesel and petrol-powered vehicles (excluding motorcycles) were evaluated by TRL in the mid-1990’s but never formally adopted for general or legislative use (Harris and Nelson, 1995; Harris et al., 1997).

For diesel-powered vehicles, three stationary test methods were evaluated:
• **Procedure 1D**: A close-proximity noise test as described in the EU type approval Directive 92/97/EEC (European Communities, 1992). This test is similar to that described in ISO 5130 (International Organisation for Standardisation, 2002) which focuses on noise from the vehicle exhaust. The microphone is positioned at 0.5 m from the exhaust outlet, at an angle of 45º. The maximum noise level is measured whilst the engine speed is allowed to freely decelerate from a specified engine speed;

• **Procedure 2D**: A close-proximity noise test using the same measurement position as Procedure 1, but with the engine accelerated rapidly from idle speed to governor run out;

• **Procedure 3D**: A close-proximity noise test recommended by Morrison and Nelson (1985), with a microphone located in close proximity to the vehicle (2 m from the centreline), midway between the centre of the engine and the exhaust outlet, and at a height of 1.2 m. The engine was accelerated rapidly from idle speed to governor run out.

Two types of vehicle were tested from each of the following categories: passenger cars, light vans/trucks, medium goods vehicles, heavy goods vehicles and buses. All the vehicles were also tested in accordance with the type approval drive-by test procedure described in Directive 70/157/EEC (European Commission, 1970) which is a full throttle acceleration test between two defined points.

The results of the study for petrol-powered vehicles showed that the best correlation with the noise level from the drive-by type approval test was obtained using Procedure 3D. The method was considered particularly relevant for the in-service testing of vehicles where there is a large separation between the engine block and the exhaust outlet. For these conditions, measurements taken close to the exhaust outlet alone would not detect excessive noise from the engine and other power unit related components.

It was considered that if this type of close-proximity test was to be used as a routine in-service test (i.e. if it were not conducted on a test track), then the predicted close-proximity limit value corresponding to a given type approval test noise level would require a correction factor to be added. This correction factor, 8 dB(A), takes account of the variability within a vehicle group, reproducibility errors and non-standard site specific factors.

It was considered that this test could potentially be carried out in an outdoor location such as an open garage forecourt or at the roadside provided that the measurement location was a flat hard surface, sufficiently clear of any reflecting facades, buildings, etc.

For petrol powered vehicles, two stationary test methods were evaluated:

• **Procedure 1P**: A close-proximity noise test as described in the EU type approval Directive 92/97/EEC (see Procedure 1D for diesel-powered vehicles);

• **Procedure 2P**: A close-proximity noise test recommended by Morrison and Nelson (1985) (see Procedure 3D for diesel-powered vehicles), but with the maximum noise level measured at 4000 rpm, based on rapid acceleration of the engine under full throttle to approximately 4500 rpm;

A range of passenger cars, a mid-engine micro-van and a large van were tested. All the vehicles were also tested in accordance with the type approval drive-by test procedure described in Directive 70/157/EEC (European Commission, 1970).

The results of the study for petrol-powered vehicles showed that the best correlation with drive-by noise levels was obtained using Procedure 2P and the repeatability was improved. It was considered that Procedure 2P offered greater scope for detecting faults from source other than the noise outlet; however, an independent means of measuring the engine speed is required.
It was considered that if this type of close-proximity test was to be used as a routine in-service test (i.e. if it were not conducted on a test track), then the predicted close-proximity limit value corresponding to a given type approval test noise level would require a correction factor to be added. This correction factor, 7 dB(A), takes account of the variability within a vehicle group, reproducibility errors and non-standard site specific factors. This would give less than 2.5% probability that a vehicle failing the in-service limit would pass the type approval test. It was considered that this test could potentially be carried out at the roadside provided that the measurement location was a flat hard surface, sufficiently clear of any reflecting facades, buildings, etc.

All of the other methods identified by the literature review are focussed on specific noise sources on a vehicle rather than whole-vehicle noise.

Measurements to allow the quantification and location of powertrain noise sources on a vehicle have been reported by Watts et al. (2003), based on a T-profile microphone array (known as an acoustic camera system) and a vertical microphone array developed in the Netherlands (see Figure 7.1). This method was used to take measurements when the vehicle was both static and driving past the microphone array. These measurements were taken on a test track, however similar work using traffic on public roads have been reported, e.g. Pallas and Lelong (2006). However, the complexity of the method and the associated test kit makes the method unsuitable for use as a routine test.

Research in the UK is currently in progress to investigate the characteristics of vehicles producing excessive noise (and ground borne vibration), considering both light and large goods vehicles. This is based around noise measurements recorded using the standard SPB method detailed in ISO 11819-1 (International Organisation for Standardisation, 1997) in conjunction with video footage of the vehicles. The initial identification of vehicles as “noisy” is based upon the subjectivity of the operators responsible for taking the measurements. An examination of the measured noise spectra is then undertaken to look for deviations from the spectra expected from “non-noisy” vehicles to try to identify the cause of the noisiness together with examination of the video footage.

Many countries across Europe and elsewhere routinely undertake exhaust noise assessments, using measurements (either directly in accordance with ISO 5130 or
incorporating elements of that standard) or subjective assessment, as part of regular roadworthiness inspections. Examples of these are given below:

- National stationary exhaust noise test procedures for in-service motor vehicles were introduced in Australia in 2000. Proposals for a revised version of the NSETTP has been prepared (National Transport Commission, 2005) which incorporate elements of ISO 5130.

- A test methodology for objective noise tests based on the ISO 5130 exhaust noise test has been developed in New Zealand, tailored specifically for that countries conditions and vehicle fleet. A tender has been issued to deliver suitable measurement equipment for use by certified testers. (New Zealand Government, 2006). Existing legislation (Section 7.4 of the Land Transport (Road User) Rule 2004) already provides for on-road enforcement of vehicle noise, whereby on-the-spot fines can be issued if a vehicle is deemed subjectively to create noise that, with regard to all the circumstances, is excessive. Police officers are also permitted to direct that noisy vehicles not be driven until they have passed the subjective noise test which is included as an element of the existing MOT test.

- In Norway, in-service noise testing forms part of the periodical roadworthiness inspection (for passenger cars, it is first performed at four years old and every two years thereafter; for LGVs it is first performed at two years old and annually thereafter). However the assessment is initially subjective; measurements are only performed (in accordance with ISO 5130) when the inspectors evaluate the noise level to be abnormal and there is no obvious visible damage to the exhaust. All vehicles registered after 1992 have the stationary noise level stated on the vehicle licence papers together with the corresponding rpm level. When this level has determined by the manufacturer, the tolerance before failing inspection is 5 dB; when the level is determined by a laboratory, i.e. the measurement has been done on the specific vehicle, e.g. on private imports, the tolerance is reduced to 2 dB.

The most common in-service test methods for roadside assessment are associated with motorcycles and focus on the noise from modified/illegal silencers. These methods, which are generally based on ISO 5130, are therefore not directly relevant to this review.

**7.2.3 Suitability of existing in-service test methods for use in London**

Based on the conclusions from Phase 1 of the study, it is considered at this stage that the most suitable and effective approach for the use of vehicle noise tests as part of the LLCS scheme will be a two-step approach as follows:

- In order to travel off the ERN, vehicles will be required to undergo and pass a specially designed in-service test together with a visual ‘condition’ inspection. The noise test could potentially be repeated at appropriate intervals to ensure that vehicles awarded exemption permits still comply with the noise requirements of the LLCS. This test would most likely be carried out either at a recognised test centre or at suitable roadside locations;

- A simpler method suitable for roadside measurements (most likely based on vehicle pass-by) which could be randomly used and allow the identification of vehicles travelling off the ERN which do not comply with a simple noise limit incorporated into the LLCS. These vehicles could then be called in for testing using the in-service test.

It is therefore necessary to consider the suitability of the methods reviewed in the previous sections. The review has identified the following:
Based on the research by Harris, the ISO 5130 exhaust noise measurement method is not suited for the objectives of this study.

Beyond the ISO 5130 method, there is no commonly used method suitable that could be used as the basis for an LLCS test method.

The method used in America, as part of the InterState Motor carrier Operations Standards, could potentially form the basis of the roadside monitoring test. Whilst engine brake noise may be one of the potential noise sources that need to be taken into account, it is not likely to be a widespread on the ERN and therefore, the Australian engine noise brake test can be ruled out for either test method.

The microphone array measurement methods are too complex and require too sophisticated equipment to be suitable for routine application although they are useful when designing a suitable test method. Results from the array can be used to ensure the microphone position chosen for the actual test is optimum regarding the capture of noise emission from the test vehicle.

7.2.4 Commercially available test equipment for in-service noise measurements

The following are examples of measurement equipment developed for the measurement of in-service vehicle noise or vehicle noise enforcement at the roadside:

- A system known as the “Amsterdam noise measurement apparatus” was developed in late 1990s for use by the Amsterdam Police in the Netherlands to simplify the roadside assessment of motorcycle exhaust noise (Institute for Traffic Care, undated). The system integrated a sound level meter, an rpm meter and a processor into a single unit, and is also appropriate for assessing noise from the exhausts of petrol engine motor cars. It has been in use with several Dutch police forces since 2000 but is no longer commercially available; it is not foreseen that any new version will be developed since there is insufficient demand. Several other similar systems are available, such as that developed by SINTEF, Norway.

- A noise camera has been developed in Australia by Acoustic Research Laboratories (undated) which is capable of continually recording road traffic noise and processing the signal for comparison against operator selected trigger criteria whilst simultaneously collecting video footage when the system is triggered.

7.3 Summary

Restrictions on the operation of LGVs are in widespread use across Europe, although it is not clear whether the purpose of such restrictions is specifically to control noise disturbance or to address other problems such as to reduce congestion.

Relatively few examples of in-service testing methods related to LGVs have been identified within the literature; those methods which are in use tend to be specific to individual countries and as such, are directly incorporated within that country’s national legislation. No assessment methods or in-service noise limits have been identified that can be considered as a best-practice as a result of widespread use.

Only a limited number of in-service test methods are reported that are applicable to other vehicle types. Whilst there is more variety in this instance, most of the methods are research-based and not used for enforcement purposes by local-national authorities.
8 Roadside noise measurements of large goods vehicles

The broad objective of performing roadside measurements was to identify and quantify the in-service noise sources from a selection of vehicles operating on different areas of the network. The information collated would then be used to inform the measurement programme to be undertaken on the TRL test track (described in the following chapter). Specifically, the roadside programme was defined to address the following aims:

- To define the “typical” noise range for specific vehicle categories operating on the network;
- To further the understanding of how the type and condition of the road surface affects these noise levels;
- To provide an indication of the typical fleet composition using the network and thereby to identify a representative sample of vehicles to be selected for use in the track tests described in the next section;
- To identify any “typical” noises from these vehicles that are audible above the general traffic noise, e.g. body rattle, air brakes, container boom, brake squeal, etc., which might require special consideration during the development of the in-service test;
- To provide input data for a noise prediction model.

It should be noted that this report expresses vehicle speeds in km/h however where national speed limits are described these will be expressed in mile/h. This follows the notation used in the UK road traffic noise prediction model, CRTN (Department of Transport and Welsh Office, 1988).

8.1 Selection of measurement sites

The measurement sites have been selected based on the need to obtain noise levels to enable the following factors to be taken into account:

- Speed limit: 30 mile/h and below, and greater than 30 mile/h;
- The type of road surface: It was considered important to include an example of a low noise road surface as well as a more traditional Hot Rolled Asphalt (HRA) type of surface;
- The condition of the road surface: good condition and poor condition

An initial eight sites were identified based on discussions with London Councils. An additional two sites were also identified by TRL. From these sites, measurements were taken at six of the locations as detailed in Table G.1 in Appendix G. The original site numbering used is retained in the table.

8.2 Details of the measurements

Measurements have been conducted, so far as possible, in accordance with the SPB measurement method detailed in the method originally developed by TRL and now incorporated in ISO 11819-1 (International Organisation for Standardisation, 1997). For this method the microphone is positioned at 7.5 m from the centre of the closest lane, at a height of 1.2 m above the ground. At each site, individual vehicles in the traffic stream are selected and as they pass the microphone, the corresponding maximum noise level, $L_{A,max}$ and the Sound Exposure Level, which is a measure of the total noise received at the microphone during the pass-by event are recorded together with the vehicle speed.
In this study, the measurements were taken during the early hours of the morning (i.e. 04:00-07:00) at Sites 2 and 4. However at sites 5, 6, 9 and 10 the measurements were taken during the daytime as there was insufficient volume of large goods vehicle traffic during the early hours of the morning. The sample size of vehicles measured was dependant upon the volume and type of vehicles at each location. However, sufficient samples were taken at each location to ensure statistically reliable results.

8.3 Results from the monitoring

8.3.1 Spectral analysis of identified noise sources

This analysis was carried out to compare the frequency spectra of vehicles that had been subjectively identified as having some form of discernable noise characteristic during the tests. The noise sources associated with these discernable noise characteristics are described as “rattle/boom noise” related to body or suspension noise, “exhaust noise” related to low frequency noise and “brake squeal noise” related to high frequency noise. Those vehicles which exhibited no discernable noise characteristics are described as “no identifiable noise source”

Figure 8.1 shows the 1/3rd octave band frequency spectra in the range 50 Hz to 10 kHz together with the overall SEL\(^6\) dB(A) level for both vehicles with and without identifiable noise characteristics. It is shown that:

- **Exhaust noise**: For the two vehicles identified with discernable exhaust noise (shown in the Figure by the light green bars), noise levels in the frequency range 50 to 63 Hz are on average about 3 to 7 dB(A) higher than similar vehicles which did not exhibit this noise characteristic (shown in red). The frequency range 50 to 63 Hz is within the typical frequency range associated with the firing frequency of the engine at the passing speed encountered. Comparing the overall SEL shown in the figure, indicates that the increase in exhaust noise contributes only about 1 dB(A) to the overall SEL. Comparing the average speed of the two vehicle groups, 63 km/h for those vehicle with no identifiable noise source and 62 km/h for those identified with exhaust noise indicate that differences in the SELs are not due to differences in speed. This example illustrates that increases in exhaust noise may not be adequately expressed in terms of the overall A-weighted level due to the sensitivity of the A-weighted filter which attenuates noise levels in the low frequency range below 100 Hz more than at higher frequencies around 1kHz.

- **Rattle/boom noise**: For the ten vehicles identified with discernable rattle/boom noise which were all recorded at sites where the road condition was poor, noise levels above the 630 Hz band were on average about 5 to 7 dB higher than similar vehicles which did not exhibit this noise characteristic. Also at lower frequencies around 125 Hz about 6 dB higher. Comparing the overall SEL shown in the figure, indicates an increase of about 3 dB(A) to the SEL. Comparing the average speed of the two vehicle groups, 63 km/h for those vehicle with no identifiable noise source and 76 km/h for those identified with rattle/boom noise indicate that differences in the SELs may have been partly due to the increase in speed and differences in road condition. However, in the frequency range around 3.15kHz, where the differences are about 7 dB and similarly at 125Hz these frequencies may be indicative of the noise characteristics perceived as rattle noise and boom noise respectively.

\(^6\) SEL refers to the sound exposure level and is a measure of the total A-weighted acoustic energy received from the vehicle pass-by
Figure 8.1: Comparison of vehicle noise spectra for vehicles with and without specific identifiable noise characteristics (values in brackets show the sample size and average speed)
Furthermore, due to the shape of the A-weighting filter the contribution these sources will have to the overall level will be minimal.

- **Brake squeal noise:** For the vehicle identified with noticeable brake squeal, noise levels in the frequency range 6.3 kHz to 8 kHz are clearly discernible and on average about 20 dB(A) higher than similar vehicles which did not exhibit this noise characteristic. This frequency range is characteristic of the high pitch frequency that is associated with this type of noise. Comparing the overall SEL shown in the figure, indicates that the increase in brake squeal noise does not contribute to the overall SEL. Comparing the average speed of the two vehicle groups, 63 km/h for those vehicle with no identifiable noise source and 40 km/h for a vehicle identified with brake squeal noise indicate that differences in the SELs are not due to differences in speed. This example illustrates that increases in brake squeal noise may not be adequately expressed in terms of the overall A-weighted level due to the sensitivity of the A-weighted filter which significantly attenuates noise levels above 5 kHz more than at lower frequencies around 1 kHz.

### 8.3.2 General relationships for different vehicle categories and road conditions

The detailed analysis of the monitoring results in relation to the development of the general relationships between different vehicle categories and vehicle speed for different road surface conditions is reported in Section G.2 of Appendix G.

These relationships allow the prediction of the maximum noise level for a vehicle category for a specified speed and surface condition for use in road traffic noise prediction models. Table 8.1 summaries the derived relationships.

<table>
<thead>
<tr>
<th>Vehicle category</th>
<th>Road condition</th>
<th>Speed level function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger cars and vans</td>
<td>Good</td>
<td>( L_{A_{\text{max}}} = 15.893 \times \log_{10}(v) + 47.439 )</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>( L_{A_{\text{max}}} = 20.075 \times \log_{10}(v) + 42.456 )</td>
</tr>
<tr>
<td>Two-axle rigid vehicles</td>
<td>Good</td>
<td>( L_{A_{\text{max}}} = 22.712 \times \log_{10}(v) + 38.729 )</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>( L_{A_{\text{max}}} = 24.154 \times \log_{10}(v) + 38.433 )</td>
</tr>
<tr>
<td>Vehicles with three or more axles</td>
<td>Good</td>
<td>( L_{A_{\text{max}}} = 22.005 \times \log_{10}(v) + 43.373 )</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>( L_{A_{\text{max}}} = 29.343 \times \log_{10}(v) + 32.919 )</td>
</tr>
</tbody>
</table>

### 8.3.3 Summary of roadside noise measurement results

The results of the roadside measurements have indicated the following:

- A number of vehicles within the vehicle group with 3 or more axles were identified with certain noise characteristics which were noted at the time of monitoring. These noise characteristics were identified into three groups; exhaust noise; rattle/boom noise; and brake squeal. The average 1/3rd octave frequency spectra of the vehicles identified with a certain noise characteristic was compared with the average spectra from vehicles which were identified with no discernable noise characteristic. This
analysis showed that although there were significant differences at certain frequencies in the spectra these differences did not appear to influence the overall A-weighted levels. Both exhaust and boom noise increased noise in the low frequency range 50 - 63 Hz and 125 Hz, respectively whereas rattle noise and brake squeal noise influenced frequencies at 3.15 kHz and above 4 kHz, respectively. At such low and high frequencies, the A-weighted filter significantly attenuates the noise compared with frequencies around 1 kHz.

- Since these types of noise can cause disturbance and annoyance, and are unlikely to be picked up by conventional measurement methods, it is important to consider ways of ensuring that vehicles that are permitted to operate off the ERN are checked for these noise sources. Much can be achieved by ensuring that vehicles are properly maintained, that the exhaust silencer system is in good condition. Additionally, body rattles can be dealt with through the guidance given in the body noise best practice manual and some suspension noise can be reduced by requiring vehicles to be fitted with air suspension. Clearly, maintaining roads to a good standard will also help to reduce noise impact particularly from body and suspension noise sources.

- The analysis of the relationship between the noise indicators SEL and $L_{A_{max}}$ for individual vehicles showed that although both indicators were found to be well correlated with speed, the higher degree of correlation was obtained using the $L_{A_{max}}$ indicator.

- After separating the data according to road condition (roads classified as in poor condition were identified as surfaces with irregularities such as rutting, bumps or hollows) it was found that for both road conditions the measured vehicles could be classified into three acoustically distinct groups:
  
  (i) Cars, car based vans and transits with single tyres on the rear axle;
  
  (ii) 2-axle rigids with twin tyres on the rear axle;
  
  (iii) Rigid or articulated vehicles with 3 or more axles.

- By examining the relationship between the maximum pass-by noise level ($L_{A_{max}}$) and the logarithm of vehicle speed for vehicles and which did not have any noticeable noise characteristics, it was shown that noise levels over the speed range 40 to 80 km/h were about 2 to 3 dB(A) higher on roads classified as in poor condition compared with roads in good condition. This difference was consistent across all vehicle categories.
9 Test track noise measurements of large goods vehicles

The broad objective of performing noise measurements on the TRL test track was to assist in the development of a noise test that could be used on vehicles in-service. The test procedure could then be used as part of the process of determining eligibility of candidate vehicles to operate off the ERN in London.

Any viable in-service test procedure has to satisfy some fundamental objectives and these should be taken fully into account when considering possible candidate test methods. They can be summarised as follows:

- **The test should offer a high degree of repeatability.** This generally means the test should be as simple to carry out as possible. Overly complex tests tend to produce difficulties in achieving repeatable results. They also tend to be more expensive to carry out.

- **The test should provide reproducible results.** This means the test when carried out on the same vehicle at different locations with different equipment and personnel should give acceptably similar results. Clearly, this objective also points to a relatively simple test but also involves other issues such as the standardisation of the test site. This, of course, has implications for in-service testing and vehicle certification applications where fully standardised test site conditions may be difficult to achieve.

- **The test should be representative of real road operations.** This objective refers to the need to ensure that the results obtained relate closely to the noise generated by vehicles when operating in-service. A close correlation with in-service noise will help to ensure that reducing limit values under the test will have a corresponding benefit in terms of reducing noise impact from traffic. It is potentially the most difficult of the primary objectives and to some extent achieving a representative test will tend to increase difficulties regarding repeatability and reproducibility. The key to achieving this objective is to ensure that the mode of operation of the vehicle is sufficiently representative of on-road operations and that the measurement positions and analysis procedures employed provide a reasonable assessment of the total noise that is generated during the test.

A further general point that needs to be considered follows from the need to ensure that the test focuses on a mode of operation that relates as closely as possible to the noise impact caused during normal operation on the network. Previous work on this topic has confirmed the importance of focussing on particularly loud events especially when these events occur relatively frequently (Watts *et al.*, 2005). This would suggest that when choosing, for example, a rate of acceleration or an engine speed, for a test a rate or speed higher than the most frequent should be considered.

Ideally any candidate test procedure should:

- Provide a clearly defined noise level for the whole vehicle that can be used to discriminate between noisy and quiet vehicles in a given category.

- Help identify noisy components on a vehicle.

- Provide data that can help to establish appropriate levels/limits which could be applied to applications such as the permit system for the LLCS.

Bearing in mind the above considerations a small programme of testing was developed as part of this study. It was planned to select a sample of vehicles that were in-service and commonly used on the network and to test these vehicles using a range of candidate in-service noise tests including the current drive-by type approval test. It was anticipated that this data would, when combined with data obtained from previous studies, help to establish
the feasibility of operating an in-service noise test for the LLCS. The following sections describe the vehicles selected, the range of tests employed and the results obtained.

9.1 Selection of vehicles

The vehicles identified for use in the test track study have been selected based on the analysis of the results from the roadside noise measurements. In each case, having identified the basic type of vehicle, SMMT (the Society of Motor Manufacturers and Traders) have been consulted to advise on the most popular make of that vehicle type. In all cases, the vehicles are less than twelve months old and have an emission class of EURO4. Based on this information, the following vehicles were selected for the study.

- Vehicle 1: DAF CF 4-axle tipper (Demonstrator - Euro 4)
- Vehicle 2: DAF CF 65 26 tonne 3 axle rigid box (12 months old - 55 plate - Euro 3)
- Vehicle 3: Volvo FH 440 SCR (i-shift) 3 axle tractor unit (brand new demonstrator - Euro 5). This was tested both with and without a 3-axle trailer.
- Vehicle 4: DAF LF 55 18 tonne 2 axle rigid (Fairly new - 06 plate – Euro 3)

9.2 Selection of test procedures

The various forms of in-service testing have been reviewed in Chapter 7 of this report. Other sources of information on this topic can be found in a TRL report by Watts et al. (2005). As has been stated earlier in this report most information relevant to in-service testing have been largely concerned with establishing the condition and effectiveness of the exhaust silencer rather than establishing noise levels that are representative of the total noise from the vehicle. This form of testing was introduced in the vehicle noise testing standards primarily to establish benchmarks for exhaust noise that could be used subsequently by relevant authorities to provide a physical measure of silencer condition as part of enforcement procedures. More recent research has attempted to provide a more comprehensive measure of in-service vehicle noise mainly to establish a measure of total noise from the vehicle that includes noise sources associated with the power unit as well as the exhaust silencer equipment. These studies have also examined the limitations that might be imposed on achieving reproducible results by the test site layout and general environmental conditions. It was assumed that in-service testing might be carried out in a variety of acoustically non-standard locations, which meant it was necessary to establish the minimum test site requirements for a valid test. To a large extent the issues of achieving both repeatable and reproducible results from in-service testing have now been largely overcome as a result of this research.

The research also indicated the need to operate the vehicle's engine in a manner that would put some load on the engine during the test, since it was considered that this would encourage higher noise levels. These levels would be more representative of the noise generated during normal driving; ensuring a test that better simulates ‘real-life’ conditions. Such a test would therefore be independent of any changes in vehicle technology.

Other information that is relevant to the choice of test method relates to the results of social surveys and jury experiments have helped to identify the types of vehicle operations and noise sources that people judge to be particularly annoying or noisy. It is clear from the social surveys that people tend to give high annoyance ratings to noises that are associated with unsociable or inconsiderate behaviour by drivers/passengers. These types of noises include, slamming doors, sounding the horn, revving the engine, tyre squeal, the vehicle radio. Unfortunately these types of noise sources are not usually amenable to control through vehicle noise testing although some could be treated through appropriate vehicle design. What is particularly interesting from the standpoint of establishing representative
vehicle operations for inclusion in the measurement programme was that from both jury and social survey studies noise from vehicles idling and low speed acceleration are regarded as relatively intrusive operations.

Bearing in mind these observations and experience gained from previous work, the following tests were identified as being suitable for this study (full details of each test are given in Appendix H.

- **Dynamic test**: The regulation 51 type approval test: A full throttle acceleration test between two defined points;
- **Dynamic test**: A steady-state cruise by test, performed at a range of speeds;
- **Stationary test**: A rapid acceleration test to GRO (Governor Run Out);
- **Dynamic test**: A pull away from rest test.

### 9.3 Results of the test programme

#### 9.3.1 Overall data set

Tables of the overall results for each of the TRL test track tests are included in Appendix I.

In order to assess the comparability of vehicles selected for testing with those observed at the sites used during the roadside measurements (Chapter 8), the maximum pass-by noise recorded under the two sets of conditions were examined in detail. Figure 9.1 shows a scatterplot and associated regression line of the maximum pass-by noise against speed for the random sample of large goods vehicles passing the roadside measurement sites. The sites were selected where the road surface was judged to be “good”. For a comparison, a regression line is presented for the test vehicles travelling over a test track surface which was also judged to be in good condition. The surface was hot rolled asphalt (HRA) which is widely used on the London network. It can be seen that there is close agreement between the two regression lines indicating that for cruise-by conditions at least the selected vehicles and test track surface are broadly representative of vehicles observed on the network. Also included in the figure are the results of the test track measurements taken with the test vehicles running on a stone mastic asphalt surface with a 14 mm maximum chipping size (SMA). This is a finer textured surface than the HRA and would, for various reasons be expected to produce less noise under cruise by conditions. It can be seen on the Figure that, in this example, the noise levels are about 1 dB(A) less on the SMA surface.
9.3.2 Test results in terms of the maximum level achieved

One method of analysis that is relevant to sleep disturbance of residents is the maximum level that is achieved (WHO, 2000). In each of the test conditions the maximum recorded level is given in Table 9.1 together with the relevant microphone position.

In the case of the stationary test this will be at the maximum engine revs allowed by the test at a position in front of the vehicle. Note that the extra microphone position very close in to the vehicle body was excluded as the vehicles body shape may unduly affect the readings invalidating fair comparisons.

For the type approval test the higher of the results from the measurements on the left and right hand side of the vehicle are presented.

For the pull away from rest test the maximum level occurred at different positions depending on the vehicle but in the majority of cases the maximum level was recorded at the position P1 i.e. the microphone position just 5 m from the start line.

It can be seen that the highest recorded levels occurred in the stationary test where the engine speed was increased to the maximum engine speed (governor run out). This is likely to expose the noisiest condition even allowing for the fact that the microphone was 2 m from the nearest vehicle contour rather than 7.5 m from the vehicle centre line as used in the other tests. Previous testing at 7 m from the vehicle contours of large goods vehicles has shown that the reduction in level at the greater distance ranged from 7 to 9.6 dB(A) (Watts et al., 2005). Allowing for this order of difference the predicted level at 7m in the stationary test would still be greater than the maximum noise levels recorded for the other test conditions.
Table 9.1: Summary of maximum A-weighted levels

<table>
<thead>
<tr>
<th>Test method</th>
<th>Vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Daf1</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Type approval test</strong></td>
<td>81.7 (LHS)*</td>
</tr>
<tr>
<td><strong>Stationary test</strong></td>
<td>92.6 (P1)*</td>
</tr>
<tr>
<td><strong>Pull away from rest test:</strong></td>
<td></td>
</tr>
<tr>
<td>Gears 1,2,3 (in green)**</td>
<td>81.3 (P1)</td>
</tr>
<tr>
<td>Normal (in green) ***</td>
<td>---</td>
</tr>
<tr>
<td>Normal (in red) ****</td>
<td>82.9 (P1)</td>
</tr>
<tr>
<td>Start in 1 end at 20 km/h *****</td>
<td>82.3 (P1)</td>
</tr>
<tr>
<td><strong>Cruise-by (constant speed) test</strong></td>
<td></td>
</tr>
<tr>
<td>On HRA at 50 km/h</td>
<td>---</td>
</tr>
<tr>
<td>On SMA at 50 km/h</td>
<td>---</td>
</tr>
</tbody>
</table>

* The microphone position where the maximum level was recorded is given in brackets
** Using gears 1, 2, 3, etc... in sequence, keeping RPM in “green band” (economy)
*** Driver selecting appropriate gears for the vehicle, keeping RPM in “green band” (economy)
**** Driver selecting appropriate gears for the vehicle using full RPM range
***** Start in Gear 1, change to an appropriate gear to reach 20 km/h at end of site (after approximately 30 m)

The column at the right hand side of the Table 9.1 provides the range of values for all vehicle options which were tested under all test conditions except cruise-by. This provides evidence of the power of the test to discriminate between vehicles. The larger the range, the greater the potential for ranking vehicles in terms of noisiness. It can be seen that the stationary test and the pull away from rest (starting in first gear and ending at 20 km/h) gave the largest differences and hence would appear to provide the greatest degree of discrimination between vehicles.

9.3.3 Examination of the reproducibility of the test

In Table 9.2 the reproducibility of the stationary and pull away tests were examined using the the Daf three-axle box lorry (Daf2). The combined effect of changing both the vehicle driver and the road surface type was studied for each test (this combination being used based on the availability of the vehicles and drivers). “Driver 1” performed the tests on an HRA surface while “Driver 2” performed the tests on the ISO 10844 standard test surface (International Organisation for Standardisation, 1991). For comparability, the four noisiest microphone
positions were selected for the stationary test. The results of the tests are shown in Table 9.2 and summarised in Figure 9.2.

It can be clearly seen from Table 9.2 and Figure 9.2 that the stationary test gives a very high degree of repeatability since the largest difference between repeat testing was 0.4 dB(A). Note that differences between results on this test for different vehicles was 2.3 dB(A) so that this is an acceptable level of accuracy.

In the case of the pull away test the results were significantly more variable ranging from -0.3 to +2.8 dB(A) for the different vehicles tested. It can be seen that in most cases the test on the ISO surface gave higher noise levels than on the HRA surface. The reasons for this are unknown and could reflect differences in the two test sites, the drivers of the vehicle or a combination of both factors. Generally the closest position to the start (Position1) gave the smallest variability. However even at this position the differences ranged from -0.3 dB(A) to +1.4 dB(A).

**Table 9.2: Summary of reproducibility test results**

<table>
<thead>
<tr>
<th>Test</th>
<th>Microphone position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mic 1</td>
</tr>
<tr>
<td>Stationary</td>
<td></td>
</tr>
<tr>
<td>1st</td>
<td>93.1</td>
</tr>
<tr>
<td>2nd</td>
<td>93.5</td>
</tr>
<tr>
<td>Difference</td>
<td>0.4</td>
</tr>
<tr>
<td>Pull away</td>
<td></td>
</tr>
<tr>
<td>Gears 1,2,3 (in green)</td>
<td></td>
</tr>
<tr>
<td>1st</td>
<td>80.8</td>
</tr>
<tr>
<td>2nd</td>
<td>82.0</td>
</tr>
<tr>
<td>Difference</td>
<td>1.2</td>
</tr>
<tr>
<td>Normal (in green)</td>
<td></td>
</tr>
<tr>
<td>1st</td>
<td>79.5</td>
</tr>
<tr>
<td>2nd</td>
<td>80.9</td>
</tr>
<tr>
<td>Difference</td>
<td>1.4</td>
</tr>
<tr>
<td>Normal (in red)</td>
<td></td>
</tr>
<tr>
<td>1st</td>
<td>81.1</td>
</tr>
<tr>
<td>2nd</td>
<td>82.2</td>
</tr>
<tr>
<td>Difference</td>
<td>1</td>
</tr>
<tr>
<td>Start in 1, end at 20 km/h</td>
<td></td>
</tr>
<tr>
<td>1st</td>
<td>80.9</td>
</tr>
<tr>
<td>2nd</td>
<td>80.6</td>
</tr>
<tr>
<td>Difference</td>
<td>-0.3</td>
</tr>
</tbody>
</table>

* The 4 noisiest positions were used for the stationary test (P1, P2, P3 and P8)
The smallest differences were observed for the test where the vehicle was started in first gear and the driver then selected a further gear change to reach 20 km/h at the end of the test area. At the first microphone position the difference was only 0.3 dB(A) and at 10m it was 0.5 dB(A).

Note that from Table 9.1 the differences between the 4 test vehicles on this pull away test was 2.5 dB(A) so that it would appear that the repeatability / reproducibility is sufficient to allow discrimination between the results from different vehicles at the closest positions. If the test was restricted to recording only maximum noise levels at the 5 m position the range would remain at 2.5 dB(A).

The repeatability / reproducibility for the other pull away tests is worse i.e. ≥ 1 dB(A) at the 5 m microphone position so on this limited data it would appear that the pull away test in first gear is a preferable test condition.

9.3.4 Relationship of in service test with other modes of operation

In simple terms the aim of these studies was to establish a simple and practicable test method which yields results that represent the potential to cause significant nuisance when driven in urban conditions. A previous study carried out for the Environmental Standards Branch of the Department for Transport had a similar aim though the emphasis was on the efficacy of the proposed type approval test ECE R51.03\(^7\) to replace the current R51.02 (Watts et al., 2005). Using a wide range of test methods including moving, pull away and stationary tests it was found for large goods vehicles (maximum mass > 3.5 tonne) that the stationary test used in the current study, was best related overall to the noise levels found under other operating conditions (see Section 5.2.4 of this previous report).

\(^7\) Proposed regulation R51.03 allows the calculation of the index \(L_{\text{urban}}\) which combines the results of an acceleration test with a cruise by test.
Of particular interest to the current study are the results found in the previous study for the
heaviest vehicles (N3 vehicles with a gross weight exceeding 12 tonnes). These vehicles
consisted of 3 rigid vehicles and two tractor units. The vehicles were tested unladen for the
type approval R51.02, laden for the R51.03 test and pull away from rest tests and no trailers
were attached to the tractor units. The stationary test was similar to that carried out in the
current study however the pull away from rest test was different. In the previous pull away
tests an appropriate gear was selected for pull away and then maintained throughout the test
section. The maximum level was recorded at 10 m from the start line. Eight test runs were
carried out for each vehicle and a regression line of maximum A-weighted level against
acceleration rate was calculated for the plotted data. Comparisons were made by
normalising to an acceleration rate of 0.5 m/s$^2$ for the large goods vehicles.

Correlation analysis was carried out for those tests that are relevant to the current tests. Due
to missing data there were only valid data for three vehicles on the stationary tests. None of
the correlations were statistically significant at the 5% level so it is not possible to draw
definite conclusions.

For the data set in the current study the type approval values could not be used for 2 out of
the 4 vehicles tested due to the fact that there was some doubt concerning whether the tests
performed included the noisiest operating condition. The lowest gears were not selected so
the existence of a nosier test condition could not be ruled out. However if the valid data for 2
vehicles were combined with the previous DfT data set it was possible to test the relationship
between type approval values to R51.02 and the stationary test for a total of 6 large goods
vehicles. However, even with this additional data the correlation was not found to be
statistically significant at the 5% level.

Because of the small number of data the statistical results are inconclusive for the stationary
test. For the pull away from rest test it was not possible to carry out similar statistical testing
because there were only 2 valid data points in the current data set. The data could not be
combined with the previous data because the test method differed substantially.

For the current tests it was possible to examine the relationship between the static test and
cruise by tests on the HRA and SMA for three of the vehicles tested.

Again there were no statistical significant correlations between any pair of tests due to the
small sample of vehicles tested.

Overall it can be stated that the relationship between the stationary and pull away test
results with the noise levels produced under other operating conditions could not be
established with any degree of confidence. A larger sample of vehicles would be needed
before firm conclusions could be drawn.

### 9.3.5 Summary of results of vehicle tests

The results indicate that the stationary test and one of the pull away test conditions may give
acceptable levels of repeatability/reproducibility which would be sufficient to differentiate
vehicles in terms of the maximum noise levels achieved under the test conditions. The space
requirement for these tests is also relatively small, particularly in the case of the stationary
test. This means it should not be difficult to find suitable tests sites. Therefore they are
candidates for a test that could be used with the permit system to allow operations off the
ERN. However, it has not been possible to establish the extent to which the test results
relate to the levels obtained under other test conditions with any accepted statistical
confidence. It is of course important to demonstrate that the test results adequately reflect
the potential to cause nuisance under the most common operating conditions.
10 Proposals for an in-service test for the LLCS

10.1 Rationale and recommendations

In order to specify the most appropriate form of in-service test for use in the LLCS it is necessary to evaluate the relative advantages and disadvantages of various options. Many of the issues relate to the test itself, e.g. whether the test is simple to carry out and whether it discriminates fairly between noisier and quieter vehicles.

The proposed test focuses on the noise generated by the vehicle; vibration is not measured as part of this test as it is outside the scope of this project. However, there are other issues that need consideration which relate, for example, to the logistics of testing e.g. test site locations, and the influence of new and emerging vehicle technologies which could affect the future feasibility of a particular test option.

It is important to note that the objective of the project was to develop an in-service test package which is applicable to LGV's in general, regardless of fuel type. The development of specialist tests for individual vehicle types, e.g. tonality tests for electric vehicles, falls outside the scope of this project and as such has not been addressed.

In the introduction to this section we set out some of the main requirements of a test procedure. Clearly the test should be repeatable and should be reproducible by giving acceptably similar results irrespective of where the test is carried out and by whom it is carried out. The short measurement programme carried out as part of this study has helped to establish both the repeatability and reproducibility of the different test methods and these data coupled with the results of previous studies of in-service test methods have helped to provide a reasonably clear picture of these issues in each case.

A rather more difficult requirement is to ensure that the test produces results that are a fair reflection of the noise produced by the test vehicle when it is driven on the network. As a guide, the degree of inter-correlation between test results can provide some insight particularly if the test conditions cover a range of driving conditions. However, it is fair to say that no particular single test condition can cover all modes of operation in practice and so choice on this basis alone can only have a limited success in reducing noise impact. An alternative approach would be to ensure the test method chosen focuses on a particular mode of operation that is known to cause annoyance and disturbance in real traffic situations. Previously reported studies have established the importance of targeting the modes of operation that generate the highest noise levels and the frequency of occurrence of these operations. In a jury experiment carried out at TRL in the 1990’s, where subjects were asked to rate the noisiness of different vehicle operations, the noise from LGVs pulling away from rest and noise from idling vehicles showed a good degree of correlation between physical measures of the noise and the subjective ratings (Watts and Nelson, 1991). It can also be seen in the results of the BRE survey (Table B.1) that vehicles accelerating or engines revving were frequently mentioned as raising annoyance. It can be seen that of those experiencing noise from starting/stopping/idling, about 36% were annoyed to some degree. These operations occur frequently in London traffic and therefore any test that limits or controls the noise from these operations are likely to provide real benefits in community settings.

Given these various issues and the results of the testing carried out, the following paragraphs examine the relative advantages and disadvantages of each of the candidate procedures.
Stationary tests:-

Historically stationary testing has tended to focus on examining the condition of the exhaust silencer system. The methods were never intended to provide an assessment of the overall noise from the vehicle. Indeed the location of the test microphone is deliberately positioned to minimise noise from other vehicle sources. This type of test is clearly not suitable for the current application as the intention is to capture and limit the noise from the vehicle as a whole.

A viable alternative is to test the vehicle with the engine accelerated from idle to governed speed. The rate of acceleration can be either rapid (accelerator pedal fully depressed) or can be more gradual. This latter type of test is often referred to as an engine sweep test. In both cases the objective is to determine the maximum noise from the vehicle over its operating range. It has been found that measurements taken at 7 m from the vehicle at the central position are reasonably representative of the total noise from the vehicle (Watts et al., 2005). Moreover, it has also been found that the measurement distance can be reduced substantially to 2 m without noticeably affecting the validity of this observation. This result has importance when considering in-service testing of vehicles where standard ‘open site’ acoustical conditions cannot be easily achieved due to space limitations and where background noise levels are relatively high. Another point worth noting is that generally the results obtained with this type of test correlate reasonably well with the moving vehicle tests although it is fair to say that the sample of vehicles tested is too small, currently, to attach significance to this observation.

The main advantages of this type of test is that it is simple to perform, it produces highly repeatable and reproducible results and, because tests can be carried out in close proximity to the vehicle, it does not require a large open space for testing. A potential problem with this type of test lies in the development of technology that affectively limits the engine speed under stationary conditions. For example, in a previous study, it was found that when testing a bus the required engine speed for the static tests could not be achieved. This was due to the engine management system blocking the higher engine speeds that, of course, would be available once the vehicle was moving. The noise levels produced during the test would therefore tend to underestimate the noise levels generated in practice. While this technology is currently mainly limited to buses, it is possible that future generation trucks will also be fitted with similar technology. However, with the current fleet there would appear to be no significant problems of reliably carrying out this type of test and given a suitable lead in period a method of circumventing the engine management system for test purposes could no doubt be found if it was needed.

An alternative form of testing while the vehicle is stationary involves simply measuring the noise at idle. Again this test gives repeatable results. Interestingly, previous studies have shown that, for the heaviest vehicles, large differences between vehicles of the order of 15 dB(A) were noted in the results. These large differences did not appear to be picked up by the moving vehicle tests. In fact there was one example, that was particularly noisy at idle but performed reasonably well when tested using the pass-by tests. In practice, idle noise may become important when deliveries are made in noise sensitive areas at night so the issue exposed is important for the application being considered here.

Another type of test that is carried out with the vehicle stationary is a test of a vehicles air brakes. EU Directive (92/97/EEC) has set a limit for air brake noise of 72 dB(A) measured at 7m with a 1 dB(A) allowance for measurement tolerance. Although none of the vehicles tested in this small sample were tested for air brake noise, it was included in the test programme carried out by TRL in the earlier study for the DfT (Watts et al., 2005). Interestingly it was found that three of the nine vehicles tested gave air brake noise levels that exceeded the limit and two of these gave noise levels substantially above the limit. In both these cases the high noise levels occurred during the venting operation of the braking system. Since the noise from air brakes does cause disturbance in the community, it is
reasonable to expect that vehicles operating off the ERN have air brake systems fitted that comply with the limits imposed in the current Directive.

Moving vehicle tests:
This type of testing requires the vehicle to be driven past a measurement microphone either at a steady speed or under some form of acceleration condition. As the speed of the test increases, clearly, the requirements of the test site change. A high speed drive by test would require a large test facility to provide adequate space for the test speeds to be achieved and to allow for safe stopping distances. Also high speed testing introduces the tyre/road surface noise which adds to the complexity of the test method. For this type of test a standard surface has to be laid at each test location in order to achieve an adequate degree of reproducibility in the test results. Partly, for these reasons, high speed testing was not considered to be a viable option for the proposed in-service test.

The low speed tests examined include a pull away from rest and a standard type approval test. Both tests are very similar in the type of operation required as, in both cases the vehicle is accelerated hard through the test site and the maximum noise level determined. In the studies carried out on large goods vehicles it was found that both test methods indicated a reasonable degree of repeatability although generally this type of test is not as consistent as the stationary test. For the pull-away from rest test there were problems reported in the earlier study related to obtaining consistent results for some of the vehicles tested (Watts et al., 2005). At the time when the earlier study was carried out the test procedure was a new procedure. There was some evidence that these problems with consistency were due, in part, to the fact that the test driving condition was new and not straightforward and the driver needed some time to become familiar with the requirements of the test. As the test programme developed, the consistency of the results obtained improved. Following familiarisation, when different drivers were asked to carry out the test on the same vehicle a high degree of reproducibility was obtained. These results suggest that the test could become a viable low speed test provided sufficient training were given to allow drivers to achieve a consistent driving style for the test condition.

In the latest measurements reported here some changes of the pull away test were introduced which allowed the driver a certain amount of freedom to carry out the operation as realistically as he/she would in practice. This relaxation in the prescription of the method was seen as an improvement from the drivers' perspective though repeatability and reproducibility of the results were only considered adequate where the driver was required to select first gear when moving off and to achieve a target speed of 20 km/h with a single gear change.

Of particular interest was the fact that in the previous study, vehicles tested using this type of low speed test were found to be ranked differently than when tested using the current or proposed type approval test. This suggests that this type of test is exposing some aspects of noise generation that is not being picked up by the other test conditions. The fact that the evidence from the jury experiments, which were reviewed previously in this report, underlined the importance of noise nuisance from low speed vehicle operations suggests that consideration should be given to this type of in-service test for the LLCS.

The main advantages of this method are that the mode of operation produces noise levels that are of importance in controlling community noise disturbance. It is also a test that, with a small amount of practice, can be carried out relatively quickly and simply at test sites where the space requirement is not too restrictive. This opens up the possibility of testing in a wider range of locations than would be possible if the test was carried out at higher speeds, e.g. the type approval test. The main disadvantage would appear to be in the prescription of the test gears and in ensuring the test is driven correctly. If a higher gear than normal is selected
or if the vehicle is driven less aggressively that normal, then the test result is likely to underestimate the noise levels generated under real driving conditions.

**Recommended tests:**

It is clear from the work reported here and from the experience gained from previous studies that there are possibly two candidate test procedures that could be considered for this application. The first and simplest test involves testing the vehicle whilst stationary and measuring the maximum noise level when the engine is run up rapidly to governed speed. The test is relatively quick and simple to carry out and produces a high degree of repeatability and reproducibility. It is also good at discriminating between noisy and quieter vehicles.

The second type of test involves a low speed acceleration test where the vehicle is driven past a fixed microphone position. Again a reasonable degree of repeatability and reproducibility can be achieved with this type of test although it is fair to say the results are generally not as good as those obtained with the stationary test. Nevertheless the ability of the method to discriminate between noisy and quiet vehicles is acceptable given the degree of repeatability achieved in this study. The mode of operation is, however, rather more difficult to control than the stationary test. A major concern is that the results can be affected not only by the choice of gear but also by the degree of acceleration imposed by the driver. It is therefore important that the tests are conducted using experienced drivers who carry out the tests correctly, and emphasises the importance of driver training in routine operation to control noise levels during acceleration. A passive style of driving the test could lead to substantially lower noise levels than the same vehicle driven more aggressively. This would be difficult to determine during testing unless suitable instrumentation were used to map acceleration rates and engine speeds. Clearly deploying such instrumentation increases the time taken to undertake the test and the costs. The skill levels required to carry out the work are also increased. The main advantage of this form of testing lies in the fact that it is a mode of operation that is commonly used in real driving, it generates relatively high noise levels and therefore should give test levels that are relevant to controlling noise nuisance particularly sleep disturbance.

However, with regard to the potential to cause sleep disturbance, the stationary test can also be regarded as acceptable since it indicates the maximum noise level that can be achieved by the propulsion unit. Of course the engine is only under inertial load as it is accelerated in such a test but it is considered engine load is of secondary importance in determining noise emissions from a modern diesel engine. Keulemans (2005) has established for a modern tractor unit a significant correlation of 0.91 between overall sound power level and engine speed over a simulated urban cycle involving a wide range of engine load conditions. The stationary test conditions are easy to replicate and are not affected by the vehicle operator.

Given the above considerations, it is clear that either the stationary or pull away test could be used as the in-service test for London. On balance, given that the stationary test is a simpler test to carry out it is recommended that this test should be taken forward to the next stage as the preferred option. However, it should be noted that in order to establish limit values for the preferred test, it will be necessary to carry out a series of tests on a larger sample of vehicles (See also Section 13.5). Given that this test programme will be needed before an in-service test can be implemented, it is recommended that both test methods are examined further with this larger sample of vehicles and a final decision on the test method taken when that measurement programme is complete.

The issue of low frequency noise was considered as part of the test selection process but discounted. This is because this type of noise can be generated by incorrect gear selection, load, vehicle maintenance, vehicle type and location. As such, the feasibility of generating such noise within an in-service test could prove to be problematic. One would have to isolate
the variables to determine real data and an appropriate test method. As such it was considered that this should be done in a separate study.

In addition to the in-service test recommended for total vehicle noise it is also recommended that when vehicles are presented for testing measurements of both idle noise and air-brake noise are also taken. The noise from the air brakes and venting system should be taken using the EU standard test procedure as detailed in EU Directive (92/97/EEC). Any vehicles that exhibit air brake noise levels, including venting noise, that exceed the 72 dB(A) limit in the Directive would not be given a permit to operate off the ERN.

The recommended test package is summarised as follows:

### Recommended in-service test package:

1. **Noise requirements including test methods, limit values and associated guidelines**
   - **Stationary vehicle noise test (including idle condition)**
     Limit value to be decided; likely to be in the range of 85 – 91 dB(A)*
   - **Pull away from rest vehicle noise test**
     Limit value to be decided; likely to be in the range of 75 – 81 dB(A)*
   - Vehicles must comply with ‘best practice guide on body noise’ (see “Control of Body Noise from Commercial Vehicles - Guide to Best Practice”; Department for Environment, Transport and the Regions, 2000)
   - Vehicles must comply with current EU Directive (92/97EEC) limit value of 72 dB(A) for airbrake noise. Airbrake suppressors may be used to achieve this

2. **Additional requirements**
   - Vehicles must have current service history
   - Fleet operator must provide evidence that drivers have undergone appropriate driver training (See Guidance Note 2 of LLCS permit conditions)

* These limit value ranges have been determined based on noise levels from a sample of 4 vehicles⁸. A wider selection of vehicles would need to be tested to determine current maximum noise levels so that the precise limit values can be specified.

### 10.2 Applying the in-service test in practice

This section considers the practical application of the recommended in-service test, which will be referred to henceforth as the ‘London in-service noise test’. Any vehicle that passed the test would be awarded a certificate, henceforth referred to as a ‘Reduced Noise Certificate’.

A key consideration is the incentive that would be offered, in order to encourage operators to submit vehicles for the test.

This report considers two possible incentive packages, which have been the subject of discussions with TfL during the project. Both packages would involve allowing a vehicle with

---

⁸ For the stationary tests, the average maximum level for the vehicles tested was 92.2 dB(A) and for the pull-away tests, the average maximum level (from all 4 tests was 80.7 dB(A).
a Reduced Noise Certificate to operate in London in some of the hours that are currently ‘controlled’, i.e. the hours during which LLCS restrictions currently apply.

The two incentive packages are shown in Table 10.1. They differ in the number of extended hours for vehicle operation. With the existing LLCS, the controlled hours are:

- Between midnight and 07:00 and between 21:00 and midnight on Mondays to Fridays inclusive;
- Between midnight and 07:00 and between 13:00 and midnight on Saturdays;
- All day on Sundays.

**Table 10.1: Incentive packages allowing vehicle operation in London associated with the in-service noise test**

<table>
<thead>
<tr>
<th>Incentive package</th>
<th>Allowed hours of operation, in addition to currently uncontrolled hours</th>
<th>% increase in available hours for operators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incentive package 1</td>
<td>0500-0700 and 2100-2300 on Monday–Friday, in addition to currently permitted hours. <em>This is a total of 96 hours per week</em></td>
<td>27%</td>
</tr>
<tr>
<td>Incentive package 2</td>
<td>All day, every day of the week. <em>This is a total of 168 hours per week</em></td>
<td>124%</td>
</tr>
</tbody>
</table>

These are examples of potential incentives and will be used later in the report for comparison purposes. However, any relaxation of permit conditions would have to go through London Councils-Transport and Environment Committee and be agreed by the boroughs before any changes were permitted.

**10.2.1 Which vehicles would be tested?**

The London in-service noise test would be voluntary. Any operator could submit any vehicle above 18 tonnes for testing. The operator and the vehicle could be based anywhere, including outside the UK.

Each individual vehicle would need to be tested. This is a different situation from type approval tests, where one example of each vehicle model is tested, prior to introduction of that vehicle model onto the market. The reason for testing each individual vehicle in the London in-service noise test is that operators specify their vehicles in a wide variety of finished body designs, which affect noise emissions. In contrast, the type approval test is only applied to the standard chassis/engine/cab combination for the vehicle, without a body being fitted.

**10.2.2 How often would vehicles need to be tested?**

The Reduced Noise Certificate should remain valid for one year after the date of passing the test.

This would mean that the London in-service noise test would be required annually for any vehicle that the operator wishes to use in London in the extended hours, unless the vehicle only makes occasional trips to London.
Unlike an MOT test there is no problem with a vehicle’s certificate lapsing and then a period of time passing before the vehicle is retested, provided that the operator does not wish to use the vehicle in London during the period between expiry of the certificate and the vehicle retest.

With a Reduced Noise Certificate lasting for one year, there might still be vehicles whose noise performance deteriorates during the year to the point where it could not pass the test. Such vehicles would be picked up by the LLCS enforcement officers (see Section J.3 on costs).

10.2.3 Where would vehicles be tested?

The Reduced Noise Certificate would confer advantages on an operator, so the London in-service noise test would need to be administered independently. Any Large Goods Vehicle testing centre could be used, provided that it had sufficient space and the equipment necessary to carry out the final configuration of test. VOSA themselves might be approached and asked to become a testing agency, given their expertise.

The London in-service noise test would need to be paid for by either the operator, Boroughs or TfL. A sufficiently high fee would provide an incentive for existing and new vehicle test centres to offer the test. In the remainder of this chapter, we assume that the vehicle operator should pay, because the Reduced Noise Certificate would confer advantages on the operator.

Table 2.1 and Table 2.2 of this report indicate an absolute upper maximum number of vehicles that might be submitted for testing. A better indicator would be to assume that the number of vehicles submitted for the test would be comparable to or greater than the number of vehicles currently operating with permits in the controlled hours. There are three main factors in this assumption:

(i) Not all vehicles operating in the controlled hours could replace their journeys with a trip during the extended hours, due to the time-critical nature of some of the deliveries.

(ii) Some firms that do not currently have a valid reason for obtaining a permit under the existing permitting conditions, however, may chose to operate in the extended hours, in order to increase vehicle utilisation.

(iii) Operators are likely to have to retro-fit existing vehicles, or obtain new ones, in order to meet the test. This will limit the number of vehicles being put forward for the test, at least in the first few years.

Accurate statistics are, however, not available for the number of vehicles that actually use permits to operate during the currently controlled hours. Such permits are free, and it is believed that many more permits are issued than are actually used.

Technological advances, mass production and competition between vehicle manufacturers will cause a fall in the price difference between a vehicle that can pass the London noise test, and other vehicles. This will take a few years. As this price difference falls, the trend will be for operators to buy increasing numbers of vehicles that can pass the test. So the number of vehicles being submitted to testing centres will rise in the medium term. This is an ideal situation, because the number and size of testing centres can rise gradually over the years, as the number of vehicles submitted for testing each year rises. This will avoid any problems with there not being enough testing stations in the first year of the London noise test, i.e. the testing centres will not be swamped by pent-up demand from day one.
10.2.4 How to determine the limit values?

Limit values need to be devised for the recommended test. The limit values need to be set such that a vehicle that passed the London in-service noise test would be one that led to a given reduction in noise damage in typical use. In order to have enough information to set the noise limits, it is estimated that approximately 60-70 different vehicle models would need to be tested. Assuming that this testing occurs in 2007, vehicles should be selected that are likely to still be in production in 2010.

There would be great advantage in testing any vehicles that are available with optional additional sound deadening. That might be through a manufacturer’s optional equipment, or through an ‘after-market’ supplier. Such vehicles would allow a measurement to be made of how much noise reduction can be achieved, relative to a standard vehicle, at a particular cost.

On this topic it is worth noting that a project currently being undertaken by DAF trucks in the Netherlands is examining the potential noise reductions that can be achieved on large goods vehicles through the use of engine encapsulation and other design measures. The reductions are achieved by targeting various different noise sources. For example, it is claimed that total engine encapsulation could reduce engine noise by up to 12 dB(A). Other measures include:

(i) Modifications to the timing of the engine to smooth the pressure changes resulting from the combustion of the fuel.

(ii) Modifications to gas flow noise through improvements to the turbocharger and exhaust silencer system.

(iii) Mechanical noise is being tackled through refinements to gears, gearbox and timing chains etc.

Overall the Dutch team are working to achieving a target noise level with a modified large goods vehicle of some 12 dB(A) below the current type approval level.

Once limit values have been devised for the London in-service noise test, one of the following situations (i) - (iii) might be found:

(i) There are some standard vehicles above 18 tonnes that are on sale in 2007, and which can pass the test. In this case, operators would have an incentive to deploy these vehicles for deliveries in London, from amongst their fleets, and/or to buy more of them.

(ii) Only vehicles with engine encapsulation and/or optional sound deadening could pass the test. This would encourage operators to buy these lower noise vehicles and/or retro-fit sound reducing equipment on existing vehicles.

(iii) No vehicles are yet available that can pass the test. The test would therefore act purely to create a market. Such legislative approaches are already known. For example, no passenger vehicles are currently on sale in the UK that would fall in the ‘A’ band of Vehicle Excise Duty for passenger cars, so this band is only available as an incentive to manufacturers to develop such vehicles.

10.2.4.1 Example of limit values

To generate an example of how a test limit value might be set and the implications of such a limit value for noise benefits in practice, the measurement results from the stationary vehicle test reported in Section 9.3 and a similar previous study (Watts et al, 2005; see Section 9.3.4) were analysed further.
The combined dataset comprises results from 7 vehicles (4 from the current series of tests and 3 from the previous study). Clearly this is a small sample and the results presented here are meant only to illustrate how possible limit values compare to currently available vehicles.

The average maximum A-weighted noise level measured during the stationary test for this combined dataset was 90.94 dB(A) (with a standard deviation of 1.94 and a 5% confidence interval of 1.79 dB). It can be shown that in order to obtain a smaller confidence interval of ±0.5 dB (which would be needed to define a benchmark for a further test limit to the nearest decibel) a sample of 66 vehicles would be required.

The range of maximum noise levels for the 7 vehicles was 5.8 dB(A). Based on this average, it was considered possible that a reduction of 3 dB below the rounded average (91 dB(A)), i.e. a limit value of 88 dB(A), could be achieved on the stationary test.

It must be stressed that this limit value is for illustrative purposes only: since it is based on the evaluation of a very small sample of vehicles (the dataset comprises only 7 vehicles). Further work, evaluating a larger vehicle sample may be needed, as it is considered that the reduction of the order of 10 dB(A)\(^9\) may be required to satisfy all concerns.

All future vehicles would be required to meet this limit value thereby putting downward pressure on noise emissions.

Other potential limit values (based on reductions below the 91 dB(A) rounded average) were also examined to check the potential impact. Assuming a normal distribution for the maximum noise levels from LGVs (measured during a stationary test) centred around the 91 dB(A) average identified above, the percentage of vehicles that would currently fail such an in-service test are given in Table 10.2.

<table>
<thead>
<tr>
<th>Reduction in maximum permitted noise below the average value of 91 dB(A)</th>
<th>Effective limit value dB(A)</th>
<th>Percentage of current vehicles failing the stationary in-service noise test</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>91.0</td>
<td>50</td>
</tr>
<tr>
<td>1</td>
<td>90.0</td>
<td>69.7</td>
</tr>
<tr>
<td>3</td>
<td>88.0</td>
<td>93.9</td>
</tr>
<tr>
<td>6</td>
<td>85.0</td>
<td>99.9</td>
</tr>
</tbody>
</table>

An example of the potential noise benefits from enforcing these limit values is included in Appendix K.

10.2.5 Phasing in the test

The London in-service test would be introduced at a certain date, for example 1 January 2010.

We need to consider two possible sets of vehicles:

\(^9\) A 10 dB(A) reduction is likely to be required to be noticeable indoors during the night-time. 10 dB(A) reduction is perceived as a halving of loudness.
(i) Vehicles that *had* operated in London prior to 1 January 2010, with a permit for operation off the ERN. In the interest of fairness to industry, such vehicles should be allowed to operate in the controlled hours, as before, provided that they apply for permits.

(ii) Vehicles that *had never* operated in London, prior to 1 January 2010, with a permit for operation off the ERN. If incentive package 1 were chosen, an operator should only be able to apply for a permit if appropriate grounds exist for the trip, and the vehicle has a Reduced Noise Certificate. If incentive package 2 were chosen, no permits should be available.

With incentive package 1, the number of applications for permits would be likely to fall gradually after 1 January 2010. With incentive package 2 the number of applications for permits would fall rapidly after 1 January 2010.

### 10.2.6 Enforcement

Enforcement of the permit system would be by officers operating at the roadside, as is the case with the current LLCS. This would involve recording number plate details and noise levels for vehicles over 18 tonnes. This could be done either as a regular activity or, in areas where infringements are more likely, as spot checks.

- **(i)** Action would be taken against any identified vehicle that was operating during the controlled hours and which did not appear on a list of vehicles with a valid permit or Reduced Noise Certificate

- **(ii)** Action would be taken against any identified vehicle that exceeded a pre-determined pass-by noise level. This pre-determined level would require to be defined based on average pass-by levels of new vehicles; this level has not been defined within the current study. This in line with the approach discussed in Section 7.2.3. An enforcement process of this type is currently being used within the United States (see Section 7.2.1)

It should be noted that the enforcement officers would not be required to stop vehicles. Operators would be sent a letter requesting that their vehicle be re-tested within a set period from the date of the letter. A penalty would need to be devised and publicised for vehicles that were then not submitted for re-testing. Whatever penalty is chosen, the penalties should rise strongly for ‘repeat offenders’.
11 Costs and benefits of in-service testing

11.1 Methodology

An analysis of costs and benefits needs to consider five main factors. These are:

(i) The annual costs of submitting vehicles for the London in-service noise test.

(ii) The reductions in costs to operators, which result from increased vehicle productivity when operators can use their vehicles in the extended hours.

(iii) Any extra costs to operators of obtaining vehicles that can pass the test.

(iv) The noise benefits that would result from use of the vehicles that had passed the test.

(v) Any changes to levels of road congestion, or other environmental 'externalities' of vehicle use.

There are two possible approaches to assessing (iv), the noise reduction that would result as a consequence of the test:

(i) We could select noise thresholds for use in the London in-service noise test from the ranges shown in Section 10.1. This would enable us to model the consequential decrease in propulsion noise, in a vehicle that just passed the London in-service noise test. We could then in turn model the decrease in traffic noise on real roads. This would require an assumption about how many vehicles would pass the London in-service noise test, i.e. would hold a valid Reduced Noise Certificate at any one time. A major DfT study is available, which would provide a figure for the value of these noise reductions (Bateman, 2004). Section 8.5 of (Watts, 2006b) shows such a calculation.

(ii) We could instead look at the costs and benefits for an individual vehicle over 18 tonnes that passes the London in-service noise test. This is the methodology chosen in the remainder of this chapter. The advantage of this approach is that it lays out the costs and benefits in a way that is easy to understand. It does not require an assumption about how many vehicles will operate with a Reduced Noise Certificate.

Once we know the costs and benefits per vehicle, we could calculate the total costs and benefits to London, if we also estimate how many vehicles are likely to have a valid Reduced Noise Certificate at any one time.

For the purpose of making these calculations, we have assumed a particular test limit for the London in-service noise test, as follows:

- The test limit is defined in terms of the amount of noise abatement that would be achieved, when a vehicle that could just pass the test is used on the road.
- A limit has been assumed that would only allow vehicles to pass the test if they produced 50% less noise disbenefits in ordinary operation than the mean for all new vehicles over 18 tonnes that are on sale when the test is introduced. Henceforth, we refer to this as the 'chosen noise test limit'.

Note: This calculation uses a hypothetical limit value. A more detailed evaluation of current and proposed technologies may be required to determine whether the 'chosen noise test limit' used in these calculations is feasible, and realistic/achievable in practice.

Considering the recommendations in Section 10.1, once again, the 50% noise test limit might, for example, correspond to a noise limit of 85 dB(A) in the stationary and 75 dB(A) in the pull away test.
Clearly, we are defining the limit in terms of the reduction in the amount of noise damage that is imposed on the public. The amount of noise damage depends on the perceived loudness of sound, which in turn depends on the acoustic energy emitted by the vehicle. It is this acoustic energy level that would be reduced by the appropriate choice of a decibel noise limit in the test.

In most cost-benefit studies, a technique called ‘discounting’ is used to bring values from future years back in to ‘current year’ prices. This aids comparisons of costs and benefits. However, the assumptions used in this report lead to relatively large error ranges in the estimates of environmental disbenefits, and the costs and benefits only lie over a period of five years. Discounting is not appropriate in the light of such uncertainty. In fact, discounting would create a false impression of ‘precision’ in the estimates in this report, so the authors consider that discounting is not appropriate here.

All of the cost and benefit calculations are included in Appendix J.

11.2 Conclusions on costs and benefits

Table 11.1 summarises the costs and benefits of the London in-service noise test, for each vehicle that just achieves the limits required for a Reduced Noise Certificate, over a 5 year period of operation of that vehicle.

<table>
<thead>
<tr>
<th>Party affected</th>
<th>Incentive package 1</th>
<th>Incentive package 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total cost (£)</td>
<td>Total benefit (£)</td>
</tr>
<tr>
<td>Vehicle operator (negative figure indicates a cost saving)</td>
<td>(-4950)</td>
<td>N/A</td>
</tr>
<tr>
<td>Society</td>
<td>N/A</td>
<td>58,000</td>
</tr>
<tr>
<td>Cost to London Councils</td>
<td>No change in enforcement cost</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>No change in enforcement cost</td>
<td>89,625</td>
</tr>
<tr>
<td>Total benefit per vehicle over 5 years (£)</td>
<td>62,950</td>
<td>99,075</td>
</tr>
</tbody>
</table>

The values in Table 11.1 lead to the following conclusions:

(i) On the basis of the costs savings for operators and the benefits in terms of noise and congestion reductions, this report recommends that the proposed London noise test be introduced.

(ii) The cost saving for vehicle operators is greater with incentive package 2 than with incentive package 1. For this reason, it is likely that more large goods vehicles with significantly lower noise impacts would be purchased by operators and used in London if incentive package 2 were offered to operators. Both operators and the public would benefit from this.
After implementation of the Low Emission Zone, consideration should be given to introducing a noise test for goods vehicles in the 3.5-18 tonne range. This would extend the benefits of the London noise test to a much larger pool of vehicles, many of which are used during the controlled hours. Eventually, goods vehicles less than 3.5 tonnes should also be subjected to a noise test. Such vehicles cover higher mileages than cars, and hence could contribute significantly to efforts to reduce noise if an incentive were found to make them quieter.
PHASE 3

This phase of the project addresses the following task:

Task 5

- Determine the requirement for an upgraded electronic traffic noise map of London
12 The need for prediction and routing tools

Previous sections of this report have considered ways in which the LLCS could be updated including methods of identifying and monitoring the operation of quieter vehicles which can operate off the ERN. In addition to this it was considered important to have available some form of tool which will allow the noise benefits from quieter vehicles to be accounted for on the network and to allow the investigation of different noise control strategies particularly in noise sensitive areas.

Phase 3 of the project is therefore concerned with considering the requirements for a form of electronic traffic noise map of London, which could potentially be used to identify and assess the need for low-noise routes on the network as well as providing information of the acoustic benefits of replacing existing vehicles with lower noise equivalent vehicles. This noise map would use real traffic flow, speed and composition information and other appropriate information to predict the noise levels for those roads on the network where the data is available. By varying these input parameters, the map would allow the effects of changes on the network to be efficiently examined and evaluated, thereby allowing the management of noisier routes and the creation of suitable new low-noise routes as necessary. The technique could also potentially have value in assisting in the identification of suitable options for noise control for the network as a whole.

It is not considered feasible at the present time to derive such a map using the same calculation methods as used in creating the London Noise Map. This map was derived using a calculation method called Calculation of Road Traffic Noise (CRTN; Department of Transport and Welsh Office, 1988) which was not designed to take account of the different goods vehicle categories that have been considered in Phase 2 of this project, or to allow any changes to the individual noise levels of different vehicles. Essentially CRTN takes the volume of traffic in the traffic stream as the main indicator defining the overall noise level and then adjustments are made according to the relative composition of trucks in the overall flow. It may be possible to manipulate the inputs to the CRTN model to reproduce the noise levels for flows comprising different large goods vehicle categories and to allow adjustments for quieter LGVs but this would require additional research. It would also be attempting to change the basic rationale of the CRTN model from a model based on overall vehicle flow to a model based on individual vehicles.

An alternative approach for determining the noise levels is therefore preferred and this is described in the following sections of the report. The procedure allows the prediction of disturbance at roadside locations based on traffic flows comprising multiple categories of large goods vehicle. This procedure uses, as an input, the maximum noise levels for individual vehicle categories which are derived from the measured relationships between vehicle speed and noise level. These relationships for London roads were determined from the noise measurements carried out in Phase 2 of the project. Results are presented for a range of different scenarios to illustrate how the procedure can be applied to model different conditions.

Although the calculation procedure will allow an alternative noise map to be generated, it is considered that a more appropriate use of the data will be to relate the levels to night-time sleep disturbance in properties along the roadside. In this way, a map of sleep disturbance could be produced which may potentially be useful in determining vehicle routes. Results are, therefore, also presented for the above scenarios expressed as a function of sleep disturbance.

Most noise mapping packages will use a noise model as an integral part of their software, and as such it may not be possible to import noise data calculated from separate sources. However, much of the information that would be needed to produce the sleep disturbance maps is likely to be already stored as GIS layers for use in these mapping packages. It may be possible to use a standard GIS package to create the sleep disturbance map.
The additional information that would be required both to expand the conditions considered in the calculations and to allow the results from the calculation procedure to be used to produce a sleep disturbance map of the ERN are also discussed in this Phase of the project.
13 Prediction of disturbance due to vehicles travelling off the ERN

13.1 The calculation procedure
The proposed calculation procedure, which aims to calculate the either percentage of people highly sleep disturbed along that section of road or estimate the number of people “highly sleep disturbed” based on the density of occupancy of residential properties along that road, is shown schematically in Figure 13.1 and described in full in Appendix L.

![Diagram of calculation procedure]

Figure 13.1: Schematic of calculation procedure for determining roadside noise disturbance

13.2 Calculations for different traffic flow scenarios
In order to demonstrate how the calculation procedure can be applied in practice, several example calculations have been made with different traffic flows and compositions. The speed level functions used for the calculations of $L_{Amax}$ have been derived for three different vehicle categories, as summarised in Table 13.1, from the measurement survey of vehicle noise levels and speed that were carried out in Phase 2 of this study, as described in Section 8.3.2 and Appendix G.
Two speed level functions have been also been derived for each vehicle category, one for roads in good condition and one for roads in poorer condition. Further work to establish a larger data base would be needed to fully validate these functions for the LLCS network.

It should be noted that this report expresses vehicle speeds in km/h however where national speed limits are described these will be expressed in mile/h. This follows the notation used in the UK road traffic noise prediction model, CRTN (Department of Transport and Welsh Office, 1988).

Table 13.1: Relationship between vehicle noise and speed for different vehicle categories and road conditions (derived from Figures G.3-G.5)

<table>
<thead>
<tr>
<th>Vehicle category</th>
<th>Road condition*</th>
<th>Speed level function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger cars and vans</td>
<td>Good</td>
<td>$L_{A\text{max}} = 15.893 \times \log_{10}(v) + 47.439$</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>$L_{A\text{max}} = 20.075 \times \log_{10}(v) + 42.456$</td>
</tr>
<tr>
<td>Two-axle rigid vehicles</td>
<td>Good</td>
<td>$L_{A\text{max}} = 22.712 \times \log_{10}(v) + 38.729$</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>$L_{A\text{max}} = 24.154 \times \log_{10}(v) + 38.433$</td>
</tr>
<tr>
<td>Vehicles with three or more axles</td>
<td>Good</td>
<td>$L_{A\text{max}} = 22.005 \times \log_{10}(v) + 43.373$</td>
</tr>
<tr>
<td></td>
<td>Poor</td>
<td>$L_{A\text{max}} = 29.343 \times \log_{10}(v) + 32.919$</td>
</tr>
</tbody>
</table>

For the purpose of these example calculations, the reference scenario against which any changes will be assessed assumes traffic to be operating on a single carriageway road in good condition with a speed limit of 50 mile/h and where the closest façades of adjacent residential properties are located at 10 m from the edge of the kerb.

Average vehicle speeds (in km/h) for the different vehicle categories have been derived from a separate study which involved taking SPB measurements on low-speed roads (Abbott et al., 2005). These speeds are summarised in Table 13.2.

Table 13.2: Summary of model vehicle speeds for different road categories and speed limits

<table>
<thead>
<tr>
<th>Speed limit</th>
<th>Road category</th>
<th>Vehicle category</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Cars and vans</td>
</tr>
<tr>
<td>Less than 50 mile/h but greater than 30 mile/h</td>
<td>Dual carriageway</td>
<td>75.0 km/h</td>
</tr>
<tr>
<td></td>
<td>Single carriageway</td>
<td>59.2 km/h</td>
</tr>
<tr>
<td>Less than 30 mile/h</td>
<td>All carriageways</td>
<td>49.8 km/h</td>
</tr>
</tbody>
</table>

The reference traffic volume and composition are based on night-time traffic counts on the A503, Seven Sisters Road, Islington (a road for which LLCS permits are required) from a 2003 study (Abbott, 2003).

For the purpose of the following calculations, it is assumed that these traffic conditions are typical of the average annual night time period. The volumes for the different vehicle classes
are shown in Table 13.3. It is assumed that all vehicles with three or more axles have been awarded permits for travelling off the ERN.

Table 13.3: Summary of night-time traffic flow and composition on A503, Seven Sisters Road, Islington

<table>
<thead>
<tr>
<th>Night time traffic flow</th>
<th>Cars and vans</th>
<th>2 axle rigid</th>
<th>Vehicles with three or more axles</th>
</tr>
</thead>
<tbody>
<tr>
<td>All cars &amp; vans</td>
<td>6295 (90.82)</td>
<td>478 (6.9)</td>
<td>122 3 2 8 23</td>
</tr>
<tr>
<td>Transit vans</td>
<td>658 (9.49)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 13.2 shows how the number of vehicles in each of the categories in Table 13.2 varies with each hour in the night-time period. The scale for cars and vans, and two-axle rigid vehicles is shown on the left-hand y-axis, while the scale for vehicles with three or more axles is shown on the right-hand y-axis. It is interesting to note that approximately 37% of the total night time flow at this location occurs during 06:00 to 07:00 hours with 4.6% of the hourly flow in that period consisting of vehicles with 3 or more axles. This period of the night is recognised as particularly important as during this period, people are most sensitive to being awakened by noise.

The scenarios to be examined in this report using the calculation procedure include replacing one vehicle category for another, based on the number of vehicles required to carry the equivalent payload. The effects of on public perception of replacing LGVs with smaller vehicles of equivalent gross weight is discussed in Section D.4 of Appendix D.

It is noted that while the calculation procedure currently only uses speed-level functions for the three vehicle categories described in Table 13.1, there is no reason why different axle configurations cannot be considered within the “3 or more axle” category to allow different payloads to be taken into account. Table 13.4 therefore provides details of the different vehicle categories broken down by payload, including the equivalent number of transit vans or 2-axle rigid vehicles required to carry the same payload.
The low volume of vehicles with four or more axles observed during the traffic counts on the A503 (Table 13.3) means that for the example scenarios in this study, it is assumed that only a single type of four-axle and five-axle articulated lorry are operating, since the payloads are not wildly different.

Calculations of %HSD have been carried out for the following different scenarios, which are based on making changes to the reference condition. In each case the scenario has been

Table 13.4: Payload information for different vehicle and axle configurations

<table>
<thead>
<tr>
<th>Type</th>
<th>Max weight (kg)</th>
<th>Payload (kg)</th>
<th>Equivalent No. of vehicles (by payload)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>&quot;Transit&quot;</td>
</tr>
<tr>
<td>Transit</td>
<td>3,500</td>
<td>1,800</td>
<td>1</td>
</tr>
<tr>
<td>2-axle rigid</td>
<td>18,000</td>
<td>12,939</td>
<td>8</td>
</tr>
<tr>
<td>3-axle rigid</td>
<td>26,000</td>
<td>16,600</td>
<td>10</td>
</tr>
<tr>
<td>4-axle rigid</td>
<td>32,000</td>
<td>22,400</td>
<td>13</td>
</tr>
<tr>
<td>2-axle tractor with 1-axle trailer*</td>
<td>44,000</td>
<td>15,300</td>
<td>9</td>
</tr>
<tr>
<td>2-axle tractor with 2-axle trailer*</td>
<td>50,000</td>
<td>20,800</td>
<td>12</td>
</tr>
<tr>
<td>3-axle tractor with 3-axle trailer**</td>
<td>70,000</td>
<td>29,936</td>
<td>17</td>
</tr>
</tbody>
</table>

* Four-axle configurations with a 3-axle tractor unit and a 1-axle trailer (payload 18,936 kg) are assumed equivalent

** Five-axle configurations, i.e. 2-axle tractor unit with a 3-axle trailer (payload 28,300 kg) and 3-axle tractor unit with a 2-axle trailer (payload 26,436 kg), are assumed equivalent
modelled for both a good condition and a poor condition road surface. The reference traffic conditions have also been applied to a road in poor condition.

1. Scenarios examining the effects on noise levels of reducing the maximum size of vehicles permitted to operate on the road from 23:00-07:00.

<table>
<thead>
<tr>
<th>Scenario Name</th>
<th>Description</th>
<th>General speed limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario SC1</td>
<td>Restrict permitted traffic to passenger cars, transit vans and 2-axle rigid goods vehicles, but do not substitute ineligible vehicles</td>
<td>50 mile/h</td>
</tr>
<tr>
<td>Scenario SC2</td>
<td>Restrict permitted traffic to passenger cars, transit vans and 2-axle rigid goods vehicles. Substitute ineligible vehicles with an equivalent combination (by payload) of transit vans and 2-axle rigid vehicles</td>
<td>50 mile/h</td>
</tr>
<tr>
<td>Scenario SC3</td>
<td>Substitute 2-axle rigid goods vehicles with an equivalent combination (by payload) of transit vans.</td>
<td>50 mile/h</td>
</tr>
</tbody>
</table>

It is noted that Scenarios SC2 and SC3 would lead to an increase in traffic volume and, particularly for Scenario 3, a possible increase in traffic congestion. The use of an increased number of smaller vehicles may also be prohibitive to operators on cost grounds due to the need for additional drivers and increased fuel usage. Differences in driving behaviour between goods vehicles and some transit vans may also have a negative impact which will not be reflected in the noise predictions using the model.

2. Scenarios examining the effects on noise levels of reducing traffic volume between 23:00 and 07:00.

<table>
<thead>
<tr>
<th>Scenario Name</th>
<th>Description</th>
<th>General speed limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario SC4</td>
<td>Substitute all transit vans and 2-axle rigid goods vehicles with an equivalent combination (by payload) of 3-axle rigid and 5+ axle articulated goods vehicles</td>
<td>50 mile/h</td>
</tr>
<tr>
<td>Scenario SC5</td>
<td>Substitute all transit vans and 2-axle rigid goods vehicles with an equivalent combination (by payload) of 5+ axle articulated goods vehicles</td>
<td>50 mile/h</td>
</tr>
<tr>
<td>Scenario SC6</td>
<td>Substitute all transit vans with an equivalent combination (by payload) of 2-axle rigid goods vehicles.</td>
<td>50 mile/h</td>
</tr>
</tbody>
</table>

It is noted that these scenarios may lead to an increase in the number of part-loaded/largely empty vehicles due to the differences in payload capacity which may be prohibitive to fleet operators on cost grounds.

3. Scenarios examining the potential noise reductions due to using quieter large goods vehicles or speed restrictions.
<table>
<thead>
<tr>
<th>Scenario Name</th>
<th>Description</th>
<th>General speed limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario SC7</td>
<td>Impose a speed reduction of 10 km/h on all vehicles with three or more axles</td>
<td>50 mile/h</td>
</tr>
<tr>
<td>Scenario SC8</td>
<td>Substitute 50% of vehicles with three or more axles with equivalent payload capacity vehicles have an $L_{A_{max}}$ value 3 dB(A) less than the equivalent existing vehicles</td>
<td>50 mile/h</td>
</tr>
<tr>
<td>Scenario SC9</td>
<td>Substitute 50% of vehicles with three or more axles with equivalent payload capacity vehicles have an $L_{A_{max}}$ value 6 dB(A) less than the equivalent existing vehicles. Substitute the remaining 50% of these vehicles with equivalent payload capacity vehicles have an $L_{A_{max}}$ value 3 dB(A) less than the equivalent existing vehicles</td>
<td>50 mile/h</td>
</tr>
</tbody>
</table>

It is noted that the use of speed restrictions on large goods vehicles may not be cost-effective for operators.

Calculations for these scenarios (with the exception of Scenario 7) have also been carried out using the traffic noise prediction model HARMONOISE, which is described in the following section

### 13.2.1 The HARMONOISE prediction model

The HARMONOISE model (Watts, 2005) was also used to determine the effects of changing the numbers of goods vehicles according to the scenarios outlined above. This noise prediction model is state-of-the-art and was developed within a consortium of European states to eventually become the EU harmonised noise mapping tool. The part of the model used was the vehicle source model. In outline the model divides vehicles into three main categories corresponding to light (category 1), medium goods (category 2) and large goods vehicles (category 3). Category 1 and 2 vehicles all have two axles except in the case of vehicle/trailer combinations. Generally category 2 vehicles have 6 or more wheels (4 on the rear axle). Category 3 contains the heaviest vehicles which have more than 2 axles.

In HARMONOISE, two point sources are used for each vehicle category – one represents mainly the tyre sources (rolling noise) and is located close to the road surface and the other represents mainly the propulsion unit sources. The tyre source is located 0.01 m above the road surface and the other, power unit source, is located either at 0.3 m for light vehicles or 0.75 m for large goods vehicles. 80% of the rolling noise is assumed to radiate from the lower source whereas 20% is assumed to radiate from the higher source. This allows for some “smearing” of the source which in practice rarely takes the form of a discrete point source.

Stone Mastic Asphalt (SMA) can be modelled within HARMONOISE using an adjustment to the maximum chipping size. These corrections only apply to light vehicles (category 1) as no correction is considered necessary for large goods vehicles (categories 2 and 3). The effects of a reduction in tyre noise on different surfaces was calculated by reducing the rolling noise source contribution while maintaining the propulsion noise levels. For modelling a rougher surface such as Hot Rolled Asphalt (HRA) the correction to rolling noise was based on an analysis of UK data developed within the EC project SILVIA (Silenda Via: Sustainable road surfaces for traffic noise control) (Morgan, 2006).

Using the HARMONOISE source model the pass-by noise energy in terms of the Sound Exposure Level dBA for Category 1, 2 and 3 vehicles were calculated. The receptor height was 1.2 m. Using a pass-by sample based on night-time flows of Category 1, 2 and 3
vehicles the average level over this period \((L_{\text{night}})\) was calculated using different proportions of light and large goods vehicles numbers according to the scenarios outlined above. In addition the effects of a very fine graded surface with a maximum stone size of 6 mm (SMA 6) was calculated to represent a low noise surface.

It was assumed for simplicity that the centre line of all passing vehicles were at a distance of 13.5 m from the receiver. This corresponds to a distance of 10m from the edge of the road. For each calculation the vehicle speeds were assumed to be the same for each vehicle category. The average speeds and proportions of vehicles were varied in order to calculate the effects of changing the number of goods vehicles.

13.2.2 Results from the calculations

The results of the calculations using both models are summarised in Table 13.5. It can be seen that the changes considered in each of the different scenarios provide only small benefits in noise reduction or %HSD. Assuming the same road surface condition, then the largest reduction in noise, 0.4 dB(A), is achieved either by restricting permitted traffic to passenger cars, transit vans and rigid goods vehicles, or by replacing transit vans and 2axle rigids with 5+axle articulated vehicles.

However, it can be seen that the road surface condition is estimated to provide a far greater influence. Using the TRL model, a poor condition surface increases noise levels by approximately 2.5 dB(A) in all cases and the %HSD by at least 2-2.5%; using the HARMONOISE model, the effect of changing from a smoother to a rougher surface (i.e. from SMA 6mm to HRA) increases the %HSD by between 2-3%.

Relative to the TRL model, the HARMONOISE model generally overestimates the benefits that can be derived from the different scenarios. However, it should be noted there is no direct comparison between the surface categories used in the two models.

It is noted that the changes for each scenario relative to the reference condition are approximately identical using the TRL model, regardless of the condition of the road surface. The HARMONOISE model shows differences of between 0.2-0.6% for the two extremes of surface.
Table 13.5: Predictions of %HSD for different road traffic flow and speed combinations
(Figures in brackets shown change relative to reference condition; negative value denotes a decrease in noise or a decrease in %HSD)

<table>
<thead>
<tr>
<th>Model scenario</th>
<th>Nightly traffic flow</th>
<th>TRL model</th>
<th>HARMONoise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total volume</td>
<td>Cars &amp; Vans</td>
<td>2 axle rigid</td>
</tr>
<tr>
<td></td>
<td></td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Reference condition</td>
<td>6931</td>
<td>90.82</td>
<td>6.90</td>
</tr>
<tr>
<td>Scenario SC1  (Remove 3+ axle vehicles)</td>
<td>6773</td>
<td>92.94</td>
<td>7.06</td>
</tr>
<tr>
<td>Scenario SC2  (Replace all 3+ axle vehicles with transit vans and 2axle rigid vehicles)</td>
<td>7320</td>
<td>89.55</td>
<td>10.45</td>
</tr>
<tr>
<td>Scenario SC3  (Replace 2axle rigids with transit vans)</td>
<td>10277</td>
<td>98.46</td>
<td>0</td>
</tr>
<tr>
<td>Scenario SC4  (Replace transit vans and 2axle rigids with 3axle rigids and 5axle articulated vehicles))</td>
<td>6078</td>
<td>92.74</td>
<td>0</td>
</tr>
<tr>
<td>Scenario SC5  (Replace transit vans and 2axle rigids with 5axle articulated vehicles)</td>
<td>5994</td>
<td>94.04</td>
<td>0</td>
</tr>
<tr>
<td>Scenario SC6  (Replace transit vans with 2axle rigid vehicles)</td>
<td>6356</td>
<td>88.69</td>
<td>8.83</td>
</tr>
</tbody>
</table>
**Table 18.5: Predictions of %HSD for different road traffic flow and speed combinations (continued...)**

(Figures in brackets shown change relative to reference condition; negative value denotes a decrease in noise or a decrease in %HSD)

<table>
<thead>
<tr>
<th>Model scenario</th>
<th>Nightly traffic flow</th>
<th>TRL model</th>
<th>HARMONoise</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total volume</td>
<td>Cars &amp; Vans</td>
<td>2 axle rigid</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td><strong>Reference condition</strong></td>
<td>6931</td>
<td>90.82</td>
<td>6.90</td>
</tr>
<tr>
<td><strong>Scenario SC7</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Impose speed reduction of 10km/h on all 3+ axle vehicles)</td>
<td>6931</td>
<td>90.82</td>
<td>6.90</td>
</tr>
<tr>
<td><strong>Scenario SC8</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Replace 50% of 3+ axle vehicles with equivalent capacity vehicles which are 3 dB L&lt;sub&gt;max&lt;/sub&gt; quieter)</td>
<td>6931</td>
<td>90.82</td>
<td>6.90</td>
</tr>
<tr>
<td><strong>Scenario SC9</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Replace 50% of 3+ axle vehicles with equivalent capacity vehicles which are 3 dB L&lt;sub&gt;max&lt;/sub&gt; quieter and replace remaining 50% of 3+ axle vehicles with equivalent capacity vehicles which are 6 dB L&lt;sub&gt;max&lt;/sub&gt; quieter)</td>
<td>6931</td>
<td>90.82</td>
<td>6.90</td>
</tr>
</tbody>
</table>
These results indicate that using $L_{night}$ as an indicator of annoyance is not the most effective approach, when the percentage of large goods vehicles is small in relation to the total flow. For example, assuming a reduced overall flow but an increase in the percentage of goods vehicles with three or more axles, e.g. a flow of 4000 vehicles and a composition of 83% light vehicles, 7% 2-axle rigid vehicles, and 10% large goods vehicles with three or more axles, then restricting the permitted traffic to only light vehicles and 2-axle rigids reduces the $L_{night}$ level by 1.6 dB(A), a level which would be more detectable for residents than the 0.4 dB(A) reduction using the same restriction on the traffic composition in Table 15.5.

In situations where the percentage of large goods vehicles is low, it is more likely to be the passage of individual “noisy” vehicles which is likely to be the main source of annoyance. It is not possible to take this into account within the modelling. However, ensuring that all permitted large goods vehicles pass the in-service noise test, described in Phase 2, would help to tackle this problem.
14 Requirements for detailed application of the calculation procedure

The basic calculation procedure described in the previous chapter could, with the provision of appropriate data, be used as the basis for a route assessment tool. This tool, based on population disturbance due to night-time road traffic, could be applied to assist in the issuing of LLCS permits and the choice of appropriate, associated routes for those permits.

The resultant numerical output from such a tool could be used to generate a simple form of sleep disturbance map that would assess the areas of the population that were likely to be highly disturbed at night across the ERN. This information could then be used to assist in identifying routes which cause significant disturbance and therefore should be targeted for remedial action.

This chapter describes the potential format of the disturbance maps and identifies the information which would be required as input to the noise-based route assessment tool.

14.1 The principle of a sleep disturbance map based noise prediction

Equations (16.4) and (16.5) allow noise disturbance along a section of road to be expressed in terms of the percentage of people highly sleep disturbed (%HSD). However, while this is useful information, it is considered that far greater benefit would be gained from expressing the disturbance in terms of the number of people highly sleep disturbed. This could be achieved by relating %HSD values to the numbers of residential properties located along the main road network and by making reasonable assumptions on occupancy.

This information could be presented in a format similar to that shown in Figure 14.1, which shows an estimate of the number of people highly sleep disturbed in properties adjacent to road sections on a small part of the London network. The noise level data used to derive this example disturbance map are based on $L_{night}$ values calculated as part of the London Road Traffic Noise mapping (LRTNM) exercise\(^\text{10}\) (www.londonnoisemap.com) since the necessary traffic flows and compositions were unavailable. The sleep disturbance map only estimates disturbance values for the occupants of buildings located adjacent to the road sections. In the Figure, the number of people disturbed is shown on a colour-graded scale, with each road segment being coloured according to the level of disturbance. It would, of course, be possible to extend the model to include all residences within a given area provided the input values of traffic flow and compositions etc were available.

In its simplest form, as shown in the Figure, each section of road on the network between major junctions, is treated as an “isolated” section, and the %HSD calculated and plotted accordingly on the map. In the longer term, the effects of disturbance due to multiple roads at junctions could also be mapped.

As permits are issued to allow operations off of the ERN, thereby increasing the number of large goods vehicles operating on any given route, the sleep disturbance map could then be recalculated to examine the effects of these increases. This, in turn would allow alternative routing scenarios to be developed with the aim of controlling/reducing night-time sleep disturbance.

14.2 Information required to generate sleep disturbance maps

It is considered that the basis for generating the sleep disturbance maps would be a GIS package which would allow different map layers to be overlaid, thereby allowing all necessary information about a particular road section to be easily collated. This section

\(^{10}\) This exercise has been carried out to meet the requirements of the EU Environmental Noise Directive (European Commission, 2002)
provides details of the “background” information layers that will be needed for the generation of the noise map based on the equations presented in Section 13.1.

![Image of a sleep disturbance map showing the number of people estimated to be highly sleep disturbed along routes on part of the London road network.](image)

**Figure 14.1: Sleep disturbance map showing the number of people estimated to be highly sleep disturbed along routes on part of the London road network.**

(Solid lines denote those routes off the ERN, i.e. those for which a permit is required; dotted lines denote routes open to all goods vehicles at all times)

- **Details of the road network forming the ERN**

  London Councils will already have details of this network, since it is available on published maps. It is considered that, if not already available, it would be beneficial for this network to be described in terms of links, for example as previously used in the LAEI (London Atmospheric Emissions Inventory), where each link is identified by a code number with the start and end points being defined as the intersections with major junctions. In this way any route assigned to a permit could be described, for mapping purposes, in terms of the component road links.

- **Details of the road surface type and condition**

  This map layer could be derived based on UKPMS (UK pavement management system) data which will provide not only the road surface type but also information on the condition of the road surface in terms of SCI (Structural Condition Index). TfL uses four grading bands of SCI (Good condition, SCI = 0-29; Minor defects serviceable, SCI = 30-49; Significant defects, SCI = 50-69; Poor condition, SCI = 70+). Utility covers and drainage grates are not included in UKPMS condition surveys.
It is known that this data already exists for the TLRN (Transport for London Road Network), however it is not known whether this data exists for the whole of the ERN or for all of those roads within the ERN that are likely to be used for routing purposes.

- **Details of the existing traffic flows and compositions along each link**
  This would allow a reference map to be determined based on current traffic conditions. Hourly traffic data collected for the TLRN has previously only been for the period 07:00-19:00 (Morgan, 2003), for eleven vehicle categories, with hours outside that period being calculated based on known expansion factors. If physical traffic counts are not available, it is recommended that a limited number of manual counts be undertaken to confirm the accuracy of the expansion factors.

- **Details of the distance between the kerb and the façade of first row properties**
  To provide reasonably accurate estimates of disturbance, the average kerb-façade separation along each road link will be required. In cases where the differences between the minimum and maximum kerb-façade separations are large, the link might require to be treated as several smaller links. This information could potentially be determined from GIS data used to generate the London Noise Map.

- **Details of population density**
  Expressing the impact of individual links in terms of %HSD is of limited use. For the maps to be most effective, this information needs to be related to the population density along each link, which could be determined from census information. As already noted, in their present form the equations only take into account the first row of properties adjacent to the road.

### 14.3 Information required to generate increased accuracy disturbance maps

At the present time, the speed level functions for each vehicle category (see Section 13.2) have only been described in terms of a single “good” or “poor” condition surface. If additional information were collected, speed level functions could be defined for the different road surface types found on the network as well as “good” and “poor” condition examples of those individual surface types.

More realistically, Equations (16.4) and (16.5) would require to be modified so that in the vicinity of road junctions, the calculated noise levels would take into account the noise contributions from each road forming the junction. In such circumstances, it may be simpler to calculate noise levels for individual residential properties rather than for short road links.

As quieter vehicles or new axle combinations are introduced, it will be necessary to determine additional speed-level functions. This will require the determination of $L_{Amax}$ values at 7.5 m in accordance with ISO 11819-1.

Whilst the equations in the previous section predict the number of people suffering sleep disturbance due to overall noise levels over the night-time period, they do not take into account disturbance or annoyance from individual vehicles or groups of vehicles. This is a factor which needs to be taken into consideration during route designation, particularly if looking to replace a large vehicle with several smaller vehicles of the same overall capacity or vice versa if the noise levels from the combinations are similar or one option is quieter. The effects on perception of vehicle substitution are discussed in Section D.4 of Appendix D.
14.4 Factors for consideration in designating routes

Once the initial “reference-scenario” maps have been determined, most likely based on current traffic flows and vehicle types, this will identify a hierarchy of routes where sleep disturbance is most significant and allow the prioritising of action plans in identifying alternative routes where impacts are greatest. It is noted that for the greatest benefits in the prioritising of action plans using this type of tool, consideration on linking the noise/disturbance data with emissions data would also be necessary.

Clearly, due to the different types of permits issued and delivery/transport logistics, not all vehicles with permits for a particular route will be in operation at the same time. Therefore, based on the number of issued permits for a given route, an estimate of the number of vehicles operating at any one time will require to be made to identify the maximum number of permits that can apply to a particular road link.

The use of a commercial routing package would potentially allow alternative routes to be proposed based firstly on vehicle type, fuel consumption, etc. Once these routes have been established, revised flow volumes and compositions could be fed into the noise prediction model to generate an updated sleep disturbance map.

A detailed study of commercial routing software would be necessary to take this idea beyond a concept phase. This would identify whether a direct linkage between the noise prediction model and the routing tool can be achieved or how the transfer of data between packages can best be undertaken. A validation of the model results and the corresponding accuracy of the sleep disturbance maps would also be required before such a process could be expanded beyond a preliminary demonstration.
15 Summary, conclusions and recommendations

This report has examined a broad range of issues associated with the noise impacts from LGVs travelling within the London Lorry Control Scheme (LLCS). This scheme was originally set up in 1986 primarily as a means of reducing inappropriate cross-London night time and weekend LGV movements and thereby helping to reduce the disturbance to residential areas during these periods. The scheme is administered by London Councils (formerly the Association of London Government).

The work described in this report has focussed on establishing whether amendments could be made to the LLCS and permit conditions given that the scheme has been in operation for 20 years. In particular, it was known (TfL 2006c) that the LLCS affects a steadily decreasing proportion of night time deliveries in London, because of the increasing proportion of deliveries that are being made by goods vehicles under 18 tonnes, which are currently exempt from the restrictions imposed by the LLCS. It was also felt that the changes that have occurred to vehicle technology could now make it possible to reduce the noise from vehicles, which would in turn provide opportunities, via the LLCS, to give incentives to operators to employ these technologies. Other factors that needed to be considered were the overall cost impact on hauliers associated with the restrictions imposed by the LLCS and the effects of introducing congestion charging and the proposed Low Emission Zones.

These and other issues were examined in some detail in Phase 1 of the work.

Following the completion of Phase 1, it was decided to extend the work into two further phases. Phase 2 would examine the possibility of improving the system of identification and certification of vehicles allowed on the network whilst at the same time encouraging the use of new vehicle technologies rather than considering major modifications to the ERN itself. A consequence of this approach was to examine, as part of the certification process, the feasibility and cost effectiveness of introducing an in-service noise test for vehicles. Phase 3 of the work was commissioned to allow consideration of the feasibility of developing an upgraded electronic traffic noise map of London that could be used to examine the benefits, particularly to sleep disturbance, of different vehicle noise control options.

The overall conclusions and recommendations that can be made from the work carried out in the three phases of study are summarised below:

**PHASE 1 Summary and Conclusions:**

1. The particular strengths of the LLCS are that, at night, it eliminates the movement of LGVs that have no business in London and controls the routing of LGVs that do have reason to be in London. Some 56,000 vehicle permits are issued per year to hauliers. Overall the cost of operating the system amounts to approx £0.5m per year, excluding appeals and debt registration.

2. It was felt that while the LLCS remains effective after 20 years of operation many aspects of travel in London have changed indicating that a review of the scheme is needed. In particular, the study found that there are issues that need consideration relating to changes in vehicle technology and the use of alternatively fuelled vehicles (e.g. CNG, LPG, fuel cell) and improvements in enforcement, involving the identification of suitably quiet vehicles and the automatic monitoring of vehicle movements. The scheme also potentially needs updating in response to the desire of residents for higher environmental standards and the needs of businesses who wish to extend their operating hours in response to the need to operate in the global economy.

3. It was concluded that while there appeared to be no compelling reasons why the LLCS should not be changed it was clear that any changes should be assessed taking full account of benefits and costs, bearing in mind that future changes should
be demonstratably more effective than at present, and should be relatively easily enforceable. More information was needed on the costs to hauliers associated with increases in delivery times and vehicle running costs. Moreover, any changes should be responsive to other traffic control measures being introduced in London as well as being consistent with measures such as congestion charging and the establishment of Low Emission Zone controls.

4. An examination of the developments of vehicle based technologies focussed mainly on alternatively fuelled vehicles. It was found that there was not sufficient evidence at present to support the contention that goods vehicles running on LPG and CNG fuels are inherently quieter than equivalent diesel or petrol powered vehicles. It was also found that the numbers of these vehicles are in decline with little likelihood of a reverse occurring in the near future. Vehicles running on electrical power are inherently quieter as combustion noise is eliminated and could increase in numbers particularly if recharging centres begin to appear in the network. Vehicles running on hydrogen and fuel cells are presently very expensive and unlikely to make a serious impact in fleet numbers in the short term unless large subsidies or other incentives are available.

5. Possible measures to enhance/improve the current LLCS were considered as part of phase 1. It was recognised at the outset that the permit system is a powerful feature of the LLCS and should be retained in future revisions although the qualifying conditions could be changed and extended. For example permit conditions could be extended to include new vehicle technologies and noise from ancillary equipment such as refrigeration unit compressors. Lower noise tyres are currently available and could be included as a requirement to be fitted to vehicles operating on the LLCS. Other measures considered included re-surfacing roads where the tyre noise component of vehicle noise is currently high. Improved enforcement by increasing the numbers of enforcement officers and/or by closer liaison with the police and other traffic agencies, and the inclusion of vehicles below 18 tonnes.

6. As part of examining how to improve the method of granting permits to vehicles, the pro’s and con’s of using a vehicle noise test were considered. The obvious advantages of a suitable test would be to ensure, objectively, that all vehicles granted permits to operate off the ERN had achieved an acceptable degree of noise emission. The main disadvantages were in identifying a suitable test that could be carried out inexpensively at a range of locations. There would also be costs involved in administering and carrying out the tests.

7. Having considered the issues raised by the review carried out in Phase 1 and the options for change identified, it was decided that in Phase 2 it would be appropriate to target the measures that focus most directly on improvements to noise control rather than methods that may invoke other changes, for example, methods involving modifications to the network itself or the use of technologies that could also impinge on safety. In addition measures that would be the subject of national policy changes such as legislation to introduce low noise tyres, smart card licence detectors and new laws on vehicle emissions were also not included in Phase 2.

**PHASE 2 Summary and Conclusions:**

It was decided that phase 2 would concentrate on examining the feasibility of establishing an in-service noise test which could, if successful, form part of a future permit system for LGVs operating on the LLCS. Phase 2 of the work also included a literature review covering vehicle noise monitoring procedures and in-service noise control methods best practice. It also included measurements aimed supporting the development of an in-service noise test
suitable for the LLCS permit system and an examination of noise monitoring of night-time LGV noise. The following main conclusions can be drawn from the studies carried out:

1. A review of existing in-service vehicle noise test procedures revealed that most roadside methods that are actually applied by enforcement authorities are confined to measurements of the vehicles exhaust system. Most commonly these measurements are carried out on motorcycles where it is used to identify malfunctioning or modified silencer systems.

2. In-service methods based on establishing whole vehicle noise have been developed as part of research studies. This research has attempted to provide a more comprehensive measure of in-service vehicle noise that includes noise sources associated with the power unit as well as the exhaust silencer equipment. These studies have also examined the limitations that might be imposed on achieving reproducible results in a variety of testing locations and environmental conditions. To a large extent the issues of achieving both repeatable and reproducible results from in-service testing have now been largely overcome.

3. With regard to the review of best practice associated with mitigating lorry noise, it was found that these can be considered to relate almost exclusively to the placing of restrictions upon the operation of LGVs on the main road network. There are, for example, currently driving restrictions of some form in place in many European countries. These generally restrict the movement of goods vehicles on weekends and public holidays although a few cases were found related to night-time movement of goods.

4. A programme of roadside noise measurements was carried out on a sample of roads in London. The broad objective was to identify and quantify the noise from vehicles operating on different areas of the network. Specifically, the work was intended to establish the noise range for specific vehicle categories and road type, to identify any “typical” noises from these vehicles that are audible above the general traffic noise, e.g. body rattle, air brake noise, container boom, brake squeal, etc. and to provide an indication of the fleet composition. The intention was to use the information gained to inform a short measurement programme designed to help develop an in-service noise test. The method employed the ISO standard Statistical Pass-by method. This method identifies the noise and speed relationships for individual vehicle categories and can be used to categorise vehicles into distinct acoustic categories and to evaluate the influence of the road surface on both vehicle and traffic noise.

5. The measurement sites were selected to cover roads where the speed limit was both above and below 30 mile/h. Attempts were made to include roads where the surface was in a good and poor condition and to include surfaces with low noise characteristics. In total, roadside noise measurements were taken at 6 different locations.

6. Analysis of the roadside measurements showed that the relationship between individual vehicle pass by noise and speed was better described using the $L_{A\text{max}}$ indicator than measurements taken using the SEL.

7. After separating the data according to road condition (roads classified as in poor condition were identified as surfaces with irregularities such as rutting, bumps or hollows) it was found that for both good and poor road conditions, the vehicles could be categorised into three acoustically distinct groups. These were (i) Cars, car based vans and transits with single tyres on the rear axle; (ii) 2-axle rigids with twin tyres on the rear axle; (iii) Rigid or articulated vehicles with 3 or more axles.

8. By examining the relationship between the maximum pass-by noise level and the speed for vehicles which did not have any noticeable noise characteristics, it was shown that noise levels over the speed range 40 to 80 km/h were about 2 to 3 dB(A)
higher on roads classified as in poor condition compared with roads in good condition. This difference was consistent across all vehicle categories.

9. A number of vehicles within the vehicle group with 3 or more axles were noted with identifiable noise characteristics that could be related to either exhaust noise, body noise e.g. rattles and suspension noise and container ‘boom’ noise, and brake squeal. A frequency analysis showed that although there were significant differences at certain frequencies in the spectra that were associated with these noise sources, these differences did not appear to influence the overall A-weighted levels. This is because these sources affect the noise in the low and high frequency ranges which are significantly attenuated by the A-weighting process.

Since these types of noise can cause disturbance and annoyance, and are unlikely to be picked up by conventional measurement methods, it is important to consider ways of ensuring that vehicles that are permitted to operate off the ERN are checked for these noise sources. This would involve ensuring that vehicles are properly maintained and that issues such as body noise are dealt with through the guidance given in the body noise best practice manual (Department for Environment, Transport and the Regions, 2000). Maintaining roads to a good standard will also help to reduce noise impact particularly from body and suspension noise sources.

10. A series of vehicle noise tests were carried out on the TRL test track facility. The measurements were intended to inform the development of an in-service test for use in the LLCS. The 4 vehicles identified for use in the test track study were selected based on the analysis of the results from the roadside noise measurements. The tests included the current type approval method as well as a range of candidate in-service test methods. These methods involved both dynamic (moving vehicle) as well as tests with the vehicle stationary.

11. The results of this study, when combined with the results from previous work, identified two possible candidate test procedures – a test involving the rapid acceleration of the engine of the test vehicle with the vehicle stationary and a test with the vehicle accelerating from rest. In order to determine which of the two methods offered the best outcome when used as part of the LLCS the two methods were assessed against a range of criteria. These included issues related to the test itself, e.g. is the test simple to carry out, does it give repeatable and reproducible results and does it discriminate fairly between noisier and quieter vehicles. In addition, other issues were considered that relate to the logistics of testing e.g. test site locations, and the influence of emerging vehicle technologies which could affect the future feasibility of a particular test option. Requirements on body noise and conformity to air brake noise limits are given below in the Recommendations section.

12. It was found that the stationary test gave a high degree of repeatability and reproducibility and it was found to be good at discriminating between noisy and quieter vehicles. The acceleration test also gave a reasonable degree of repeatability and reproducibility although the overall results are more variable than those for the stationary test. Nevertheless, with provisos regarding the choice of gear and maximum speed achieved during the test, the ability of the method to discriminate between noisy and quieter vehicles is found to be acceptable. The mode of operation of the acceleration test is, however, rather more difficult to control than the stationary test. The results can be affected not only by the choice of gear but also by the degree of acceleration imposed by the driver. This would be difficult to determine during testing unless suitable instrumentation were used to map acceleration rates and engine speeds.

13. The candidate test methods were also examined in relation to their ability to control and reduce sleep disturbance on the network. Unfortunately it was not possible to determine, with statistical confidence, how the test levels for each method relate to
the noise produced by other modes of vehicle operation. A larger sample of vehicles
would be needed to establish the statistical significance of these findings. On a more
practical level, it is concluded that since both test conditions tend to expose the
greatest noise from the vehicle being tested, they both should offer a degree of
control of the noisiest operations in real driving, i.e. driving operations that tend
to give rise to sleep disturbance.

14. This report looked at practical aspects of an in-service test, henceforth the ‘London
in-service noise test’. The main conclusions were that the test should be voluntary,
and for vehicles over 18 tonnes. If a vehicle passed the London in-service noise test,
it would be awarded a ‘Reduced Noise Certificate’ that would be valid for one year.
The Reduced Noise certificate would entitle the vehicle to operate anywhere in
London without the need for a permit.

15. The report considered a scenario where the noise limits in the London in-service
noise test were set at a point where a vehicle that just passed the test would produce
50% less noise disbenefits than the mean for all new vehicles above 18 tonnes. Such
a limit would lead to a reduction in the value of noise damage and congestion, over 5
years of vehicle operation, of between £58,000 and £89,625 per vehicle, depending
on the number of currently “controlled hours” that were opened up to operators. This
benefit would accrue to all in society. The costs for operators would fall by around
between £4,950 and £9,450 respectively. This mainly represents the increase in
productivity per vehicle passing the test (based on the assumption that passing the
noise test entitles the vehicle to operate throughout London during some of the
current “controlled hours”). However, the cost figure also takes account of the cost
of taking the test annually and the extra cost of obtaining vehicles that can pass the
test.

PHASE 3, Summary and Conclusions:

Phase 3 of the study considered the feasibility of developing a noise calculation model which
would allow the noise benefits from quieter vehicles to be accounted for on the network as
well as providing opportunities to investigate a broad range of other noise control strategies.
It was anticipated that the model would differ from existing noise prediction models by
allowing the determination of disturbance to residential communities. The model would be
based on inputs related to the numbers of vehicles in different categories operating on the
network, road to building distances and the population densities of affected residential areas.
The following summarises the main conclusions of this phase of the work:

1. Consideration was given to whether the noise calculation model (CRTN), used to
determine the London Noise Map, could be suitably adapted for this application. It
was concluded that since CRTN was not designed to take account the influence of
different goods vehicle categories or to allow any changes to the individual noise
levels of different vehicles it would not be suitable. It was suggested that it may be
possible to manipulate the inputs to the CRTN model to reproduce the noise levels
for flows comprising different large goods vehicle categories but this would require
additional research and would still only produce a model that was adapted to suit a
purpose which was fundamentally alien to the original formulation of the model. An
alternative approach for determining the noise levels was therefore preferred.

2. The formulation of the model took, as a starting point, the information relating $L_{A_{max}}$
noise levels to the speed of vehicles of different categories operating on the network.
These level-speed functions had been measured on a selected sample of roads on
the LLCS network as part of phase 2. Three categories of vehicles were considered
at this stage and were the same as those established from the work undertaken for
phase 2. Using values of night time traffic flows and composition, the functions were
then used to determine values of SEL which were then used to determine the percentage of the population that would be 'Highly Sleep disturbed (%HSD). Using this approach a model formulation was developed that could be used to relate traffic flows, comprising any specified number of vehicle categories each with their own noise level and speed characteristic, to a measure of overall sleep disturbance in nearby residences.

3. In order to examine how the model can be applied in practice, several example calculations have been made with different traffic flows and compositions. Scenarios examining the effects on noise levels of reducing the maximum size of vehicles permitted to operate on the road from 23:00-07:00 were examined as part of this exercise. This included substituting larger vehicles with an equivalent number of smaller vehicles with the same overall payload and scenarios examining the potential noise reductions due to using quieter large goods vehicles or imposing speed restrictions.

4. The results of the calculations demonstrated the both the feasibility and range of application of the calculation procedure and showed that small overall noise benefits and hence reduction in %HSD were achievable using the different scenarios examined. Assuming the same road surface condition, the largest reduction in noise obtained for this particular example, 0.4 dB(A), (and the corresponding 0.4% reduction in %HSD) is achieved either by restricting permitted traffic to passenger cars, transit vans and rigid goods vehicles, or by replacing transit vans and 2-axle rigids with 5+axle articulated vehicles. Such a small reduction is unlikely to be able to be perceived by the public. Greater benefits could be achieved on some roads by improving the surface condition. A poor condition surface was shown to increase noise levels by 2 dB(A) in all cases and the %HSD by at least 2%. It was noted however, that in situations where the percentage of large goods vehicles is low, it is more likely to be the passage of individual “noisy” vehicles which is likely to be the main source of annoyance. It is not possible to take this into account within the modelling. However, ensuring that all permitted large goods vehicles pass the in-service noise test, recommended in Phase 2, would help to tackle this problem.

5. Overall it is concluded that the basic noise calculation procedure could, with the provision of appropriate data, be used as the basis for a route assessment tool, although for the greatest benefits it would need to be linked also to vehicle emission. This tool, based on population disturbance due to night-time road traffic, could be applied to assist in the issuing of LLCS permits and the choice of appropriate routes for those permits. The output from the model could be used to generate a simple form of sleep disturbance map that would identify residential areas where residents could be affected by sleep disturbance. This information could then be used to target remedial action.

**Recommendations:**

The main recommendations that follow from this study are as follows:

1. A voluntary noise test, henceforth the 'London in-service noise test' should be introduced for vehicles above 18 tonnes operating in London. Consideration should be given to a test with the following features:
• A ‘Stationary’ test of vehicle noise, including idle condition
• A ‘Pull away from rest’ test of vehicle noise
• A check that vehicles comply with:
  (iii) The current EU Directive limit value for airbrake noise; and
  (iv) The government’s best practice guide on body noise
    (Department for Environment, Transport and the Regions, 2000).

This test would provide improved discrimination between noisy and quieter vehicles, and would encourage the more rapid introduction of new technologies that offer reduced noise emissions.

2. Vehicles that pass the test should be awarded a ‘Reduced Noise Certificate’, which would be valid for one year. The Reduced Noise Certificate would allow the vehicle to be used in London during some of the current “controlled hours” in addition to the current uncontrolled hours (0700-2100).

3. Any vehicle that had held a permit to operate off the Exempt Road Network prior to the introduction to the test could be given a permit, exactly as before. However, any vehicle that had never held a permit prior to the introduction of the test would be required to obtain a Reduced Noise Certificate, before a permit could be granted.

4. As a next step, the test method would need to be applied to around 60-70 vehicles. This would allow a final decision on the method, and establish noise limits for each component of the test. These 60-70 vehicles would need to span the range of vehicle types and sizes that are on sale above 18 tonnes. Vehicles should also only be included if they meet the requirements of the Low Emissions Zone.

5. Further work should be undertaken to develop the concept of a noise-based sleep disturbance map into a full modelling tool. This tool could be used alongside a route assignment model, to provide information on noise mitigation strategies. Such a model would be useful in controlling night time noise impacts from vehicles travelling off the Exempt Road Network, particularly in identifying hotspots, and in optimising traffic management options.

6. After implementation of the Low Emission Zone, consideration should be given to introducing a noise test for goods vehicles in the 3.5-18 tonne range. This would extend the benefits of the London in-service noise test to a much larger pool of vehicles, many of which are used during the controlled hours.
Acknowledgements

The work described in this report was carried out in the Infrastructure and Environment Division of TRL Limited. The authors are grateful to Dr Paul Nelson who carried out the quality review and auditing of this report.

References


Appendix A. Summary of goods transport driving restrictions in European Countries (excluding the UK)

The details given below in connection with public holiday dates and driving restrictions for heavy goods vehicles throughout Europe summarise the main general provisions as listed on the website of FEDEMAC (the Federation of European Movers Associations, www.fedemac.com/informartioncenter.php). There are a number of other local & regional holidays and restrictions as well as derogations in certain instances. More detail can be obtained from the FEDEMAC website and through the national road freight association for each individual country.

There also exist a number of city-based schemes. However, it is not appropriate to detail these here as they are subject to change.

A.1 Austria

General Restrictions

| Vehicles concerned | - Trucks with trailers, if the maximum permitted weight (MPW) of the motor vehicle or the trailer > 3.5t  
|                    | - Trucks, articulated vehicles and self-propelled industrial machines with an authorised total weight of > 7.5t. |

| Area               | Nationwide, with the exception of journeys made exclusively as part of a combined transport operation within a radius of 65km of specified trans-loading stations (see http://www.fedemac.com/_pdf_informationcenter/Austria-2006.pdf for further details) |

| Prohibitions       | - Saturdays from 15:00 – 24:00  
|                    | - Sundays and public holidays from 00:00 – 22:00 |

| Exemptions         | - The prohibition concerning trucks with trailers exceeding 3.5t is not applicable to vehicles transporting milk  
|                    | - The prohibition concerning vehicles with an authorised total weight of more than 7.5t is not applicable to  
|                    |   - the transport of meat or livestock for slaughter (but not the transport of heavy livestock on motorways), perishable foodstuffs or the supply of refreshments to tourist areas  
|                    |   - urgent repairs to refrigeration plant,  
|                    |   - towing services, breakdown assistance vehicles and emergency vehicles  
|                    |   - vehicles of a scheduled transport company (regular lines)  
|                    |   - local trips on the two Saturdays preceding 23 December |

Local Restrictions

Special local restrictions apply on specified local roads in Carinthia, Lower Austria, Vorarlberg, Upper Austria and Salzburg.
### General Night-time Restrictions

<table>
<thead>
<tr>
<th><strong>Vehicles concerned</strong></th>
<th>Large goods vehicles with an MPW &gt; 7.5t</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area</strong></td>
<td>Nationwide</td>
</tr>
<tr>
<td><strong>Prohibitions</strong></td>
<td>22:00 – 05:00</td>
</tr>
</tbody>
</table>
| **Exemptions**         | Vehicles belonging to the highway maintenance service  
                        | Vehicles belonging to the Federal Army, and which are essential for the pursuit of military operations  
                        | Low-noise vehicles showing the green ‘L’ plate – these are limited to a maximum speed of 60km/h, although a speed of 80km/h may be authorised on certain sections. |

**Applications for exemption from general night-time restrictions:**

Derogations to driving restrictions will be authorised only for journeys which serve exclusively for the transport of milk, fresh meat and livestock, perishable foodstuffs, newspapers and periodicals, essential repairs to refrigeration plant or the operation of road maintenance vehicles to enable traffic flow to be maintained in all other cases an exceptional authorisation shall be granted only if there is a substantial public interest in doing so. The applicant shall prove in both instances that the journey cannot be avoided by organisational measures or by choosing a different means of transport.

For details on special local night-time traffic bans and winter driving restrictions, see [http://www.fedemac.com/_pdf_informationcenter/Austria-2006.pdf](http://www.fedemac.com/_pdf_informationcenter/Austria-2006.pdf).

### A.2 Bulgaria


### A.3 Croatia

#### Local Restrictions

| **Vehicles concerned** | Lorries and combined vehicles with an MPW > 7.5t  
                        | Lorries and combined vehicles which exceed 14m in length;  
                        | Tractors  
                        | Horse-drawn vehicles  
                        | Working machines and all other vehicles which cannot exceed a speed of 40 km/h on a straight road;  
                        | Vehicles being used for driving lessons |
|------------------------|---------------------------------------------------|
| **Area**               | On specified State Roads and Local Roads (For further details see [http://www.fedemac.com/_pdf_informationcenter/Croatia-2006.pdf](http://www.fedemac.com/_pdf_informationcenter/Croatia-2006.pdf)) |
| **Prohibitions**       | From 12 June to 19 September  
                        | o on Saturdays from 04:00 – 14:00;  
                        | o on Sundays from 12:00 – 23:00  
                        | o on Good Friday and on the eve of a public or religious holiday from 15:00 – 23:00 |

If a public holiday, or the last day of a series of public holidays falls on a Friday or Saturday, the prohibition is effective on the Sunday from 12:00 – 23:00. If a public holiday falls on a Sunday or Monday, the prohibition is effective on the preceding Friday from 15:00 – 23:00.
### Local Restrictions continued...

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>• Lorries and combined vehicles with an MPW &gt; 7.5t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>State Road 2 between Varazdin and Dubrava Krizovljanska</td>
</tr>
<tr>
<td>Prohibitions</td>
<td>• Sundays from 06:00 – 22:00</td>
</tr>
</tbody>
</table>

### Exemptions

| • Vehicles of the Ministry of the Interior and of the armed forces; |
| • Vehicles for maintenance of roads, electrical and similar installations, as well as vehicles for the distribution of mail and the press; |
| • Vehicles belonging to radio or TV broadcasting companies; |
| • Vehicles used for the transport of drinking water; vehicles transporting material or equipment for use in case of emergency; |
| • Vehicles of over 14m in length and articulated vehicles transporting |
| • concrete, asphalt or fuel for motor vehicles |
| • perishables such as fresh meat, fresh meat products, fresh milk and dairy products, fresh fish and fish products, perishable fruit and vegetables |
| • livestock or poultry, except on the State Road 2 between Varazdin and Dubrava Krizovljanska where they must comply with the traffic restrictions imposed under Article III of the driving restrictions |
| • Vehicles with an authorisation. |

### A.4 Czech Republic

#### General Restrictions

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>• Goods vehicles with an MPW &gt; 7.5t</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Combination vehicles with an MPW &gt; 3.5t</td>
<td></td>
</tr>
</tbody>
</table>

### Area

| On motorways and trunk roads (1st class roads) |

### Prohibitions

| • On Sundays and public holidays from 00:00 – 22:00; |
| • On Saturdays between 1 July and 31 August, from 07:00 – 20:00 |

### Vehicles concerned

| • Special motor vehicles and carts whose overall width exceeds 0.60 m |

### Area

| On trunk roads (1st class roads) outside built-up areas |

### Prohibitions

| • From 15 April to 30 September on Fridays |
| • The eve of a public holiday from 15:00 – 21:00; |

### Exemptions

| • Vehicles engaged in combined transport operations, from the forwarder to the nearest loading point or from the nearest unloading point to the consignee; |
| • Vehicles used for seasonal agricultural transport |
| • Vehicles used in the construction and maintenance of roads |
| • Vehicles transporting perishable goods; |
| • Vehicles transporting livestock |
| • Vehicles transporting fuel for service stations; |
| • Vehicles used for the loading or unloading of aircraft, ships or trains up to a distance of 100km; |
| • Vehicles carrying postal cargo; |
| • Empty vehicles in connection with any of the transport operations mentioned in the preceding points; |
| • Vehicles needed in cases of natural disaster |
| • Vehicles belonging to the armed forces, police and fire brigade; |
| • Vehicles carrying chemical substances susceptible to temperature change or crystallisation; |
| • Vehicles used for driver training. |
A.4.1 Road user charging in the Czech Republic

The use of trunk roads and motorways by vehicles with at least four wheels or vehicles with trailers is subject to a user charge. Proof of payment is a 2-part coupon which can be bought at post offices, filling stations, border crossings and from motoring associations. The police is authorised to impose a fine of up to CZK 15000 on vehicles travelling without a valid coupon. The details given in the vehicle registration certificate are decisive in determining the total weight of the motor vehicle or the vehicle combination. The following table presents the charges (as of January 01 2005)

<table>
<thead>
<tr>
<th>Duration of permit</th>
<th>Weight of vehicle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Up to 3.5t</td>
</tr>
<tr>
<td>One day</td>
<td>---</td>
</tr>
<tr>
<td>15 days</td>
<td>200</td>
</tr>
<tr>
<td>2 months</td>
<td>300</td>
</tr>
<tr>
<td>One year</td>
<td>900</td>
</tr>
</tbody>
</table>

A.5 Denmark

There are no driving restrictions on goods traffic at weekends or on public holidays. There are, however, local driving restrictions in the centre of Copenhagen for goods vehicles with a maximum permitted weight > 18t.

A.6 France

Permanent Restrictions

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>Area</th>
<th>Prohibitions</th>
<th>Exceptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trucks and combination vehicles with an MPW &gt; 7.5t</td>
<td>Throughout the road and motorway network</td>
<td>From 22:00 on Saturdays and the eve of public holidays until 22:00 on Sundays and public holidays</td>
<td>Permanent derogations, which are not subject to special authorisation, are granted for the following transport operations:</td>
</tr>
</tbody>
</table>

- Trucks transporting, to the exclusion of all else, live animals or perishable goods or foodstuffs, provided that the quantity of goods constitutes at least half of the loading surface of the vehicle or half of the truck’s payload. Special circumstances apply to multiple deliveries.
- Vehicles engaged in the seasonal collection and transport of agricultural produce from the place of harvesting to the place of storage, processing or packaging, within an area made up of the region of origin and the neighbouring departments or of the region of origin and adjacent regions within 150 kilometres of the first collection point.
- Vehicles engaged in the seasonal transport of beet pulp from the processing plant to the place of storage or use. These vehicles may not use the motorway network.

Empty return is authorised under specified conditions.
Permanent Restrictions continued…

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>Trucks and combination vehicles with an MPW &gt; 7.5t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Throughout the road and motorway network</td>
</tr>
<tr>
<td>Prohibitions</td>
<td>From 22:00 on Saturdays and the eve of public holidays until 22:00 on Sundays and public holidays</td>
</tr>
</tbody>
</table>

Exceptions

Permanent derogations, which are not subject to special authorisation, are granted for the following transport operations:

- Vehicles whose load is indispensable for the installation of economic, sporting, cultural, educational or political events which have been duly authorised, on condition that the said event is to take place on the same day or, at the latest, on the day following the transport.
- Vehicles transporting newspapers and magazines only.
- Vehicles carrying out office or factory removals in an urban area.
- Vehicles specially equipped for the itinerant sale of the goods transported, within an area made up of the region of origin and the neighbouring departments or of the region of origin and adjacent regions within 150 kilometres of the first point of sale.
- Vehicles belonging to tradesmen and which are used for the sale of their produce at fairs or markets within an area made up of the region of origin and the neighbouring departments or of the region of origin and adjacent regions within 150 kilometres of the first point of sale.

Empty return is authorised under specified conditions

Application for exemption:
Short-term and long-term exemptions to these restrictions may be granted under exceptional circumstances.

Permanent Restrictions

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>All vehicles transporting dangerous goods, including tankers travelling empty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Throughout the road and motorway network</td>
</tr>
<tr>
<td>Prohibitions</td>
<td>From 12:00 on Saturdays and the eve of public holidays, until 24:00 on Sundays and public holidays</td>
</tr>
</tbody>
</table>

Exceptions

A general derogation is granted for deliveries of hydrocarbons and liquid gas for domestic use on Saturdays and the eve of public holidays from 12:00 – 20:00

A.7 Germany

**General Restrictions**

| Vehicles concerned | • Trucks with a total permissible weight of over 7.5t  
|                    | • Trucks with trailers  
| Area               | Throughout the road and motorway network  
| Prohibitions       | • Sundays and public holidays from 00:00 – 22:00  
| Vehicles concerned | • Trucks with a total permissible weight of over 7.5t  
|                    | • Trucks with trailers  
| Area               | Additional summer restrictions on certain stretches of motorway and trunk roads  
| Prohibitions       | • Saturdays between 1 July and 31 August from 07:00 to 20:00  
| Exceptions         | • Combined rail/road goods transport from the shipper to the nearest loading railway station or from the nearest designated unloading railway station to the consignee up to a distance of 200km (no limitation on distance during the additional summer restrictions); also combined sea/road goods transport between the place of loading or unloading and a port situated within a radius of 150km maximum (delivery or loading).  
|                    | • Deliveries of fresh milk and other dairy produce, fresh meat and its fresh derivatives, fresh fish, live fish and their fresh derivatives, perishable foodstuffs (fruit and vegetables).  
|                    | • Empty vehicles, in connection with the transport operations mentioned under the preceding item.  
|                    | • Transport operations using vehicles subject to the Federal Law on the obligations of service; the relevant authorisation must be carried on board and produced for inspection on request.  
|                    | • Also exempted from the prohibition are vehicles belonging to the police and federal border guard, fire brigades and emergency services, the federal armed services and allied troops. 

*Application for exemption:*  
For operations which are not covered by the above-mentioned exceptions, authorisations must be obtained. These, however, will be issued only in the event of an emergency, when delivery by other means of transport is not possible.

**Night driving restrictions**  
There exist a certain number of night driving restrictions on specific routes. These are indicated by road signs.

A.7.1 Road user charging in Germany  
The revised German Toll scheme (MAUT) was relaunched at the beginning of 2005. The scheme applies to all vehicles weighing more than 12 tonnes using the Autobahn routes.
A.8 Greece

General Restrictions

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>Goods vehicles with a payload of over 1.5t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>On specified motorways (see <a href="http://www.fedemac.com/_pdf_informationcenter/Greece-2006.pdf">http://www.fedemac.com/_pdf_informationcenter/Greece-2006.pdf</a> for further details)</td>
</tr>
<tr>
<td>Prohibitions</td>
<td>On 5 January, 6 January, 3 March, 20April, 21 April, 9 June, 11 August 2006 and every Friday throughout the year, from 15:00 – 21:00</td>
</tr>
<tr>
<td>Exceptions</td>
<td>Vehicles transporting fresh milk, fresh fish, fresh meat or livestock as well as vehicles carrying fresh fruit and vegetables from Corinth to Rio</td>
</tr>
</tbody>
</table>

A.9 Hungary

General Restrictions

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>Goods vehicles, agricultural tractors and their trailers of over 7.5t MPW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Throughout the road and motorway network</td>
</tr>
<tr>
<td>Prohibitions</td>
<td>From 15 June to 31 August:</td>
</tr>
<tr>
<td></td>
<td>o from Saturday 08:00 to Sunday 22:00;</td>
</tr>
<tr>
<td></td>
<td>o from 22:00 on the eve of a public holiday to 22:00 on the day of the holiday</td>
</tr>
<tr>
<td></td>
<td>From 1 September to 14 June:</td>
</tr>
<tr>
<td></td>
<td>o From 22:00 on the eve of Sundays and public holidays to 22:00 on Sundays and public holidays</td>
</tr>
<tr>
<td>Exceptions</td>
<td>Vehicles operated by the armed forces, police, national security services, prison authorities, fire brigade, civil defence, customs authorities, emergency vehicles;</td>
</tr>
<tr>
<td></td>
<td>In the case of combined transport if the road transport leg is less than 70km, vehicles travelling between the combined transport terminal and the place of loading or unloading, or between the combined transport terminal nearest to the border crossing point and the border crossing point;</td>
</tr>
<tr>
<td></td>
<td>Vehicles used for prevention or assistance in cases of disaster;</td>
</tr>
<tr>
<td></td>
<td>Vehicles used in cases of accident or breakdown;</td>
</tr>
<tr>
<td></td>
<td>Vehicles involved in community work (including town/village cleaning services, waste removal, public utilities repair services);</td>
</tr>
</tbody>
</table>
### General Restrictions continued...

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>Area</th>
<th>Prohibitions</th>
</tr>
</thead>
</table>
| • Goods vehicles, agricultural tractors and their trailers of over 7.5t MPW | Throughout the road and motorway network | • From 15 June to 31 August:  
  o from Saturday 08:00 to Sunday 22:00;  
  o from 22:00 on the eve of a public holiday to 22:00 on the day of the holiday | • From 1 September to 14 June:  
  o From 22:00 on the eve of Sundays and public holidays to 22:00 on Sundays and public holidays |

NB: There are no driving restrictions on international traffic from 4 November to 1 March

NB: when a public holiday precedes or follows a Saturday or Sunday within the periods specified above, the driving restrictions apply non-stop from 08:00 on the first day to 22:00 on the last day.

<table>
<thead>
<tr>
<th>Exceptions</th>
</tr>
</thead>
</table>
| • Vehicles used in the construction, maintenance, repair or cleaning of roads, railways and public utilities;  
• Vehicles used for the transport of harvested crops or fodder or for the relocation of agricultural machines or slow vehicles;  
• Vehicles transporting livestock, fresh milk, fresh dairy produce, fresh and deep-frozen meat and meat products, fresh bakery products or other perishable foodstuffs;  
• Vehicles travelling from the Hungarian border to the nearest parking area designated by the authorities for this purpose;  
• Empty vehicles travelling from the border to their premises in Hungary;  
• Vehicles used for the transport of equipment or animals necessary for cultural, business or sports events (including transport in connection with radio, television or cinema recordings);  
• Humanitarian consignments;  
• Passenger transport vehicles;  
• Vehicles involved in the transport to and from railway stations, river ports or airports (between the premises of the consignor/consignee and the nearest such station, port or airport) of goods arriving or forwarded during the period affected by the prohibition;  
• Vehicles delivering mixed concrete;  
• Postal services. |

### Application for exemptions:

As an exceptional measure, the Minister of Economy and Transport may grant exemptions to the above restrictions for a period not exceeding one calendar year.
### A.10 Luxemburg

<table>
<thead>
<tr>
<th>General Restrictions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicles concerned</strong></td>
</tr>
<tr>
<td><strong>Area</strong></td>
</tr>
<tr>
<td><strong>Prohibitions</strong></td>
</tr>
<tr>
<td><strong>Vehicles concerned</strong></td>
</tr>
<tr>
<td><strong>Area</strong></td>
</tr>
<tr>
<td><strong>Prohibitions</strong></td>
</tr>
<tr>
<td><strong>Exceptions</strong></td>
</tr>
</tbody>
</table>

- Vehicles transporting livestock, animal-based perishable goods irrespective of their state (fresh, frozen, deep-frozen or salted, smoked, dried or sterilised), fresh or untreated vegetable-based perishable goods (fruit and vegetables), cut flowers or potted plants and flowers;
- Empty vehicles making a trip in relation with the transport operations referred to above, on condition that the vehicles are heading for Germany;
- Vehicles which, during the harvest period, are engaged in the collection and transport of agricultural produce from its place of harvest to its place of storage, packing, processing or transformation;
- Vehicles carrying loads which are indispensable for the installation of duly authorised economic, sports, cultural, educational or political events;
- Vehicles carrying only newspapers;
- Vehicles carrying out office or factory removals;
- Vehicles belonging to tradesmen and which are used for the sale of their products at fairs or markets;
- Vehicles involved in a combined rail-road transport operation between the place of loading and the station of transfer, or between the station of transfer and the destination of the goods, on condition that the distance covered does not exceed 200km and that the transport takes place in the direction of Germany;
- Vehicles for emergency use by the police, army, customs, civil defence and fire brigade as well as those used to transport vehicles which have broken down or been involved in an accident;
- Vehicles being driven under cover of an exceptional authorisation from the Minister of Transport and which exceed the maximum statutory weight as specified above, in particular for transport operations intended to allow the non-stop operation of factories, to prevent any breakdown in supplies or to contribute to the execution of public services in response to immediate local needs; the Ministerial authorisation must be shown on demand to officers responsible for controlling road traffic. |

In addition to Luxemburg’s official public holidays, the above restrictions will be in force on 8 May, 14 July and 11 November for transport operations to France and on 14 April, 15 June, 3 October and 26 December for transport operations to Germany.

Permanent prohibitions for goods vehicles whose MPW exceeds 3.5t are also in place on specified route sections. See [http://www.fedemac.com/_pdf_informationcenter/Luxembourg-2006.pdf](http://www.fedemac.com/_pdf_informationcenter/Luxembourg-2006.pdf) for further details.
A.11 The Netherlands

There are no driving restrictions on goods vehicles at weekends or on public holidays. Information on restrictions during bad weather and restrictions on exceptional loads can be found at [http://www.fedemac.com/_pdf_informationcenter/Netherlands-2006.pdf](http://www.fedemac.com/_pdf_informationcenter/Netherlands-2006.pdf).

The Dutch PIEK scheme, a government sponsored initiative that supports projects aimed at tackling noise during the whole delivery process (see Appendix B) focuses primarily on the activities that take place when the delivery vehicle is either arriving at the location or during the actual delivery. Any restrictions imposed by the work of PIEK do not therefore fall within the scope of the guidelines issued by FEDEMAC.

A.12 Poland

### General Restrictions

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>Nationwide</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Area</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>From 07:00 – 22:00 on all public holidays</td>
<td></td>
</tr>
<tr>
<td>From 18:00 – 22:00 on the eve of specified public holidays (see <a href="http://www.fedemac.com/_pdf_informationcenter/Poland-2006.pdf">http://www.fedemac.com/_pdf_informationcenter/Poland-2006.pdf</a> for further details)</td>
<td></td>
</tr>
<tr>
<td>From the first Friday after the end of the school year (30 June 2006) to 31 August, except on 15 August:</td>
<td></td>
</tr>
<tr>
<td>o on Fridays from 18:00 – 22:00</td>
<td></td>
</tr>
<tr>
<td>o on Saturdays from 07:00 – 14:00</td>
<td></td>
</tr>
<tr>
<td>o on Sundays from 07:00 – 22:00</td>
<td></td>
</tr>
</tbody>
</table>

Exemptions:

- Vehicles belonging to the armed forces, police, fire brigade, emergency services, border guard authorities and other authorities specialised in chemical, radiological and contamination protection;
- Vehicles used in the construction or maintenance of roads and bridges;
- Technical service vehicles used in case of emergency;
- Vehicles used in rescue operations;
- Emergency vehicles used in cases of natural disaster;
- Vehicles carrying perishable goods or foodstuffs;
- Vehicles carrying livestock;
- Vehicles used for the collection of fresh milk, corn or livestock;
- Vehicles transporting liquid fuel, oil products, lubricants, spare parts or fresh water for ships;
- Slow-moving agricultural vehicles and tractors;
- Transport of transmission equipment for radio or TV stations;
- Transport of equipment intended for mass events;
- Vehicles transporting newspapers and magazines;
- Empty vehicles following the unloading of perishable foodstuffs and vehicles intended for loading perishable foodstuffs;
- Transport of medicines and medical products;
- Vehicles carrying postal cargo;
- Vehicles engaged in the production cycle up to a distance of 50km from their home base;
- Vehicles transporting dangerous goods, as covered by separate regulations, in quantities for which the orange plate is required;
- Vehicles used for humanitarian aid;
- Transport of concrete;
- Vehicles used for transporting municipal waste;
### General Restrictions continued…

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>• Goods vehicles with an MPW of over 12t</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Nationwide</td>
</tr>
<tr>
<td>Prohibitions</td>
<td>• From 07:00 – 22:00 on all public holidays</td>
</tr>
<tr>
<td></td>
<td>• From 18:00 – 22:00 on the eve of specified public holidays (see <a href="http://www.fedemac.com/informationcenter.php">http://www.fedemac.com/informationcenter.php</a> for further details)</td>
</tr>
<tr>
<td></td>
<td>• From the first Friday after the end of the school year (30 June 2006) to 31 August, except on 15 August:</td>
</tr>
<tr>
<td></td>
<td>o on Fridays from 18:00 – 22:00</td>
</tr>
<tr>
<td></td>
<td>o on Saturdays from 07:00 – 14:00</td>
</tr>
<tr>
<td></td>
<td>o on Sundays from 07:00 – 22:00</td>
</tr>
<tr>
<td>Exemptions</td>
<td>• Transport of goods after unloading at a railway station, within a radius of 50km from the railway station;</td>
</tr>
<tr>
<td></td>
<td>• Vehicles entering Poland after the date or time of the prohibition up to a distance of 25km from the border crossing, and vehicles in the border zone waiting to exit Poland;</td>
</tr>
<tr>
<td></td>
<td>• Vehicles engaged in combined transport operations between the point where the goods are loaded and the nearest rail loading station for the initial leg, and between the nearest rail unloading station and the point where the goods are unloaded for the final leg, or within a radius of 150km in the case of a maritime terminal;</td>
</tr>
<tr>
<td></td>
<td>• Vehicles returning from abroad on condition that the 6-month or annual road use charge has been paid and the relevant document is on board the vehicle (does not apply in the case of temporary restrictions or to vehicles in transit through Poland).</td>
</tr>
</tbody>
</table>

### A.12.1 Road user charging in Poland

All goods vehicles over 3.5 tons are subject to a road use charge. Charge cards are on sale at border and international customs offices. Daily, weekly, monthly and yearly cards are available. Daily and weekly cards are available from service stations. Monthly and yearly card should be filled out by the issuer. However daily and weekly cards registrations number and the date of validity can be filled in by the haulier (within 7 days from the date of issue for the daily card and within 14 days from the date of issue for weekly card).

### A.13 Portugal

Special restrictions apply to vehicles in excess of 3.5t MPW used for the transport of dangerous goods. Special local restrictions apply to other vehicle categories. See [http://www.fedemac.com/_pdf_informationcenter/Portugal-2006.pdf](http://www.fedemac.com/_pdf_informationcenter/Portugal-2006.pdf) for further details.
### A.14 Romania

#### General Restrictions

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>• Those which exceed the authorised weights and dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Throughout the national road network</td>
</tr>
<tr>
<td>Prohibitions</td>
<td>• Saturdays, Sundays and public holidays from 00:00 – 24:00</td>
</tr>
<tr>
<td>Vehicles concerned</td>
<td>• Vehicles transporting dangerous goods</td>
</tr>
<tr>
<td></td>
<td>Throughout the national road network</td>
</tr>
<tr>
<td></td>
<td>• Every night between 22:00 and 05:00</td>
</tr>
<tr>
<td></td>
<td>• On Saturdays, Sundays and public holidays from 00:00 – 24:00</td>
</tr>
</tbody>
</table>

#### Exceptions

- Goods which have the following UN numbers: 1202, 1203, 1223 or 1965 (see [http://www.fedemac.com/_pdf_informationcenter/Romania-2006.pdf](http://www.fedemac.com/_pdf_informationcenter/Romania-2006.pdf) for further details)

Additional local restrictions apply to vehicles in excess of 3.5t MPW and vehicles in excess of 7.5t MPW on some national routes and to vehicles in excess of 5t MPW in Bucharest. See [http://www.fedemac.com/informationcenter.php](http://www.fedemac.com/informationcenter.php) for further details.

### A.15 Slovakia

#### General Restrictions

| Vehicles concerned | • Trucks and combination vehicles with a total authorised weight of more than 7.5t; |
|--------------------|• Trucks with a total authorised weight of more than 3.5t with trailer or semi-trailer |
| Area               | On motorways, trunk roads and main roads (Class 1) |
| Prohibitions       | • On Sundays and public holidays from 00:00 to 22:00; |
|                    | • On Saturdays between 1 July and 31 August from 07:00 to 20:00 |
| Vehicles concerned | • Special motor vehicles and carts with a width exceeding 0.60 m |
| Area               | On motorways, trunk roads and main roads (Class 1) |
| Prohibitions       | • Between 1 July and 31 August |
|                    | • On the last working day before a Saturday or a public holiday |
|                    | • On the last day of a series of public holidays, from 15h00 to 21h00 |

#### Exceptions

- Coaches and caravans
- Vehicles of the armed forces, police and the Slovak Security Service
- Vehicles used for indispensable seasonal agricultural work
- Vehicles transporting medical instruments, or biological or pharmaceutical products to hospitals or medical institutions, or to ensure the operation of medical equipment in hospitals or medical institutions
- Vehicles used in combined transport or for loading or unloading ships or trains on the territory of the Slovak Republic
- Vehicles used for cultural or sporting events, and in particular for the transport of boats, motorcycles, horses, birds etc.
- Aid vehicles required at scenes of accidents or of natural disaster
- Vehicles used for the supply of petrol stations
- Vehicles transporting perishable goods or livestock.
Application for exemption:

Authorisation to drive during the hours of the driving restriction may be obtained in extraordinary and inevitable cases, if to do so would not endanger public safety. If the authorisation is required for the territory of one region, the relevant Regional Traffic Inspectorate is competent to deal with the request for exemption. If the authorisation is required for an area covering more than one region, the request for exemption should be at a national level (see http://www.fedemac.com/informationcenter.php for further details). The issue of authorisations is subject to administrative fees. An authorisation is granted if the request is justified and on presentation of certified documents indicating the necessity of the transport operation. The authorisation remains valid for a period of 30 days.

A.16 Slovenia

General Restrictions

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>Trucks and combination vehicles with a maximum authorised weight &gt; 7.5t or a length &gt; 14 m (Foreign-registered vehicles of these types may not enter Slovenia when the restrictions are in force)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Specified sections of road on 38 routes (see <a href="http://www.fedemac.com/_pdf_informationcenter/Slovenia-2006.pdf">http://www.fedemac.com/_pdf_informationcenter/Slovenia-2006.pdf</a> for further details)</td>
</tr>
</tbody>
</table>
| Prohibitions       | All Sundays, public holidays and non-working days throughout the year from 08:00 – 22:00  
|                    | During the period from 15 June to 15 September:    
|                    |   • On Saturdays from 07:00 – 13:00  
|                    |   • On Sundays, public holidays and non-working days from 07:00 – 22:00  
|                    | On Good Friday from 14:00 – 22:00  
|                    | During the tourist season (from 15 June to 15 September):  
|                    |   • On Saturdays from 05:00 – 16:00  
|                    |   • On Sundays, public holidays and non-working days from 05:00 – 24:00  |
| Exceptions         | The transport or towing of damaged or broken down vehicles  
|                    | Humanitarian aid transport  
|                    | Vehicles involved in combined transport operations (rail or sea)  
|                    | The refrigerated transport of perishable goods  
|                    | The transport of fresh flowers  
|                    | Empty vehicles travelling to the place of loading or from the place of unloading |

Additional restrictions apply during winter conditions and adverse weather (see http://www.fedemac.com/_pdf_informationcenter/Slovenia-2006.pdf for further details)
### A.17 Spain

**General Restrictions**

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>Trains with a maximum authorised weight &gt; 7.5t</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area</strong></td>
<td>Certain national roads giving access to Madrid and Barcelona, depending on traffic density</td>
</tr>
<tr>
<td><strong>Prohibitions</strong></td>
<td>Sundays and public holidays from 17:00 to 24:00</td>
</tr>
</tbody>
</table>

**Vehicles concerned**

<table>
<thead>
<tr>
<th>Trains transporting dangerous goods</th>
</tr>
</thead>
</table>

**Area**

| Throughout Spain |

**Prohibitions**

- The eve of public holidays from 13:00 – 24:00
- Sundays and public holidays from 08:00 – 24:00

### Regional Restrictions

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>Trains with a maximum authorised weight &gt; 7.5t</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area</strong></td>
<td>Basque region</td>
</tr>
<tr>
<td><strong>Prohibitions</strong></td>
<td>From 22:00 on Saturdays and on the eve of public holidays to 22:00 on Sundays and public holidays</td>
</tr>
</tbody>
</table>

**Vehicles concerned**

<table>
<thead>
<tr>
<th>Trains with a maximum permitted weight &gt; 3.5t used for the transport of dangerous goods</th>
</tr>
</thead>
</table>

**Area**

| Basque region |

**Prohibitions**

- The eve of public holidays from 13:00 – 24:00
- Sundays and public holidays from 08:00 – 24:00
- The following dates (from 00:00 – 24:00): 31st July, 1st August, 31st August

### A.18 Switzerland

**General Restrictions**

<table>
<thead>
<tr>
<th>Vehicles concerned</th>
<th>Lorries with maximum authorised weight &gt; 3.5t</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Area</strong></td>
<td>Throughout Switzerland</td>
</tr>
<tr>
<td><strong>Prohibitions</strong></td>
<td>Sundays and public holidays from 00:00 – 24:00</td>
</tr>
<tr>
<td></td>
<td>At night from 22:00 – 05:00</td>
</tr>
<tr>
<td></td>
<td>The following dates:</td>
</tr>
<tr>
<td></td>
<td>o 22:00 13th April – 05:00 15th April</td>
</tr>
<tr>
<td></td>
<td>o 22:00 15th April – 05:00 18th April</td>
</tr>
<tr>
<td></td>
<td>o 22:00 24th May – 05:00 26th May</td>
</tr>
<tr>
<td></td>
<td>o 22:00 3rd June – 05:00 6th June</td>
</tr>
<tr>
<td></td>
<td>o 22:00 31st July – 05:00 2nd August</td>
</tr>
<tr>
<td></td>
<td>o 22:00 23rd December – 05:00 26th December</td>
</tr>
<tr>
<td></td>
<td>o 22:00 30th December – 05:00 2nd January</td>
</tr>
</tbody>
</table>

**Application for exemption:**

Vehicle exemptions for the whole of Switzerland may be issued by the authorities of the cantons in which the journey starts or through which it passes. The allocation of these authorisations is no longer within the jurisdiction of a canton if its territory is no longer concerned.
Appendix B. The Dutch PIEK programme

The PIEK programme is a government sponsored initiative that supports projects aimed at tackling noise during the whole delivery process (PIEK, 2002).

The work began in 1998, when the Dutch government set maximum noise limit values for loading and unloading activities. This came about when delivery times were extended due to an increase in shop opening hours. While delivery noise was an area that required addressing, it would appear the potential increase in noise due to extra shoppers (e.g. an increase in vehicles) during the extended delivery hours was not addressed. This may have had far more of an overall impact on the noise climate, although the delivery fleet clearly was addressed by the noise limits.

Much of the work of PIEK is related to the activities that take place when the delivery vehicle is either arriving at the location or during the actual delivery. This is considered a slightly narrow approach as far more people are exposed during the passage of a vehicle from a depot to the delivery yard than are exposed during a delivery, yet there has been little focus on this area in the PIEK programme. Therefore, most of the work conducted under the PIEK programme is not directly relevant to vehicles on the move and is outside the scope of this project.

However, a small part of the work was concerned with noise generated when the vehicle is travelling from depot to the delivery yard. These include the use of hush kits, speed limiters (both engine and vehicle speed) and automatic gearboxes. Using such devices would prove useful in the development of a ‘quiet vehicle’, as discussed later in Section 5.6.2.

There are three interesting areas where the lessons from the Dutch PIEK programme might help with revisions to the LLCS:

(i) The vehicle and engine speed limiters used in the PIEK programme were designed to act only with a short distance of each delivery point. This suits urban conditions in the Netherlands, where relatively small supermarkets are located in suburbs, rather than ‘out of town’. The limiters detected when a vehicle was close to the delivery depots, and prevented extreme driving actions in order to eliminate the consequential noise. This has demonstrated the viability and the precision of the technology.

(ii) The PIEK programme highlighted the possibilities for reducing noise when a vehicle is moving in the immediate vicinity of a delivery point, and during the period when a delivery vehicle is stationary at the depot. The problems in London are different, because the phase where a delivery vehicle is in motion well away from a delivery depot is the predominant period where noise and pollution are generated. However, the PIEK results would help if an in service vehicle noise test for London were developed. Information from the PIEK programme would help decide what proportion of that test should cover noise generation from low speed and stationary vehicle operation, and what proportion should cover higher speed operation.

(iii) The PIEK programme involved training drivers in a wide variety of techniques for avoiding noise generation. A simplified version of this form of training programme might bring the majority of the benefits to the LLCS, but minimise the expense involved in training a large number of drivers. Such a training programme might be delivered through Work Package LFP3 of the London Freight Programme (LFP; see Section 5.6.4).
Appendix C. Brief review of factors affecting night-time LGV noise disturbance

This Appendix addresses the specific sources of road traffic noise that have been identified as causing annoyance or disturbance, and considers the effects on sleep disturbance of night-time LGV operations.

C.1 Disturbance from specific sources of road traffic noise

In 1999/2000, the Building Research Establishment (BRE) undertook a National Noise Attitude Survey (NNAS) which sampled the population of the UK to assess attitudes to environmental noise experienced in the home (Skinner et al., 2002). In total, 2876 interviews were completed of which 2849 interviews were related to road traffic noise. Compared with other sources of noise heard in the home, road traffic noise caused the most respondents to be bothered, annoyed or disturbed (40 ±3% to some extent and 8 ±1% very or extremely). More detailed questions relating to specific road traffic noise sources provided the results shown in Table C.1.

Table C.1: Proportion of respondents who heard and reported being bothered, annoyed or disturbed by specific road traffic noise sources (abridged version of Table 8, Skinner et al. (2002))

<table>
<thead>
<tr>
<th>Specific road traffic noise source</th>
<th>Hear (%)</th>
<th>Bothered, annoyed or disturbed (%)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>To some extent</td>
</tr>
<tr>
<td>Vehicles accelerating/going too fast</td>
<td>63</td>
<td>34 (54)</td>
</tr>
<tr>
<td>Large goods vehicles</td>
<td>59</td>
<td>24 (41)</td>
</tr>
<tr>
<td>Engine revving</td>
<td>57</td>
<td>19 (33)</td>
</tr>
<tr>
<td>Private cars/taxis</td>
<td>85</td>
<td>27 (32)</td>
</tr>
<tr>
<td>Brake squeal</td>
<td>48</td>
<td>16 (33)</td>
</tr>
<tr>
<td>Motor bikes/scooters</td>
<td>73</td>
<td>24 (33)</td>
</tr>
<tr>
<td>Small lorries</td>
<td>64</td>
<td>20 (31)</td>
</tr>
<tr>
<td>Noise caused by surface irregularities</td>
<td>37</td>
<td>7 (19)</td>
</tr>
<tr>
<td>Vehicles starting/stopping/idling</td>
<td>53</td>
<td>13 (25)</td>
</tr>
<tr>
<td>Buses/coaches</td>
<td>50</td>
<td>12 (24)</td>
</tr>
<tr>
<td>Air brakes</td>
<td>38</td>
<td>8 (21)</td>
</tr>
<tr>
<td>Delivery vans</td>
<td>66</td>
<td>12 (18)</td>
</tr>
</tbody>
</table>

¹ Values in brackets are the proportion of respondents expressed as a percentage of those who experience the noise.

The specific noise sources have been ranked according to the proportion of respondents very or extremely bothered, annoyed or disturbed expressed as a percentage of those who experienced the noise. The results in the Table show that when experienced, the noise from vehicles accelerating/going too fast and the noise from LGVs are ranked the highest. Clearly, despite dramatic reductions in the noise emission levels from LGVs under type
approval conditions\textsuperscript{11}, the noise levels from these vehicles under normal traffic conditions are still perceived as a serious problem. However, small goods vehicles were ranked as being less disturbing than private cars/taxis, with delivery vans being ranked as the least disturbing. Tentatively it may be concluded from these results that the impact of noise from night-time large goods vehicle traffic could be alleviated if an equivalent number of smaller goods vehicles were used. However, research has identified that there is a trade-off between maximum noise levels and the number of vehicle pass-bys, which affect the relationship between perceived annoyance and exposure (European Commission, 2004).

The third most disturbing road traffic source noise identified was revving engines; this is a problem that could be addressed to some extent through better driver training, public information advertising, etc. Noise caused by surface irregularities was the least experienced source of disturbance but still features relatively highly in the Table. Studies carried out by TRL have identified that noise emission levels from large goods vehicles can significantly increase by about 10 dB(A)\textsuperscript{12} when travelling over road profiles simulating poorly maintained road surfaces. This was particularly noticeable for un-laden vehicles with steel-leaf suspension systems (Abbott \textit{et al.}, 1995; Abbott, 1996). Specifying LGVs with air suspension systems and ensuring that the road surface of routes that allow night-time access for large goods vehicles are well maintained and regularly monitored for surface condition may reduce the incidence of this form of night time LGV noise disturbance.

Traffic-induced vibrations from low frequency sound emitted by vehicle engines and exhausts can be a source of annoyance to local people and can occur to some extent along any type of road. LGVs are likely to produce the largest effects. Such sound may result in detectable vibrations in building elements (for example, windows and doors may rattle and in some cases floors may vibrate perceptibly). It was found in a survey at 50 sites (Watts, 1984) that $L_{A10,18h}$ index was among the physical variables most closely associated with average vibration disturbance ratings.

Note that the relationship between the percentage of people bothered by largely airborne vibration and this noise exposure index is similar to that for noise nuisance, except that the percentage of people bothered by vibration is lower at all exposure levels.

“Lorry rumble” and “whoosh” were mentioned in social surveys as causing annoyance but are not well defined noise descriptors. The term “lorry rumble” may include the effects of traffic-induced vibration but equally may refer to suspension noise or body rattles as goods vehicles pass over uneven road surfaces. “Whoosh” may refer to the experience of air displacement felt by pedestrians and cyclists as a large vehicle passes by.

The following section identifies the sources of low frequency lorry rumble and typical faults which can give rise to disturbing noise events e.g. brake squeal, hissing from air brakes, body/component rattle. The aim is to provide an overview of noise generation and its perception.

\section{C.2 Noise sources on LGVs and perception}

This section briefly reviews the main sources of noise from LGVs, and how they are perceived in urban areas. Particular concern is with the generation and propagation of low frequency noise. Initially, a general definition of low frequency noise is given together with the problems associated with its control and mitigation. In addition, specific noise sources which have been identified as particularly annoying but not necessarily associated with low frequency noise are also described. These sources may be associated with particular design features, for example the type of suspension system, or sources which may arise due to poor maintenance, e.g. brake squeal, or by the way the vehicle is driven.

\textsuperscript{11} Over the past 30 years there has been approximately a halving in the loudness of the noise emitted by LGVs under type approval conditions e.g. under full-throttle acceleration.

\textsuperscript{12} An increase in noise level of 10 dB(A) is approximately equivalent to a doubling of loudness.
Low frequency noise may be considered to span the frequency range from about 10 Hz to 200 Hz, although these boundaries are not fixed (Leventhal, 2003)

The frequency characteristics of this type of noise have important implications on noise mitigation and control, particularly in terms of noise propagation, screening and transmission into buildings including room resonance. As the noise propagates away from the source the normal rules of attenuation associated with geometric spreading of the acoustic energy from a point source applies i.e. 6 dB per doubling of distance. In addition, attenuation due to air absorption can become important at long distance from the source i.e. over several km. The rate of attenuation is dependent on frequency. For example, at 63 Hz the attenuation rate is about 0.1 dB/km compared with 1.1 dB/km at a frequency of 250 Hz. As a result, noise which has travelled over long distances is normally biased towards the low frequencies and often perceived as a low frequency ‘rumble’. The problems of controlling low frequency noise, particularly in urban areas, by way of screening and insulation are limited due to the relative long wavelengths associated with low frequency noise. Typically, the dominant low frequency noise generated by road traffic noise corresponds to wavelengths in the region from about 6.8m (50 Hz) to 3.4m (100 Hz)\(^{13}\). For noise barriers to be effective in reducing noise, the dimensions of the barrier must be significantly larger than the spectrum wavelength of the noise source. Typically, a long 3 m high barrier may achieve noise reductions of about 10 dB at frequencies around 1 kHz but only achieve reductions of about 1 to 3 dB in the low frequency range. Similarly, with sound insulation, absorption requires a thickness of absorbing material up to about a quarter wavelength thick, which could be several metres, to be effective.

Once the noise enters a building, there are further problems associated with room resonances which are particularly relevant to lower frequencies. Resonance occurs in enclosed, or partially open, spaces. Resonances in a normal sized domestic room occur in the low frequency region. For example, a room of dimensions 4 m × 5 m × 2.5m has low frequency resonances from 34 Hz upwards. Resonances increase the sound level in parts of the room whilst decreasing it in others. Generally, the level is highest at the end walls and lowest in the centre of the room. It is often possible to detect the differences in level, at different room locations, within a room which has been driven into resonance by low frequency noise. However, a room with an open door or window can act as a Helmholtz resonator. This is the effect which is similar to that obtained when blowing across the top of an empty bottle. The resonance frequency is lower for greater volumes, with the result that Helmholtz resonances in the range of about 5 Hz to 10 Hz are possible in rooms with a suitable door, window or ventilation opening.

The firing frequencies of the vehicle exhausts are important in causing this type of resonance. However, while the tests described in this report do address vehicle exhaust noise, they are concentrated on the overall A-weighted level rather than the specific spectral content.

**C.2.1 Sources of low frequency noise on LGVs including external influences on generation and propagation.**

- *Engine exhaust and transmission:* For example a V8, four stroke diesel engine running at 1000 rpm has a peak in the sound spectrum at about 67 Hz (rpm × No: of cylinders /120 Hz). In addition there may be harmonics of this fundamental frequency appearing at 133, 200…. Hz. The height of this source will vary from perhaps 0.25 m if the exhaust outlet is under the chassis up to 3-4 m in height for a vertical stack exhaust. It will be harder to screen the higher source using barriers. Exhaust noise tends to increase when the vehicle is under load for example when a vehicle is

\(^{13}\) This frequency range is typically associated with the fundamental frequency of the combustion noise inside the engine.
accelerating or travelling uphill. In addition the presence of tall buildings on both sides of the road will enhance the effect especially if the separation is small. Under such circumstances multiple reflections may take place leading to standing waves in the “canyon”. Where relatively high levels of low frequency noise are present this may induce chest vibrations and a muffled sensation in the ears (Watts, 1984) and can be perceived as “rumble”.

- **Body noise**: This may range from high frequency tinkles from loose equipment, through rattles of heavier equipment to the booming of large metal side panels of box lorries. Again the perception may be a “rumble” noise. Body rattles are particularly noticed if the load moves or there are loose loads e.g. a flatbed truck with loose scaffold poles, or tools or where there are loose sides to the load beds or metal ramps poorly secured e.g. car transporters. Booming may be noticed on large tipper lorries especially when empty so that damping is at a minimum. The largest effects may give rise to impulsive noise more than 10 dB(A) above the normal pass-by noise level for the class of vehicle (Abbott et al., 1995). Because the events can be short lived and impulsive in nature they have the potential to seriously disturb especially during night-time. The condition of the road surface is crucial to reducing the incidence of body rattle noises. Where the surface is poorly maintained or reinstatement has left a series of raised or sunken patches the problem will be particular acute.

- **Air brakes**: If a suppressor is not fitted the release of compressed air from these brake systems can produce a high level of noise over a short duration. Even vehicles less than a year old can produce high levels as demonstrated by a recent test programme (Watts et al., 2005). Such impulse noise has the potential to seriously annoy residents especially at night-time.

- **Brake Squeal**: This is an important source of intrusive noise especially for buses where the high frequency tonal noise can be extremely irritating (Nelson, 1987). On trucks it is not thought to be so prevalent. Vibration of some components of the braking system is responsible but its complete elimination can be problematic.

- **Tyre noise**: Tyre/road noise becomes noticeable in trucks at speeds over about 30 mile/h. Therefore it is not usually an issue under congested urban condition or in a 30 mile/h speed limit. At the higher speeds the tyre noise can be perceived as a roar especially if many vehicles are contributing e.g. on a busy motorway. If individual vehicles are involved the effect may be perceived as a “whoosh” especially if the road is wet. Tyre noise can be reduced by an appropriate road surface. Replacing a hot rolled asphalt (HRA) surface which usually has a maximum stone size of 20 mm with a finer graded surface material would be beneficial. For example a thin layer surface or a stone mastic asphalt can significantly reduce tyre/road noise especially if the maximum stone size is of the order of 10 mm or lower. Reductions in pass-by noise of > 3 dB(A) are quite feasible if the original surface is HRA (Watts et al., 2006).

- **Tyre squeal**: This is caused by excessive slip of the vehicle wheel on the road surface (Sandberg and Ejsmont, 2002). Normally this is a result of high levels of acceleration or braking though it can also occur on bends where there is a lateral force on the tyre. The problem should not be too severe in urban areas where speeds and accelerations are generally limited by traffic conditions and speed limits. At junctions where accelerations tend to be high as vehicles accelerate away from rest, or a relatively low speed, the problem can be reduced by treating the junction with an anti-skid treatment. This will also improve wet weather braking performance and may have a beneficial effect on accident rates.
• **Aerodynamic noise**: This will depend on the speed of the vehicle and the degree of streamlining of the vehicle (Nelson, 1987). The frequency of the sound is proportional to speed and inversely proportional to the principle dimension of the structure creating the noise. In urban areas where speeds are low due to congestion, speed limits or junction controls, the opportunity for the generation of significant aerodynamic noise from the vehicle body or load is relatively low. Large air displacements due to the bow wave formed at the front of the vehicle may be perceived close to the road as “whoosh” as the air streams pass the listener. Fan noise is a type of aerodynamic noise which is related to the blade passage frequency. Water cooling fans in front of the radiator may produce significant amounts of noise across a wide frequency range.

• **Ancillary equipment noise**: Refrigeration units attached to trucks are frequently a source of noise. Usually these will not be a problem when the vehicle is operating as propulsion and rolling noise sources will be dominant. However, under idle conditions this noise may tend to dominant and cause problems for residents. For example where a vehicle is making a delivery and is waiting to load or unload. By careful design of such units, or the use of nitrogen cooling the noise can be reduced to acceptable levels. Problems can also occur with tail gate lifts and hydraulically operated cranes attached to the load bed. It is difficult to get an accurate impression of the extent of this type of problem although some measurements have been carried out recently suggest it can be an important source of noise (Watts et al., 2005)

### C.3 Sleep disturbance and night-time vehicle operations

An additional factor important with regard to night-time lorry noise disturbance is the time when people are most sensitive to disturbance. The most common cause of reported sleep disturbance is noise, either during the period when trying to get to sleep or the period just prior to normal wakening.

A National Noise Incidence Survey (NNIS) undertaken by BRE in 2000 (Wright et al., 2002), provided objective measurements of noise outside homes in England and Wales together with the results from self-reported questionnaire surveys about road traffic noise, including sleep disturbance.

Results from the National Noise Incidence Survey showed that about 15% of the population go to bed between 21:00 to 22:00 hours and that about 90% are in bed by midnight.

Of those that had difficulties in getting to sleep (8%)\(^{14}\), the noise levels outside their properties measured at the time when they went to bed were about 8 dB(A) higher than the corresponding levels for those who experienced no difficulty, implying that maximum noise levels are an important factor in determining disturbance during this period.

During the night and early morning, there were indications that both maximum noise levels and the duration of noisy events were important in differentiating between those disturbed and those not disturbed, with about 7% being woken during the night and 15% woken during the early morning period.

\(^{14}\) This analysis was undertaken for the sub-sample of respondents who slept in a room overlooking the microphone position, and had the window open. It would be expected that the levels measured in this sub-sample would be more representative of the actual levels experienced by the respondents.
This has important implications with regard to scheduling night-time LGV control schemes and suggests that any potential changes in the existing arrangements or conditions operating in London should take into account these findings\textsuperscript{15}.

\textsuperscript{15} The London Lorry Control Scheme operates from 21:00 on weekdays and from midday on Saturdays.
Appendix D. Changes in exposure due to improved traffic management and the subsequent changes in night-time disturbance

This Appendix addresses the potential reductions in night-time disturbance that might be achieved by alternative traffic management schemes. These schemes include:

- Re-routeing night time LGV flows;
- Introduction of the Low Emission Zone (LEZ) scheme;
- Effects of using dedicated lanes;
- Replacing large lorries with a number of smaller lorries with similar combined gross weight.

Proposals for the introduction of the Low Emission Zone scheme have already been issued for consultation by Transport for London in November 2006 (Transport for London, 2006), with the consultation scheduled to end in February 2007; as such consideration of the scheme as a specific option for adapting the LLCS is not included within this document, although use of LEZ technology that will be in place after the introduction of the LEZ is considered. The other traffic management schemes listed are not considered within this study as specific options for changing the LLCS, but it is acknowledged that their use might arise as a consequence of the options put forward for consideration in Chapter 5.

As such it is considered necessary to be aware of the effects of all of these options on night-time disturbance.

D.1 Effects of re-routeing night-time LGV flows

Re-routeing night-time LGV flows will change night time noise exposure. Assessing the impact on night time disturbance brought about by these changes in exposure is a complex task. It requires the following information:

- Typical noise emission levels from LGVs for traffic conditions under consideration;
- The change in LGV flow over the night time period;
- The relationship between changes in exposure and perceived night time disturbance.

A number of databases allow typical noise emission levels from LGVs in urban traffic conditions to be estimated. One example is the European prediction model, HARMONOISE (Jonasson et al., 2004). HARMONOISE requires, as input, sound power levels from individual vehicle sources. These take into account different traffic conditions, which have been developed from empirical measurements. Further refinements are planned in the development of the HARMONOISE model, to allow the estimation of noise emission levels from LGVs in traffic conditions typical of urban areas.

Night-time traffic flows on most roads in the London area are unknown. However, this situation may change with the introduction of the recent EU Directive for assessing and managing environmental noise (European Commission, 2002). Part of this European legislation requires Member States to produce noise maps of most urban areas in the EU, including specifically the night time period (23:00 to 07:00 hours). To improve the accuracy of the night time noise maps, better estimates of traffic flows and composition will be required, and therefore will provide the impetus for more accurate assessment of night traffic flows.

The remaining ingredient required in assessing the impact on night time disturbance from re-routeing night-time LGV flows is the relationship between changes in night-time exposure and the change in perceived disturbance. Recent research has examined the relationship between sleep disturbance and exposure at sites where night-time exposure has remained...
relatively stable over time. This situation is referred to as the dose/response relationship for steady state conditions.

Research carried out on the dose/response relationship between exposure and annoyance for road traffic noise has shown that assessing impacts using the steady state relationship underestimates changes in perceived annoyance. This is particularly the case where changes in exposure are due to changes in traffic flow, e.g. where a by-pass is built. Further research is required to establish whether a similar effect occurs when assessing the impact on changes in sleep disturbance due to re-routeing night-time LGV flows.

D.2 Potential Effects of implementing the Low Emission Zone (LEZ)

London's air quality is the worst in the UK, and is also among the worst in Europe (Kings College London, 2006). Implementing and enforcing the Low Emission Zones (LEZ) in London will increase the proportion of low emission vehicles in the vehicle fleet, and fine those that are most polluting.

Prior to implementation, a feasibility study was carried out by TRL. Among other tasks, an assessment of the likely impact of such a scheme on road traffic noise levels was carried out (Watkiss et al., 2003). The study assumed that Euro 3 vehicles16 would replace all pre-Euro 3 vehicles, except for private cars. The assessment considered two zones. There was a central zone, which corresponded to the Congestion charging scheme area, and an outer zone within the M25 corridor.

The results of this research indicated that introducing low emission vehicles into the traffic fleet would have only modest noise benefits. The benefit would be approximately a 0.3 dB(A) decrease in central London, and a 0.1 dB(A) decrease in outer London. The effect on night time disturbance would therefore be small.

The predicted reduction in noise was due to the introduction over time of progressively stricter type approval noise limits for new vehicles. It assumed that maximum vehicle pass-by noise levels would reduce in-line with the reduction in noise limits at type approval. It is now however generally accepted that emission levels from road vehicles in normal traffic conditions have not reduced in-line with these noise limit reductions (WP-NERV, 2001).

If the scheme does not exclude cars from the LEZ zone, the proportion of noisier vehicles that would be replaced by quieter vehicles would be small. This would lead to only small overall reductions in traffic noise levels.

D.3 Effects of using dedicated lanes

Specific lanes of some roads are dedicated to only one type of traffic. Bus lanes are by far the most common example in the UK.

Combined ‘bus/LGV’ lanes have been used in the UK. However, the noise reduction and other benefits of large goods vehicles using bus lanes have not been conclusive, from the literature available. The one evaluation report that was found concluded that the experimental lane concerned had 'produced rather less benefit than expected because of the poor location of the lane and its unfamiliarity amongst lorry drivers'.

Tyne and Wear installed combined bus/LGV lanes during the 1990s. However, that Authority’s latest investment to boost freight movement is in ‘No car’ lanes. See the text box on ‘The evolution of no-car lanes’ at reference Sunderland (2006). These dedicated lanes permit motorcycles and bicycles, besides buses and LGVs.

---

16 Since 2001 all new cars first registered in Europe must meet Euro 3 emission standards.
Allowing LGVs to use bus lanes has several advantages. The main advantage is that LGVs will move more freely. In particular, they would be involved in much less ‘stop-start’ queuing during periods when roads are significantly congested. This reduces:

(i) The noise and particulates that lorries emit for a given journey;
(ii) The time that a given journey will take, and the amount of fuel used. Both of these effects reduce costs to operators. Reduced fuel use results in less CO₂ emitted per journey.

In order to fully assess the effects of LGV lanes, a broad description of the proposed scheme would be needed. Would LGVs be allowed to use bus lanes at all times? How does this fit with protection of vulnerable road users? (cyclists) Would some very busy bus lanes not be available to LGVs? Given this information, it would be possible to provide a cost benefit analysis of:

(i) Advantages to the public and LGV operators of (i) and (ii) above;
(ii) The benefits and costs of journey time changes for buses and cars. Combined LGV/bus lanes, or ‘No car’ lanes, are likely to be a justified use of road space on some roads where there is currently in-sufficient justification for just a bus lane.
(iii) Any second order effects. For example, LGVs in a bus lane would produce more noise for dwellings near to roads and for pedestrians than if all LGVs were one carriageway further from the kerb. However, LGVs that travel more smoothly emit less noise than they otherwise would, although noise does rise significantly above 60 km/h.

Table D.1 highlights four key issues for schemes involving dedicated lanes. We would need to look at these if this subject were taken forward as part of this project.

<table>
<thead>
<tr>
<th>Issue</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conditions for using the lanes</td>
<td>These conditions would need to be agreed with stakeholders.</td>
</tr>
<tr>
<td>Enforcement</td>
<td>Many bus lanes are currently enforced both from cameras mounted inside buses and roadside cameras. Roadside mounted systems would be suitable if the LGVs entitled to use the dedicated lanes were registered.</td>
</tr>
<tr>
<td>Education</td>
<td>Commercial vehicle operators would need to understand the system, in order to use the right lanes at the right times for the right vehicles. The reasons and benefits behind such schemes would need to be clearly defined and publicised, so that the public do not perceive that LGVs are unfairly using the dedicated lanes.</td>
</tr>
<tr>
<td>Safety and design of lane</td>
<td>Some dedicated lanes may be of restricted width, or not have surfaces that are designed to withstand use from a large number of LGVs.</td>
</tr>
</tbody>
</table>

The acoustic benefit of such dedicated lanes is difficult to quantify without any real-life trials. However, the introduction of a new dedicated lane somewhere in the UK would offer an opportunity to measure noise levels from all traffic, and noise just from LGVs, both before and after the introduction of the scheme.
If roadside mitigation measures such as noise barriers or other screening devices are present, the benefit that these deliver would be increased. Another factor that would influence the acoustic benefit would be the surface used for the lane. Very low noise surfaces are available. These include surfaces that absorb most engine and transmission noise, rather than reflecting it.

D.4 Effects of replacing LGVs with smaller vehicles of equivalent gross weight.

Earlier studies (Rosman, 1976) examined public preference to convoys of different size goods vehicles (either a single, large vehicle (carrying capacity 16 tons), two medium-size vehicles (each with a carrying capacity of 8 tons) or four small vehicles (each with a carrying capacity of 4 tons)) passing residential properties. These studies showed that there was little difference between the number of people for or against a single LGV, in comparison to four smaller size goods vehicles of equivalent gross weight. Preference for the single vehicle combination was based on negative attitudes towards the longer duration taken by the four vehicle combination. Preference for the four vehicle combination was based on negative attitudes towards the higher noise levels generated by the single heavier vehicle. It is noted that the experimental situation was artificial in the sense that the smaller vehicles were driven in convoy rather than randomly distributed in the traffic stream.

These findings were drawn from a limited study carried out in the mid-1970’s. However, they do support the findings from later studies. These have found that peoples’ attitudes to noise disturbance in their homes, particularly during the night, are correlated with both maximum pass-by noise levels and the duration of noisy events (Lansdell and Cameron, 1998).

Further work in this area based on current vehicle types may provide further support. However, there are other economic, logistic and environmental factors, which may outweigh any noise benefits gained from this approach. In particular, congestion and CO₂ emissions are likely to be large factors.
Appendix E. The potential effects on noise and other impacts of different vehicle technologies

The Table is shown on the following page.
Table E.1: The potential for various vehicle technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Effect on noise</th>
<th>Other impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed Limiters, Acceleration limiters (Collectively ISA)</td>
<td>Table 4.1 shows that high speeds and hard acceleration cause the greatest annoyance. Limiters of speed and/or acceleration would cut this. 'Intelligent Speed Adaptation' equipment can slow vehicles to the limit for the street that they are in. Vehicles could be restricted to lower limits by night than by day.</td>
<td>Limiters would cut: CO₂ and other engine emissions; accident rates and severity; wear and tear on vehicles and drivers.</td>
</tr>
<tr>
<td>'Pay As You Drive™' insurance. Two insurance companies offer an in-vehicle ‘black box’, which enables payment of insurance per mile actually driven.</td>
<td>The ‘black boxes’ monitor location and speed of the vehicle. This has two effects: (i) Once fitted, it deters extreme driving actions, particularly speeding; (ii) Only drivers who are happy to have their speeds monitored sign up to this technology, so it ‘self-selects’ drivers with less extreme styles. Both effects produce improvements in noise through reductions in speed and acceleration.</td>
<td>See European Commission (2001) and Carsten and Tate (2000)</td>
</tr>
<tr>
<td>'Low noise vehicle', defined by noise measurement in either the existing type approval test, or a bespoke London test</td>
<td>The type approval test has been used as the main mechanism to reduce vehicle noise for the past 20 years. A threshold, such as 7 dB(A) (or as defined by further work) below the legal limit for the class of vehicle, would be used as a criterion for 'off ERN' operation. To reflect more accurately the particular driving conditions and vehicles used in London at night, a greater benefit could come from an in-service noise test.</td>
<td>1. CO₂ and other emissions are reduced</td>
</tr>
<tr>
<td>Low noise tyres</td>
<td>The maximum emissions of noise from tyres are regulated by a type approval test. However, some standard tyres perform substantially better than the permitted noise limit. Mandating these tyres on vehicles that go off the ERN would bring benefits to new and existing vehicles. Most benefit would be at speeds above 60km/h, but significant benefits would be noticeable at speeds below this.</td>
<td>2. Only the insurance companies have access to data, unless an accident occurs, so 'surveillance by government' is avoided.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Charges could be collected by the insurance companies, and remitted to London Councils.</td>
</tr>
</tbody>
</table>

1. Setting a threshold of 7dB(A) below the type approval limit is straightforward, and could be used for existing vehicles.
2. Deriving a bespoke test would involve testing vehicles for compliance. The noise reductions would be greater, but there would be some additional costs.
3. Compliance and enforcement would be necessary. However, London is a sufficiently large market that manufacturers would be easily able to supply tyres with the noise values from the type approval test stamped on them, if vehicle operators created demand for this.
Table E.1: The potential for various vehicle technologies (continued...)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Effect on noise</th>
<th>Other impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel cell powered vehicles. Only prototypes and technology demonstrators currently available. See TNT on the Smiths webpage.</td>
<td>Fuel cell vehicles have very low noise levels, because the only significant noise source is tyre/road noise.</td>
<td>Fuel cell vehicles should emit negligible quantities of harmful emissions, so offer the greatest potential improvement in air quality possible but a performance standard is still needed to incentivise acoustic optimisation.</td>
</tr>
<tr>
<td>LPG, CNG vehicles; Vehicles with Hydrogen powered internal combustion engines; Hybrid vehicles</td>
<td>These engines still produce combustion noise. Their noise characteristics may be better or worse than diesels. Tyre/road noise remains.</td>
<td>These vehicles offer improvements in air quality. LPG and CNG vehicles are proven and cost-competitive, so would be used if sufficient incentive available.</td>
</tr>
<tr>
<td>Euro IV and V emissions engines</td>
<td>Only a loose link to noise. However, commercial vehicles with engines of the most recent emissions standards meet the latest vehicle and tyre type approval limits, and are in a newer, less worn, condition than older vehicles.</td>
<td>Permitting only vehicles with the latest engines would cut emissions, other than CO₂, and would ensure the latest designs of vehicle were in use, with e.g. the highest safety standards for drivers</td>
</tr>
<tr>
<td>Smart card' licence detectors in vehicles</td>
<td>There is no direct link to noise. However, vehicles can be fitted with locks that require a certain driver to be driving, before the engine will start. This could be used to restrict use of the vehicle at night to drivers who have up-to-date training in low noise driving.</td>
<td>TfL/London Councils could issue ‘Smart cards’ to drivers who have up-to-date driving training. Clearly, other conditions could be imposed for night time driving in London, such as an acceptable accident rate. Vehicles that are not driven by their owner have higher accident rates, and these cards would provide deterrence.</td>
</tr>
</tbody>
</table>
Appendix F. Administrative issues associated with changes to noise tests

Table F.1 and Table F.2 below list issues related to the administration of the tests. The table considers both a lower noise limit in the type approval test, and the introduction of an in-service test.

Table F.1 considers how changes to both tests would affect new vehicles. Table F.2 considers vehicles already in the fleet.

Table F.1: Administrative issues associated with changes to the tests and new vehicles

<table>
<thead>
<tr>
<th>Administrative issue related to new vehicles</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>How the vehicle is labelled at type approval as being ‘low noise’.</td>
<td>The marking of low noise or the actual noise level would be simple as documents are already in place to administer the type approval process.</td>
</tr>
<tr>
<td>Number of vehicles currently available that meet the new limit.</td>
<td>A staged implementation time would be required to ensure that manufacturers would have time to develop additional vehicles.</td>
</tr>
<tr>
<td>Tested with body or trailer</td>
<td>The test is aimed at replicating real life operating conditions; it may be too restrictive to test with a body on a rigid vehicle or a trailer on an articulated vehicle, unless each possible combination is tested. The number of such combinations could be high. If tested without a body, then consideration could be given to introducing a compulsory compliance with the best practice on body rattle as an additional requirement for a permit. If the vehicles are to be tested with the intended body type then the testing is likely to be the responsibility of the operator and then the issues associated with the testing of existing vehicles (see below) would need to be considered.</td>
</tr>
<tr>
<td>Test all new vehicles or just one example</td>
<td>If conducted by the manufacturer, an example of each vehicle model would be sufficient for type approval.</td>
</tr>
<tr>
<td>Who pays – manufacturer or operator</td>
<td>Test would need to be relatively cheap and be able to do at short notice. However, if it were made expensive then operators would insist on purchasing a vehicle that has passed type approval rather than buying a vehicle and paying for the test themselves.</td>
</tr>
<tr>
<td>Enforcement</td>
<td>When an application is made to operate off the ERN, a check can be made of the vehicle’s paperwork to determine if the vehicle has passed the in-service test. For roadside enforcement, a sticker could be placed in the windscreen of the vehicle to prove the test has been passed. If the benefits of the forthcoming LEZ could be utilised for enforcement of the LLCS, numberplate recognition could potentially used for this purpose.</td>
</tr>
</tbody>
</table>
Table F.2: Administrative issues associated with changes to the tests and existing vehicles

<table>
<thead>
<tr>
<th>Administrative issue related to existing vehicles</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do existing vehicles continue as they are until the vehicle is replaced?</td>
<td>The permitting arrangements of the LLCS would have to remain for any vehicles that already receive permits. Any new noise test requirement could only apply from a future date, and for vehicles that had not previously received a permit.</td>
</tr>
<tr>
<td>How the vehicle is labelled at type approval as being 'low noise'.</td>
<td>The marking of low noise or the actual noise level would be simple as documents are already in place to administer the type approval process.</td>
</tr>
<tr>
<td>Could testing stations cope with a sudden workload?</td>
<td>If existing vehicles are to be considered for testing then sufficient time would be required for the manufacturers to have vehicles tested and, if necessary, work undertaken on the vehicle.</td>
</tr>
<tr>
<td>Are existing rigid vehicles tested with body shells</td>
<td>At type approval the chassis of a rigid vehicle is usually tested alone and is therefore not representative of real life operating conditions. The presence of a vehicle body could affect the noise level and this may need to be considered during the test as it would be unreasonable to expect vehicle operators to have the body of a rigid vehicle removed. An allowance of, for example, 1 dB lower could be given where the body shell is present. A trailer can readily be detached from a tractor unit so the testing of this type of vehicle would be similar to that at type approval.</td>
</tr>
<tr>
<td>Do all similar vehicles in an operator's fleet need to be tested?</td>
<td>If an operator has similar vehicles that have been unmodified then only one would need testing. But any vehicles fitted with retrospective noise reducing devices would require individual testing.</td>
</tr>
<tr>
<td>Can a manufacturer test one vehicle and then all operators of this type of vehicle can say their vehicles conform?</td>
<td>Would be difficult as obviously use their vehicles for different purposes.</td>
</tr>
<tr>
<td>Enforcement</td>
<td>If the vehicle is fitted with noise reducing equipment then an in-service test would be required to check the equipment is still functioning correctly.</td>
</tr>
</tbody>
</table>
Appendix G. Results from the roadside noise measurements

G.1 Details of measurement sites
Table G.1 on the following page provides a summary of the final six measurement sites used in the study, including the location, speed limit, surface information, a description of the site and the typical vehicles encountered during the measurements.

G.2 Relationship between vehicle noise and speed
The analysis of the results from measurements of the vehicle noise surveys examined the relationship between vehicle noise and speed.

The general relation between maximum sound level ($L_{A_{\text{max}}}$) and the speed of a passing vehicle for a measurement taken at 7.5 m from the centre line of the vehicle path has been shown to take the general form:--

$$L_{A_{\text{max}}} = 10 \log_{10}(v) + B dB\quad (G.1)$$

where $v$ is the speed of the vehicle in km/h and $A$ and $B$ are constants dependent on the tyre and surface combination (Harland, 1974).

During the vehicle noise surveys, measurements of the noise from individual vehicles passing the microphone including both, the maximum pass-by noise level, $L_{A_{\text{max}}}$, and the SEL were recorded. A preliminary analysis of the data examined which of these noise descriptors would be most suitable in predicting vehicle noise based on vehicle speeds. Vehicles were categorised into groups, vehicles within each were classified as acoustically similar. The initial classification grouped vehicles into 3 groups; cars, goods vehicles with 2 axles and twin tyre configuration on the rear axle and finally LGVs with 3 or more axles.

Figure G.1 shows the relationship between the logarithm of speed and each noise descriptor for vehicles with 3 or more axles. A regression line for each relationship is shown together with the corresponding regression equation and variance ($R^2$). The Figure shows that for vehicles with 3 or more axles the $L_{A_{\text{max}}}$ noise descriptor is better correlated than compared with the SEL indicator. The regression statistics indicate that 58% of the variance in $L_{A_{\text{max}}}$ can be explained by changes in road speed compared with only 30% for SEL. This is because there problems in the measurement of SEL with isolating vehicles from the extraneous noise from other vehicles. A similar analysis was carried out for the other vehicle categories and similar results were obtained.

Further analysis showed that both descriptors are highly correlated. Figure G.2 shows this relationship indicating that 86% of the variation in SEL values can be explained by the maximum noise level, $L_{A_{\text{max}}}$ where vehicles were identified with no noticeable noise characteristics such as body rattles, suspension noise, brake squeal etc. This variance reduced to about 73% for those vehicles with an identified noise source. Clearly, using $L_{A_{\text{max}}}$ as an indicator will improve prediction accuracy where noise is correlated with road speed. In addition, it was found that measuring SEL was difficult because there is more likelihood of the measurement being contaminated by other noise sources compared with $L_{A_{\text{max}}}$ due to the longer period required to carry out the measurement. It was therefore decided that the relationship between the logarithm of speed and the maximum pass-by noise level, $L_{A_{\text{max}}}$ would be further developed in providing input to a prediction method for roadside noise levels.
Table G.1: Summary of roadside measurement sites

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Location</th>
<th>Speed (mile/h)</th>
<th>Surface Type</th>
<th>Condition</th>
<th>Site description</th>
<th>Typical vehicles</th>
<th>Additional information</th>
</tr>
</thead>
</table>
| 2       | A307, Kew Road            | 40             | HRA                | Average condition, some bumps and potholing (‘Poor’) | Outside entrance to Richmond Squash Club                                      | • 4 axles tippers  
• 3 axle semi-trailers (few)  
• Rigid (various 2 & 3 axle)  
• Buses                                             |                                                                |
| 4       | Woolwich Road (from A102M flyover) | 30/40          | HRA                | Worn but generally in good condition (‘Good’) | Outside entrance to disused warehouse next to Plumbase                         | • 4 axles tippers  
• 3 axle semi-trailers  
• Rigid (various 2 & 3 axle)  
• Buses                                             | High traffic flow                                            |
| 5       | Western Way               | 50             | SMA (14 mm)        | Good condition. Appears reasonably new (‘Good’) | Outside disused entrance to Belmarsh prison                                     | • 4 axles tippers  
• 3 axle semi-trailers  
• Rigid (various 2 & 3 axle)  
• Buses                                             | High traffic flow                                            |
| 6       | Eastern Way               | 50             | SMA                | Good condition. However, site has a dip where the road has sunk at the bridge joints; good for exciting vehicle suspensions (‘Poor’) | On the sliproad bridge over the stream                                           | • 4 axles tippers  
• 3 axle semi-trailers  
• Rigid (various 2 & 3 axle)  
• Buses                                             | High traffic flow                                            |
| 9       | A205, Mortlake Road       | 30             | SMA (14 mm)        | Worn surface with some rutting and cracking (‘Poor’) | Disused entrance to Mortlake crematorium                                        | • 4 axles tippers  
• 3 axle semi-trailers  
• Rigid (various 2 & 3 axle)  
• Buses                                             | Good site for low-speed vehicles                            |
| 10      | A21, Farnborough Road     | 40             | Surface dressing (14 mm) | Worn surface with some cracking (‘Good’) | Midway between B2158 and The Rose & Crown P.H (Southbound)                     | • 4 axles tippers  
• 3 axle semi-trailers  
• Rigid (various 2 & 3 axle)                                             |                                                                |
Regression equation for noise indicator SEL:
\[ SEL = 12 \log_{10} (v) + 64.5 \text{ dB} \]
\[ R^2 = 0.3094 \]

Regression equation for noise indicator LAmax:
\[ LA_{\text{max}} = 25.2 \log_{10} (v) + 39.5 \text{ dB} \]
\[ R^2 = 0.5846 \]

Figure G.1: Relationship between the logarithm of speed and the noise descriptors LAmax and SEL measured at all test sites vehicles with 3 or more axles

Regression equation for vehicles with no identifiable noise source:
\[ SEL = 0.7445 LA_{\text{max}} + 22.869 \text{ dB(A)} \]
\[ R^2 = 0.864 \]

Regression equation for vehicles with identifiable noise source:
\[ SEL = 0.6153 LA_{\text{max}} + 33.5 \text{ dB(A)} \]
\[ R^2 = 0.726 \]

Figure G.2: Relationship between SEL and LAmax for different vehicle groups
G.3 Development of a general relationship for different vehicle categories and road condition.

The first stage in developing a general relationship between vehicle noise and speed for different vehicle categories was to divide the data according to the road surface condition described for each site in Table G.1. Sites where there were noticeable surface irregularities such as bumps and hollows, rutting or other features which could induce body rattle were identified as in poor condition (Sites 2, 6 and 9) the other sites were classified as in good condition (Sites 4, 5 and 10). The data recorded at sites where the road surfaces where classified as poor were combined into a separate data set from the data collected on good condition roads.

For both road conditions the relationship between vehicle noise and the logarithm of vehicle speed was examined. This analysis excluded any vehicles which were identified with a discernable noise characteristic. Figure G.3 to Figure G.5 show the relationship between the maximum pass-by noise level, $L_{Amax}$, and vehicle speed for the three groups of vehicles; cars, car based vans and transits with single tyres on the rear axle; 2-axle rigids with twin tyres on the rear axle; and rigid or articulated vehicles with 3 or more axles.

For each vehicle category, the figures show that the maximum noise level from vehicles travelling on the poor conditioned roads were about 2 dB(A) higher than compared with vehicles travelling on roads in good condition.

![Figure G.3: Relationship between noise and speed for cars and vans on good and poor road conditions](image-url)
Regression equation at sites 2, 6 and 9 - road condition poor:
\[ L_{\text{Amax}} = 24.154 \log(v) + 38.433 \text{ dB(A)} \]
\[ R^2 = 0.6853 \]

Regression equation at sites 4, 5 and 10 - road condition good
\[ L_{\text{Amax}} = 22.712 \log(v) + 38.729 \text{ dB(A)} \]
\[ R^2 = 0.2378 \]

Figure G.4: Relationship between noise and speed for 2-axle commercial vehicles on good and poor road conditions

Regression equation at sites 2, 6 and 9 - road condition poor:
\[ L_{\text{Amax}} = 29.343 \log(v) + 32.919 \text{ dB(A)} \]
\[ R^2 = 0.7344 \]

Regression equation at sites 4, 5 and 10 - road condition good
\[ L_{\text{Amax}} = 22.005 \log(v) + 43.373 \text{ dB(A)} \]
\[ R^2 = 0.2229 \]

Figure G.5: Relationship between noise and speed for commercial vehicles with 3 or more axles on good and poor road conditions

In Figure G.5 a regression line derived from similar data collected in urban areas in the mid-1970’s is also shown for vehicles with 3 or more axles. This data was added to the figure in order to examine whether there were significant differences been the current data set and data collected over thirty years ago. Although, for the 1970’s data, there is no information about the condition of the roads, it is clear that overall for urban traffic conditions the
relationship between vehicle noise and speed has not significantly changed over the past thirty years. This is despite the fact that substantial reductions have occurred in the noise limit values for vehicles of this category in the type approval test. Since the 1970’s, reductions of at least 10 dB(A) have been introduced.

This observation has been noted elsewhere. For example, Sandberg in a report for the INCE Working Party on Noise Emissions of Road Vehicles (Sandberg, 2001) acknowledges the failure of the type approval test method and associated noise limits in controlling traffic noise, particularly under steady speed conditions. Amongst the reasons for the limited effectiveness, it was observed that:

(i) Initial limit values were so liberal that subsequent reductions were not as stringent as they may appear.

(ii) The type approval test is designed to control the maximum noise capable from the engine, exhaust and transmission which may not be representative or indeed relevant to the noise sources which are important under typical driving conditions e.g. tyre noise.

(iii) Type approval limits only apply to new vehicles and any benefits they introduce takes several years to be effective as older vehicles are replaced in the vehicle population.

Current work to introduce test methods which are more representative of vehicle noise in traffic is being developed but it is expected that it will take several years before new noise limits are in place and for them to become effective.

Further analysis was carried out on the vehicles which were identified with discernable noise characteristics. Although there was not a sufficient number of vehicles in each vehicle category to examine the relationship between road speed and noise and therefore compare with those vehicles with no discernable noise characteristics, an analysis of the noise spectra showed some interesting comparisons and are discussed in the next section.
Appendix H. Description of vehicle noise tests

The following sections describe the different test procedures used for the noise measurements conducted on the TRL test track.

H.1 Regulation 51 type approval test

This test was included as the results indicate the maximum noise the vehicle can generate from the power train sources which include the engine and exhaust systems.

Measurements were performed on the ISO surface of the TRL test track according to the layout shown in Figure H.1.

![Diagram of the site layout for type approval test](image)

**Figure H.1: Site layout for type approval test**

**H.1.1 Vehicle operation**

The letter symbols used in the following paragraphs have the following meaning:

- **$S$:** engine rotation speed at maximum rated power
- **$N_A$:** uniform engine rotational speed at the approach of line AA'
- **$V_A$:** uniform vehicle speed at the approach of line AA'
- **$V_{max}$:** maximum speed declared by the vehicle manufacturer.

**Approach speed:** The vehicle approached the line AA' at a steady speed such that:

either \[ V_A = 50 \text{ km/h} \]
or \( V_A \) corresponding to \( N_A = 3/4 \) S and
\[ V_A \leq 50 \text{ km/h} \]
in the case of vehicles of category M1 and in the case of vehicles of
categories other than M1 having an engine power not greater than 225
kW (ECE);

or \( V_A \) corresponding to \( N_A = 1/2 \) S and
\[ V_A \leq 50 \text{ km/h} \]
in the case of vehicles not belonging to category M1 having an engine
power greater than 225 kW (ECE);

Choice of the gear ratio: Vehicles of categories other than M1 and N1 whose number of
forward gears is \( x \) (including those obtained by way of an auxiliary
transmission or a multi-gear axle) were tested successively with the
gear selection equal to or higher than \( x/n \).\(^{17}\)

The test result was that obtained from the ratio producing the maximum sound level. Shifting
up gears from \( x/n \) was terminated in that gear \( X \) where the engine speed \( S \), at which the
engine developed its maximum rated power was for the last time reached when passing the
line BB’.

H.1.2 Noise measurement

At least two measurements were made on each side of the vehicle. Any preliminary
measurements made for adjustment purposes were disregarded.

The microphone was located at a distance of 7.5 ± 0.2 m from the reference line CC’ (Figure
H.1) of the track and 1.2 ± 0.1 m above the ground. Its axis of maximum sensitivity was
horizontal and perpendicular to the path or the vehicle (line CC’).

Two lines, AA’ and BB’, parallel to line PP’ and situated respectively 10 m forward and 10 m
rearward of that line were marked out on the test runway.

The vehicle was driven in a straight line over the acceleration section in such a way that the
longitudinal median plane of the vehicle was as close as possible to the line CC’ and
approached line AA’ at a steady speed as specified below. When the front of the vehicle
reached the line AA’, the throttle was fully opened as rapidly as practicable and held in the
fully-opened position until the rear of the vehicle crossed line BB’; the throttle was then
closed again as rapidly as possible.

In the case of articulated vehicles consisting of two non-separable units regarded as a single
vehicle, the semi-trailer was disregarded in determining when line BB’ was crossed.

The maximum sound level expressed in A-weighted decibels, dB(A), was measured as the
vehicle was driven between lines AA’ and BB’. This value constituted the result of the
measurement.

H.1.3 Test result

The measurements of noise emitted by the vehicle in motion were considered valid if the
difference between the two consecutive measurements on the same side of the vehicle was
not more than 2 dB(A).

\(^{17}\) Where \( n = 2 \) for vehicles having an engine power not greater than 225 kW (ECE); \( n = 3 \) for vehicles having an
engine power greater than 225 kW (ECE). If \( x/n \) does not correspond to a whole number, the nearest higher ratio
must be used.
The figure recorded was that corresponding to the highest sound level. If that figure exceeded by more than 1 dB(A) the maximum sound level authorized for the category of vehicle tested, a second series of two measurements at the corresponding microphone position was made. Three out of the four results obtained in this position must fall within the prescribed limits.

To allow for lack of precision in the measuring instrument the figures read from it during measurement were each reduced by 1 dB(A).

H.2 Cruise-by (constant speed) test

This test was included so that noise levels from the selected vehicles could be compared with levels from similar vehicles measured during the noise surveys in London.

Measurements were performed on the Hot Rolled Asphalt (HRA) and Stone Mastic Asphalt (SMA) surfaces on the TRL test track.

H.2.1 Microphone positions

Two microphones were positioned at 7.5 m from the centre line of the vehicle trajectory at a height of 1.2 m. One microphone was positioned alongside the HRA surface and the other alongside the SMA surface. The minimum distance between the surface interface and the sites alongside the microphone position was ≥ 30m.

H.2.2 Vehicle operation:

The vehicle travelled at constant speed past each microphone in the appropriate gear for the speed designated.

- Designated speeds: 40, 50, 60, 70, 80 km/h. Speeds were measured using a radar system.
- Number of tests: Two runs were conducted for each designated test speed.

H.2.3 Noise measurement:

For each test, the maximum A-weighted sound level (recorded using Fast exponential averaging) was recorded. In addition, the speed as the vehicle travelled through the site was recorded using radar.

H.2.4 Test result:

A regression equation of maximum noise level against the logarithm of vehicle speed was calculated from the 10 measurements for each surface, separately.

H.3 Rapid acceleration to GRO test

The rapid acceleration test is a test procedure based on earlier work carried out at TRL which has shown to provide a reasonable indicator of the noise generated under type approval conditions and under other operating conditions such as pull-away from rest. However, these results were from a limited data set and so these additional tests conducted here would help to explore these relationships. It is a test carried out with the vehicle stationary and is therefore best suited for in-service testing.
H.3.1 Instrumentation
All instrumentation used conformed to that specified in the ISO standard or EU Directive. All sound level instrumentation used was set to fast exponential averaging and A-weighting. Calibration of the equipment was carried out according to the manufacturers' instructions prior to and immediately following testing. Periodic checks of calibration were made during the testing period. Variations in calibration of more than 0.5 dB(A) would invalidate the results.

H.3.2 Conditions of measurement
The test site had a uniform hard reflecting surface within the microphone configurations shown below. Measurements were only taken in good weather conditions. Checks were made to ensure that wind gusts did not affect meter readings. Ambient noise was to be at least 10 dB(A) below test levels.

H.3.3 Microphone array locations
The measurements were performed at the microphone positions shown in Figure H.2 below.

![Microphone array locations](image)

Figure H.2: Site layout for rapid acceleration test

H.3.4 Method of measurement
The method required the test vehicles' engine to be accelerated as rapidly as possible. The engine was accelerated rapidly from idle to the maximum allowable speed (e.g. GRO) and...
then the throttle released and the engine allowed to return to idle. The maximum noise level was recorded during the whole operation.

The maximum noise level at each microphone and the maximum engine speed achieved were recorded. The results from three tests were recorded.

H.4 Pull away from rest test

This test was included to represent typical driving conditions encountered at junctions, roundabouts and light-controlled road sections where complaints from road traffic are not uncommon.

H.4.1 Instrumentation

All instrumentation used conformed to that specified in the EU vehicle noise type approval Directive. All sound level instrumentation used was set to fast exponential averaging and A-weighting. Calibration of the equipment was carried out according to the manufacturer instructions prior to and immediately following the completion of testing. Periodic checks of calibration were made during the testing period. Variations in calibration of more than 0.5 dB(A) would invalidate the results. Engine and vehicle speed were measured to an accuracy of 2% or better.

H.4.2 Conditions of measurement

The test site was a uniform hard surface including the area where the microphones were located. Measurements were only taken in good weather conditions and when the track was dry. Checks were made to ensure that wind gusts do not affect meter readings.

The A-weighted sound level of sound sources other than those of the vehicle to be tested and of wind effects were required to be at least 10dB(A) below the sound level produced by the vehicle.

H.4.3 Method of measurement

The test site layout is shown in Figure H.3. The test procedure required that the maximum noise level in dB(A) was determined during an operation involving accelerating the vehicle from rest with microphones positioned at 5, 10, 20 and 30 m from the start position at a distance of 7.5 m from the vehicle centre line at a height of 1.2 m. Only one side of the vehicle was tested, i.e. the side which produced the highest noise level during the Reg. 51 type approval test. The objective was to simulate the type of vehicle operation that commonly occurs at traffic lights and at road junctions.
To carry out the test the vehicle was initially positioned with its front opposite the start line of the test strip, i.e. 20 m downstream of the centre of the test site. When testing, the gear selected was that which is considered to be normal for the type of vehicle and operation. The vehicle was accelerated smoothly and the change in gear selection consistent with normal driving conditions until the rear of the vehicle passed the stop line of the test strip. Having passed the stop line, the throttle setting was released.

During the test, the maximum noise level was recorded at all microphone positions. Any noise generated by the air brakes was discarded. In addition measurements of the speed of the vehicle and the acceleration were taken during the drive-by. At least 40 individual readings of speed and acceleration were recorded during each drive-by.

The test was repeated 5 times with the vehicle accelerating at different rates to cover a wide range of possible smooth accelerating conditions. As a guide, the target speed range at the stop line position was in the range 15 - 35 km/h. In all cases the objective was to obtain a good spread of data over the range applicable for the vehicle under test.

H.4.4 Results

For each test run the complete time history of the noise level at both microphones and the speed and acceleration was recorded.
Appendix I. Test track results

I.1 Vehicle measurements

Type approval test

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>LHS</th>
<th>RHS</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF1</td>
<td>81.7</td>
<td>80.2</td>
<td>81.0</td>
</tr>
<tr>
<td>DAF2</td>
<td>80.4</td>
<td>81.1</td>
<td>80.8</td>
</tr>
<tr>
<td>Volvo (exc. trailer)</td>
<td>79.9</td>
<td>80.3</td>
<td>80.1</td>
</tr>
<tr>
<td>Volvo (inc. 3-axle trailer)</td>
<td>80.1</td>
<td>81.0</td>
<td>80.6</td>
</tr>
<tr>
<td>DAF3</td>
<td>79.3</td>
<td>79.7</td>
<td>79.5</td>
</tr>
</tbody>
</table>

Stationary test – ISO

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>P7</th>
<th>P8</th>
<th>Extra</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF1</td>
<td>92.6</td>
<td>91</td>
<td>91.6</td>
<td>81.3</td>
<td>80.5</td>
<td>81.3</td>
<td>89.8</td>
<td>91.3</td>
<td>97.2</td>
</tr>
<tr>
<td>DAF2</td>
<td>93.5</td>
<td>90.8</td>
<td>88.7</td>
<td>79.4</td>
<td>78.1</td>
<td>78.7</td>
<td>88.4</td>
<td>91.5</td>
<td>95.1</td>
</tr>
<tr>
<td>Volvo (exc. trailer)</td>
<td>91.6</td>
<td>88.3</td>
<td>88</td>
<td>79.9</td>
<td>79.5</td>
<td>80.7</td>
<td>88.7</td>
<td>88.7</td>
<td>91.9</td>
</tr>
<tr>
<td>DAF3</td>
<td>91.2</td>
<td>90.4</td>
<td>88.1</td>
<td>79.9</td>
<td>75.4</td>
<td>79.4</td>
<td>87.9</td>
<td>89.2</td>
<td>94.3</td>
</tr>
</tbody>
</table>

Pull away from rest – ISO. Through gears (1-2-3 etc) in green

Using gears 1, 2, 3, etc... in sequence, keeping RPM in “green band” (economy)

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF1</td>
<td>81.3</td>
<td>79.7</td>
<td>79.6</td>
<td>79.7</td>
</tr>
<tr>
<td>DAF2</td>
<td>82.0</td>
<td>81.7</td>
<td>81.2</td>
<td>80.9</td>
</tr>
<tr>
<td>Volvo (exc. trailer)</td>
<td>78.4</td>
<td>79.3</td>
<td>79.2</td>
<td>77.2</td>
</tr>
<tr>
<td>Volvo (inc. 3-axle trailer)</td>
<td>79.3</td>
<td>80.5</td>
<td>78.7</td>
<td>78.2</td>
</tr>
<tr>
<td>DAF3</td>
<td>80.4</td>
<td>79.8</td>
<td>78.0</td>
<td>78.6</td>
</tr>
</tbody>
</table>

Pull away from rest – ISO. Normal for driver but in green

Driver selecting appropriate gears for the vehicle, keeping RPM in “green band” (economy)

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF1</td>
<td>Test not done on this vehicle</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAF2</td>
<td>80.9</td>
<td>80.7</td>
<td>79.8</td>
<td>79.7</td>
</tr>
<tr>
<td>Volvo (exc. trailer)</td>
<td>79.0</td>
<td>78.5</td>
<td>78.0</td>
<td>77.0</td>
</tr>
<tr>
<td>Volvo (inc. 3-axle trailer)</td>
<td>79.1</td>
<td>79.1</td>
<td>78.6</td>
<td>78.6</td>
</tr>
<tr>
<td>DAF3</td>
<td>77.4</td>
<td>76.9</td>
<td>78.1</td>
<td>78.0</td>
</tr>
</tbody>
</table>
Pull away from rest – ISO. Normal for driver but can go in red
Driver selecting appropriate gears for the vehicle using full RPM range

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF1</td>
<td>82.7</td>
<td>82.9</td>
<td>82</td>
<td>82.9</td>
</tr>
<tr>
<td>DAF2</td>
<td>82.2</td>
<td>81.9</td>
<td>81.7</td>
<td>80.8</td>
</tr>
<tr>
<td>Volvo (exc. trailer)</td>
<td>80.9</td>
<td>81.2</td>
<td>81.4</td>
<td>78.9</td>
</tr>
<tr>
<td>Volvo (inc. 3-axle trailer)</td>
<td>81.2</td>
<td>80.8</td>
<td>80.7</td>
<td>79.9</td>
</tr>
<tr>
<td>DAF3</td>
<td>81.6</td>
<td>80.8</td>
<td>78.6</td>
<td>79.9</td>
</tr>
</tbody>
</table>

Pull away from rest – ISO. Start in 1, end at 20 km/h
Start in Gear 1, change to an appropriate gear to reach 20 km/h at end of site (after approximately 30 m)

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF1</td>
<td>82.3</td>
<td>80.6</td>
<td>81.3</td>
<td>80.5</td>
</tr>
<tr>
<td>DAF2</td>
<td>80.6</td>
<td>80</td>
<td>79.2</td>
<td>78</td>
</tr>
<tr>
<td>Volvo (exc. trailer)</td>
<td>79.9</td>
<td>80</td>
<td>78.3</td>
<td>77.5</td>
</tr>
<tr>
<td>Volvo (inc. 3-axle trailer)</td>
<td>81.4</td>
<td>81.8</td>
<td>81.8</td>
<td>79.3</td>
</tr>
<tr>
<td>DAF3</td>
<td>79.8</td>
<td>78.9</td>
<td>77.0</td>
<td>75.3</td>
</tr>
</tbody>
</table>

Cruise-by (constant speed) on HRA

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>40 km/h</th>
<th>50 km/h</th>
<th>60 km/h</th>
<th>70 km/h</th>
<th>80 km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF1</td>
<td>Missing data due to poor weather</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAF2</td>
<td>78.9</td>
<td>79.3</td>
<td>81.1</td>
<td>82.5</td>
<td>84.2</td>
</tr>
<tr>
<td>Volvo (inc. 3-axle trailer)</td>
<td>77.7</td>
<td>80.3</td>
<td>82.4</td>
<td>84.8</td>
<td>86.8</td>
</tr>
<tr>
<td>DAF3</td>
<td>77.3</td>
<td>77.8</td>
<td>80.1</td>
<td>82.3</td>
<td>84.5</td>
</tr>
</tbody>
</table>

Cruise-by (constant speed) on SMA

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>40 km/h</th>
<th>50 km/h</th>
<th>60 km/h</th>
<th>70 km/h</th>
<th>80 km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF1</td>
<td>Missing data due to poor weather</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAF2</td>
<td>78.7</td>
<td>78.5</td>
<td>80.3</td>
<td>80.3</td>
<td>82.6</td>
</tr>
<tr>
<td>Volvo (inc. 3-axle trailer)</td>
<td>76.8</td>
<td>78.9</td>
<td>81.3</td>
<td>82.8</td>
<td>85.4</td>
</tr>
<tr>
<td>DAF3</td>
<td>74.9</td>
<td>76.6</td>
<td>78.9</td>
<td>81.9</td>
<td>84.3</td>
</tr>
</tbody>
</table>
I.2  Repeatability/reproducibility measurements using DAF2 vehicle

**Stationary test – ISO**

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>P7</th>
<th>P8</th>
<th>Extra</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF2 (Driver 1 – HRA)</td>
<td>93.1</td>
<td>91.1</td>
<td>88.8</td>
<td>80.3</td>
<td>78</td>
<td>79.4</td>
<td>88.5</td>
<td>91.2</td>
<td>94.5</td>
</tr>
<tr>
<td>DAF2 (Driver 2 – ISO)</td>
<td>93.5</td>
<td>90.8</td>
<td>88.7</td>
<td>79.4</td>
<td>78.1</td>
<td>78.7</td>
<td>88.4</td>
<td>91.5</td>
<td>95.1</td>
</tr>
</tbody>
</table>

Pull away from rest – ISO. Through gears (1-2-3 etc) in green

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF2 (Driver 1 – HRA)</td>
<td>80.8</td>
<td>80.4</td>
<td>79.8</td>
<td>78.8</td>
</tr>
<tr>
<td>DAF2 (Driver 2 – ISO)</td>
<td>82</td>
<td>81.7</td>
<td>81.2</td>
<td>80.9</td>
</tr>
</tbody>
</table>

Pull away from rest – ISO. Normal for driver but in green

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF2 (Driver 1 – HRA)</td>
<td>79.5</td>
<td>81.9</td>
<td>80.1</td>
<td>77.9</td>
</tr>
<tr>
<td>DAF2 (Driver 2 – ISO)</td>
<td>80.9</td>
<td>80.7</td>
<td>79.8</td>
<td>79.7</td>
</tr>
</tbody>
</table>

Pull away from rest – ISO. Normal for driver but can go in red

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF2 (Driver 1 – HRA)</td>
<td>81.1</td>
<td>81.0</td>
<td>78.9</td>
<td>78.9</td>
</tr>
<tr>
<td>DAF2 (Driver 2 – ISO)</td>
<td>82.2</td>
<td>81.9</td>
<td>81.7</td>
<td>80.8</td>
</tr>
</tbody>
</table>

Pull away from rest – ISO. Start in 1, end at 20 km/h

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>P1</th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
</tr>
</thead>
<tbody>
<tr>
<td>DAF2 (Driver 1 – HRA)</td>
<td>80.9</td>
<td>80.5</td>
<td>79.8</td>
<td>78.6</td>
</tr>
<tr>
<td>DAF2 (Driver 2 – ISO)</td>
<td>80.6</td>
<td>80</td>
<td>79.2</td>
<td>78</td>
</tr>
</tbody>
</table>
Appendix J. Cost-benefit analysis

J.1 Methodology
For the purpose of making these calculations, we have assumed a particular test limit for the London test. We define the test limit in terms of the amount of noise abatement that would be achieved, when a vehicle that could just pass the test is used on the road. We assume a limit that would only allow vehicles to pass the test if they produced 50% less noise disbenefits in ordinary operation than the mean for all new vehicles over 18 tonnes that are on sale when the test is introduced. Henceforth, we refer to this as the 'chosen noise test limit'.

Considering the recommendations in Section 10.1, once again, the 50% noise test limit might, for example, correspond to a noise limit of 85 dB(A) in the stationary and 75 dB(A) in the pull-away test.

Clearly, we are defining the limit in terms of the reduction in the amount of noise damage that is imposed on the public. The amount of noise damage depends on the perceived loudness of sound, which in turn depends on the acoustic energy emitted by the vehicle. It is this acoustic energy level that would be reduced by the appropriate choice of a decibel noise limit in the test.

In most cost-benefit studies, a technique called 'discounting' is used to bring values from future years back into 'current year' prices. This aids comparisons of costs and benefits. However, the assumptions used in this report lead to relatively large error ranges in the estimates of environmental disbenefits, and the costs and benefits only lie over a period of five years. Discounting is not appropriate in the light of such uncertainty. In fact, discounting would create a false impression of 'precision' in the estimates in this report, so the authors consider that discounting is not appropriate here.

J.1.1 Which environmental values should we use?
In 2005, the DfT agreed a set of financial values for the environmental 'disbenefits' due to each mile driven by large goods vehicles. These are set out in reference DfT/SRA(2005).

In this report, we use the values shown in Table J.1. The values in the first column have been selected from Table 2 of DfT/SRA(2005). The values in subsequent columns are our assumptions of how these values vary by time of day in London.

<table>
<thead>
<tr>
<th>Environmental impact</th>
<th>Value per Large Goods Vehicle mile (pence)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean values provided in table 2 of DfT/SRA(2005)</td>
</tr>
<tr>
<td>Noise</td>
<td>9</td>
</tr>
<tr>
<td>Road congestion</td>
<td>136</td>
</tr>
</tbody>
</table>
Two issues are important here:

(i) Table 2 of reference DfT/SRA2005 also offers valuations for damage to infrastructure, and for ‘Pollution’. We have not used these in this cost benefit study. The values for infrastructure damage will not vary significantly if journeys in London are made at different times of the day or night. So changes to the LLCS will have little effect on the total value of damage. The values for Pollution in London from Large Goods Vehicles will fall greatly when the Low Emission Zone is introduced. The values in DfT/SRA2005 for pollution are therefore far higher than those that will arise from the new vehicles used in London after 2010, with which this study is concerned.

(ii) We do not have accurate information about how the noise and congestion damage levels vary in London at different times of the day and night. In Table J.1, we have based the three values for noise damage on the relative weightings given to noise in these time periods by the European ‘Day-evening-night’ (L\textscript{DEN}) calculation. For congestion, the values reflect levels of traffic across all London, on various classes of road. A major technical study would be required to provide more accurate values for congestion at various times of the day and night. In the absence of such information, we have used expert judgement to decide on the values in Table J.1. ‘Table B-21 of reference UNITE2003 provides values for ‘HGV’ noise in a European city by day and by night. UNITE2003 is a major EU study of the value of environmental externalities. The night time value in UNITE2003 is greater by a factor of 2.4 than the daytime value. This provides support for the assertion in Table 11.1 of this report that the value assigned to night time noise from Large Goods Vehicles should be at least twice the value of noise by day.

J.1.2 How much would operators use the hours that are newly available?

If incentive package 1 were offered to operators, we assume in this study that a vehicle with a Reduced Noise Certificate would operate for all the additional hours available to it. So the vehicle would operate for 20 hours more per week than an equivalently sized vehicle that did not have a Reduced Noise Certificate. See Table 10.1, upper row.

We need to consider how many extra hours a vehicle would be operated, if incentive package 2 were offered. We know that vehicles would not be used for all 168 hours per week. Major factors in this are the cost of drivers at night, and the fact that many sites in London are subject to planning conditions that prohibit deliveries at certain hours. With incentive package 2, we assume that a vehicle with a Reduced Noise Certificate would operate during the following hours that are currently ‘controlled’:

(i) From 0500-0700 and 2100-2400, Monday-Friday; and

(ii) From 0900-1700 on Sunday. Sunday is a more attractive day for operators than Saturday, due to the need to replenish work places and shops ready for Monday.

So, with incentive package 2, the vehicle would operate for 33 more hours than an equivalently sized vehicle that did not have a Reduced Noise Certificate.

With both incentive packages, we assume that a delivery made during the controlled hours by a vehicle with a Reduced Noise Certificate would replace a delivery that would otherwise have been made by the same vehicle in the ‘uncontrolled’ hours.
J.2 Benefits

With both incentive packages, we assume that a delivery made during the controlled hours by a vehicle with a Reduced Noise Certificate would replace a delivery that would otherwise have been made by the same vehicle in the 'uncontrolled' hours. However, if any decisions regarding the introduction of in-service testing and the Reduced Noise Certificate are to be made based on the financial benefits, quantification of the actual demand for such replacement of deliveries in the 'uncontrolled' hours would be needed. We will henceforth use the term “typical vehicle" for LGVs over 18 tonnes that do not have a Reduced Noise Certificate.

Table J.1 provides the costs of noise emissions and congestion due to a large goods vehicle, per mile, at each time of day and night. We assume that a large goods vehicle will travel at 10 miles per hour, at all times. This mean figure covers a wide range of actual speeds:

(i) Various speeds at different times of day and night, due to varying congestion.
(ii) Various speeds on different types of road. Speeds would be highest on the TfL network. Speeds would be lowest in inner London and on the smaller roads.
(iii) Time spent stationary when unloading.

The congestion values in Table J.1 therefore need to be multiplied by ten, to convert them into values per hour of lorry operation. However, a large goods vehicle with a Reduced Noise Certificate incurs only half as much noise disbenefits per mile as typical large goods vehicles. So the noise values in Table J.1 therefore only need to be multiplied by five, to convert them into values per hour of lorry operation. These values are shown in Table J.2, which relates to each hour of vehicle operation. The first row in Table J.2 shows noise disbenefits per hour for a typical vehicle, which are simply double those in the row below.

<table>
<thead>
<tr>
<th>Environmental impact</th>
<th>Value 0700-2100 Monday-Saturday</th>
<th>Value 2100-2300 Monday-Saturday</th>
<th>Value 2300-0700 Monday-Saturday and all day Sunday</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise from typical vehicle</td>
<td>0.80</td>
<td>1.20</td>
<td>1.60</td>
</tr>
<tr>
<td>Noise from vehicle with a reduced noise certificate</td>
<td>0.40</td>
<td>0.60</td>
<td>0.80</td>
</tr>
<tr>
<td>Road congestion for typical or reduced noise certificate vehicles</td>
<td>15.00</td>
<td>7.50</td>
<td>2.50</td>
</tr>
</tbody>
</table>

(Derived from Table J.1)

J.2.1 Calculation of Noise benefits

We calculate the noise benefits by considering that each delivery made by a large goods vehicle with a Reduced Noise Certificate replaces a journey that would otherwise be made by a typical large goods vehicle during the uncontrolled hours. This calculation of noise...
benefits takes into account the fact that a given lorry design produces differing levels of noise damage at different times of the day and night.

A more sophisticated calculation is possible, however, it is not considered appropriate at this stage in policy development. The various columns in Table J.2 show the value of the noise damage incurred at each time, so we can calculate the difference in noise damage between these two alternative delivery journeys.

**Incentive package 1**

The 10 hours of deliveries per week in the period 0500-0700 incur a noise cost of 80 pence per hour, which is the same as the cost of a journey in the uncontrolled hours by a typical vehicle. The 10 hours of deliveries in the hours 2100-2300 incur a noise cost of 60 pence per hour, which is 20 pence per hour less than the cost of a journey in the uncontrolled hours by a typical vehicle. So the operation in the period 0500-0700 and 2100-2300, per week, incurs lower noise damage by an amount equal to:

\[
\£0.20 \times 10 = \£2/week
\]

However, when operating during the uncontrolled hours, the vehicle with a Reduced Noise Certificate is also quieter than a typical vehicle. There are 75 uncontrolled hours per week. The vehicle with a Reduced Noise Certificate incurs a noise cost 40p/hour less during this time than the typical vehicle. This saves noise damage per week of:

\[
\£0.40 \times 75 = \£30/week
\]

The total value of noise saving is £32/week. Assuming that the lorry operates 50 weeks per year for five years, the noise saving is:

\[
\£32 \times 50 \times 5 = \£8000
\]

**Incentive package 2**

The 23 hours of deliveries per week by a vehicle with a Reduced Noise Certificate in the periods 0500-0700 and 2300-2400 Monday to Friday and 0900-1700 on Sunday incur a noise cost of 80 pence per hour, which is the same as the cost of a journey in the uncontrolled hours by a typical vehicle. The 10 hours of deliveries in the hours 2100-2300 incur a noise cost of 60 pence per hour, which is 20 pence per hour less than the cost of a journey in the uncontrolled hours by a typical vehicle. So the operation in the period 0500-0700 and 2100-2400, per week, incurs lower noise damage by an amount equal to:

\[
\£0.20 \times 10 = \£2/week
\]

When operating during the uncontrolled hours, the vehicle with a Reduced Noise Certificate is also quieter than a typical vehicle. There are 75 uncontrolled hours per week. The vehicle with a Reduced Noise Certificate incurs a noise cost 40p/hour less during this time than the typical vehicle. This saves noise damage per week of:

\[
\£0.40 \times 75 = \£30/week
\]

The total value of noise saving is £32/week. Assuming that the lorry operates 50 weeks per year for five years, the noise saving is:

\[
\£32 \times 50 \times 5 = \£8000
\]

**J.2.2 Calculation of congestion benefits**

We calculate the congestion benefits by considering that each delivery made by a large goods vehicle with a Reduced Noise Certificate in the controlled hours replaces a journey that would otherwise be made in the uncontrolled hours. The various columns in Table J.2...
show the value of the congestion damage incurred at each time, so we can calculate the
difference in congestion damage between these two alternative delivery journeys.

**Incentive package 1**
The 10 hours of deliveries per week in the period 0500-0700 incur a congestion cost of £2.50 per hour, which is £12.50 per hour less than a journey in the uncontrolled hours. The 10 hours of deliveries in the hours 2100-2300 incur a congestion cost of £7.50 per hour, which is £7.50 per hour less than the cost of a journey in the uncontrolled hours. So the operation with incentive package 1 would incur lower congestion costs by an amount equal to:

\[
(£12.50 \times 10) + (£7.50 \times 10) = £200/\text{week}
\]

Assuming that the lorry operates 50 weeks per year for five years, the congestion saving is:

\[
£200 \times 50 \times 5 = £50,000
\]

**Incentive package 2**
The 23 hours of deliveries per week in the period 0500-0700 and 2300-2400 Monday-Friday, and 0900-1700 on Sunday, incur a congestion cost of £2.50 per hour. This is £12.50 per hour less than a journey in the uncontrolled hours. The 10 hours of deliveries in the hours 2100-2300 incur a congestion cost of £7.50 per hour, which is £7.50 per hour less than the cost of a journey in the uncontrolled hours. So the operation with incentive package 2 would incur lower congestion costs by an amount equal to:

\[
(£12.50 \times 23) + (£7.50 \times 10) = £362.50/\text{week}
\]

Assuming that the lorry operates 50 weeks per year for five years, the congestion saving is:

\[
£362.5 \times 50 \times 5 = £81,625
\]

**J.3 Costs**
Operators will experience cost reductions, due to the increased productivity of vehicles that obtain a Reduced Noise Certificate. Indeed, it is this increase in productivity that provides the financial incentive for operators to acquire vehicles that can pass the test.

The major additional costs for operators relate to the cost of the test, and the cost of obtaining each vehicle that can pass the test.

We also discuss costs of enforcement below.

For costing purposes, it is assumed that a vehicle that passes the test is used for 5 years in London from new. The vehicle would therefore take the test five times.

**J.3.1 The test itself**
We estimate from our own experience that the test would take around 45 minutes, when carried out by experienced staff. However, we assume:

(i) That a vehicle would be out of service for two hours for the test.

(ii) That most vehicles would be tested at the same time as undergoing their MoT test.

(iii) £60 to cover two hours of lost operation and the cost of a driver’s time.

(iv) A test centre would charge £100 for the test. This would enable test centres to earn enough to cover staff, land and equipment costs.
The total cost to an operator of the test is therefore £160 per annum. The total would therefore be £800 for five years.

### J.3.2 The cost of each vehicle

It is likely that some vehicles would not need expensive modification to pass the noise test and receive a Reduced Noise Certificate. Some mass produced vehicles may already meet the limit value. Many more are likely to be able to meet the standard with an engine encapsulation system fitted. We assume that a vehicle meeting the test limit would involve an extra cost of £750 to the purchaser. This estimate is based on the costs given in the table in section 7.1 of reference PIEK (2002). The table in chapter 6 of reference PIEK (2005) provides a longer list of technologies that can abate noise, together with achievable noise limits.

### J.3.3 Increased vehicle productivity

Increased productivity results from vehicles being used in the controlled hours, compared to the present situation where these vehicles stand idle in that time. It is only possible to estimate the value of this productivity in an idealised situation. This is because:

1. In the real world, operators may currently use their vehicles outside London during controlled hours, so the vehicles would therefore not be idle.
2. The extended hours of operation available to an operator based outside London might only translate into greater flexibility in the times for which the vehicle can deliver to London. This is a relatively minor reduction in costs to operators.
3. Some vehicle deliveries in the controlled hours might replace deliveries made by several smaller vehicles, which is a very complex situation to model.

In order to account for these factors, we assume now that the extended hours available to operators with either incentive package 1 or 2 would be 50% as productive as the same number of delivery hours in the uncontrolled period.

### J.3.4 Increased vehicle productivity with incentive package 1

The 20 extra hours of delivery time equate to a saving of ten hours of delivery time in the uncontrolled hours. There are 76 uncontrolled hours per week. So each vehicle with a Reduced Noise Certificate is more productive by:

\[
\frac{10}{76} \times 100\% = 13\%
\]

The operator would save 13% of the cost of purchasing and operating one vehicle. We will estimate the cost of one vehicle as £50,000, as a mean value for the cost of a vehicle in the 18-38 tonne range. This is higher than the cost of a basic 18 tonne box vehicle. However, a cab and trailer combination or a specialised vehicle such as a fuel tanker would cost well in excess of this amount. So an increase in productivity of 13% translates into a saving in vehicle purchase costs of:

\[
0.13 \times £50,000 = £6500
\]

In the example above, the vehicle with a Reduced Noise Certificate would be used more intensively. There would be increased maintenance costs. However, an operator with several vehicles would actually need fewer vehicles, so costs such as insurance and the provision of parking land would fall appreciably.

We must offset the £6500 saving against the increased price of each vehicle, and the costs of five annual tests. The left column of Table J.3 summarises the change in costs to an
operator of acquiring and using one vehicle above 18 tonnes in London for five years, with incentive package 1.

**J.3.5 Increased vehicle productivity with incentive package 2**

We assumed that an operator would use vehicles for 33 of the currently controlled hours, with incentive package 2. Carrying out a similar calculation to that shown above for incentive package 1, leads to the figures in the right column of Table J.3.

<table>
<thead>
<tr>
<th>Cost incurred for:</th>
<th>Cost with incentive package 1 (£)</th>
<th>Cost with incentive package 2 (£)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attending for test</td>
<td>800</td>
<td>800</td>
</tr>
<tr>
<td>Purchase of compliant vehicle</td>
<td>750</td>
<td>750</td>
</tr>
<tr>
<td>Increase in productivity</td>
<td>-6500</td>
<td>-11,000</td>
</tr>
<tr>
<td>Total change</td>
<td>-£4,950</td>
<td>-£9,450</td>
</tr>
</tbody>
</table>

**J.3.6 The cost of enforcement**

Some of the enforcement costs would differ from those with the current LLCS. In particular:

(i) Enforcement officers would need some training.

(ii) The list of large goods vehicles that held a current Reduced Noise Certificate would need to be kept up to date.

With the availability of a Reduced Noise Certificate, there would be fewer applications for permits to operate off the ERN in any of the controlled hours. Indeed, large goods vehicles operating off the ERN at night with permits would become a rarity. The staff who currently enforce the LLCS would simply spend a rising proportion of their time checking vehicles that should have a Reduced Noise Certificate, and a correspondingly lower proportion of their time enforcing permits to operate off the ERN. The transition would be gradual and would take several years. It would occur faster with incentive package 2 than with incentive package 1.

Further discussions would be required to confirm any changes to enforcement regimes but overall, we assume no change in enforcement costs, relatively to those at present for the LLCS.
Appendix K. Potential noise benefits of example limit values

Section 10.2.4.1 of the report, presents an examination of the results from stationary tests undertaken on a sample of 7 vehicles. The rounded, average maximum A-weighted noise level from these tests was 91 dB(A).

The stationary test involves a rapid acceleration of the engine to its maximum allowable rpm. Setting a noise limit relating to the maximum allowable engine speed under stationary conditions may not be fully realised under normal driving conditions. If we assume that $2/3$rd of any reduction in the noise limit can be directly translated into a similar reduction in propulsion noise, the HARMONOISE model (see Section 13.2.1) can be used to predict the effects of changes in the noise limit values on traffic noise levels.

The road traffic conditions assumed for the predictions are those for the reference case reported in the modelling work in Phase 3 of the project (see Section 13.2). Specifically, an average-textured road surface has been assumed (SMA 11 mm), the percentage of whole vehicle LGVs with 3 or more axles was 2.28% and the number of 2-axle trucks (> 3.5 tonnes, < 18 tonnes) was 6.9%. All vehicles have been assumed to be travelling at 50 km/h. It is also assumed that the propulsion noise from all of the LGVs travelling along the route has been affected by any reduction in limit values to the same degree, i.e. that all of the vehicles operating on the route pass the stationary test for a given limit value.

To simplify the calculation, it is assumed that the limit value applied to the stationary test is set so that only a small proportion, e.g. 5%, of all LGVs tested would fail. NB. In section 10.2.4.1, based on 7 vehicles, a limit value of 91 dB(A) was shown as causing 50% of LGVs to fail the test.

The precise value of the limit for any given percentage of failures cannot be determined from such a small sample of vehicles as used in Section 10.2.4.1. Therefore in this example calculation, we assume that an average, maximum noise level in the stationary test of 91 dB(A) corresponds to a limit value causing only 5% failure, which is significantly higher than a limit of 91 dB(A).

Using the LGVs that lead to this average test level in the traffic scenario described above results in an average noise level for the traffic flow of 71 dB(A) and a maximum level for a single LGV of 79 dB(A) at a distance of 7.5 m from the centre of the nearside lane.

By reducing the limit value by an appropriate amount, we can bring down the average test level accordingly. In the following Table, we have considered the effects of reductions in the average test level of 1, 3 and 6 dB(A). The actual average test levels needed to bring about these decreases would be based on a consideration of the results from a larger sample of vehicles than used in the current study.

<table>
<thead>
<tr>
<th>Reduction in average test value from an initial value of 91 dB(A)</th>
<th>Roadside noise levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduction in average value ($L_{A\text{eq}}$) from an initial value of 71 dB</td>
<td>Reduction in maximum value ($L_{A\text{max}}$) from an initial value of 79 dB</td>
</tr>
<tr>
<td>1</td>
<td>0.06</td>
</tr>
<tr>
<td>3</td>
<td>0.17</td>
</tr>
<tr>
<td>6</td>
<td>0.28</td>
</tr>
</tbody>
</table>
Figure K.1 gives the trends of these benefits with limit value reductions.

![Figure K.1: Noise benefits of limit value set below mean value](image)

It can be clearly seen that reductions in average levels are smaller than for maximum levels. This is due to the fact that light vehicles which make-up about 90% of the traffic flow, contribute significantly to the average traffic noise level. However, in contrast, maximum noise levels are influenced by the noisier vehicles i.e. LGVs, and hence the benefits of reducing the noise limits for LGVs are more apparent.

It is clear from Figure K.1, that due to the low flow of LGVs in the traffic stream for this example, reductions in limit values have only a marginal influence in reducing average traffic noise levels i.e. less than 0.5 dB(A) and therefore may not have a significant impact on perception. However, results shown in the Figure for reductions in maximum noise levels are more encouraging, particularly from research which has shown that maximum noise levels are significant particularly for sleep disturbance. (Lansdell and Cameron, 1998).
Appendix L. The calculation procedure for the prediction of disturbance due to vehicles travelling off the ERN

As already reported in Section 8.3.2 and Appendix G of this report, the relationship (speed level function) between the maximum noise level $L_{A_{\text{max}}}$ emitted during a vehicle pass-by and the corresponding vehicle speed has been established for different categories of vehicle based on measurement data recorded at six different sites on the London road network (both on and off the ERN). In the longer term, as quieter vehicles are introduced into the market, or if the categories proposed in Phase 2 require revision, additional speed-level relationships can be derived to expand and improve the accuracy of the calculation procedure.

It uses $L_{A_{\text{max}}}$ values as the main input, derived from the average traffic speeds for the road in question, together with the traffic flow composition. The following text describes how the calculation procedure is applied.

It is first necessary to convert the predicted $L_{A_{\text{max}}}$ levels into their equivalent Sound Exposure Levels (SELS). This can be achieved using Equation (14) from the procedure developed by the Noise Advisory Council (1978) for predicting $L_{\text{eq}}$ levels which states that

$$SEL = L_{A_{\text{max}}}(v) - 10 \log_{10}(v) - 10 \log_{10} d + 10 \log_{10} 0 + 5.5 - 0.40 \text{ dB}$$

(L.1)

where $L_{A_{\text{max}}}$ is the maximum noise level at a distance of 7.5 m from the vehicle centre line corresponding to a vehicle speed $v$ km/h, $d$ is the shortest distance from the receiver to the edge of the nearside kerb or carriageway and $\theta$ is the angle of view of the road segment at the receiver position which generally may be assumed to be 180º.

The final term in equation (L.1), -0.4 dB(A), is to take account of the fact that the traffic travelling in both directions on the road is considered in the equation as a single flow in the nearest lane, i.e. the correction takes account of the additional distance of the far side traffic lane from the receiver position.

This equation effectively allows the prediction of SEL at individual roadside properties along a single stretch of road providing that the relevant values for $d$ are known.

The next step in the calculation is to use the SEL values to estimate average night-time noise levels. This requires the night-time vehicle flow figures for the period 23:00-07:00 on the road in question. Emmerson et al. (2003) proposed a method for using SEL values to estimate the annual average night-time noise level (for the period 23:00-07:00) $L_{\text{night}}$ (European Commission, 2002), based on the equation:

$$L_{\text{night}} = 10 \log_{10} \left( \sum_{i=1}^{N} 10^{0.1i\times SEL_i} T_s \right) \text{ dB(A)}$$

(L.2)

where $T_s = 10,512,000$ is the number of seconds in a year in the night period 23:00-07:00 and $SEL_i$ is the sound exposure level of each individual noise event, with $i = 1, 2, \ldots, N$ where $N$ is the total number of events (vehicle passages) in a year.

The above equation predicts $L_{\text{night}}$ values for a single category of vehicles. However, the proposed application of this calculation procedure requires the differentiation of LGVs from other vehicles in the traffic stream. Based on the available speed level functions (Chapter 8.3.2 and Appendix G), we can adapt equation (L.2) to predict $L_{\text{night}}$ levels based on three categories of vehicle (passenger cars and vans, two-axle goods vehicles and vehicles with three axles or greater). Their contribution to $L_{\text{night}}$ using the appropriate SEL values for each category is therefore expressed as:
\[ L_{\text{night}} = 10 \log_{10} \left( \sum_{j=1}^{M} \frac{N_j}{T_i} \sum_{i=1}^{N_j} 10^{0.1xSEL_j} \right) \text{dB(A)} \]  

where \( M \) is the total number of different vehicle categories (which for this model is 3) and \( N_j \) is the total number of vehicles classified in vehicle category \( j \).

If the numbers of vehicles in each category are expressed as percentages of the overall total number of vehicles, then this equation further simplifies to:

\[ L_{\text{night}} = 10 \log_{10} \left( \frac{N}{100T_i} \sum_{j=1}^{M} p_j \times 10^{0.1xSEL_j} \right) \text{dB(A)} \]  

Having calculated the annual average night-time noise level, for use as a routeing tool, it is more advantageous if this level can be expressed in terms of the disturbance that it is likely to cause. Miedema et al. (2003) presented a relationship between \( L_{\text{night}} \) levels and the percentage of people highly sleep disturbed (%HSD), as shown in Figure L.1, which states that

\[ \% \text{HSD} = 0.0148(L_{\text{night}})^2 - 1.05(L_{\text{night}}) + 20.8 \]  

**Figure L.1:** Relationship between night-time noise, \( L_{\text{night}} \), and a measure of sleep disturbance \( \% \text{HSD} \) (Miedema et al., 2003)

Therefore, using Equations (L.1),(L.4) and (L.5) together with \( L_{\text{Amax}} \) values determined from the relevant speed level functions, it is theoretically possible to predict the change in the percentage of people disturbed based on changes in traffic speed, volume and composition for a given road. However the following points need to be taken into account.

- Equation (L.1) only predicts SEL values at the façade of the property located closest to the road; therefore the %HSD will only address the population in the closest row of houses to the main road in question. Noise levels at properties behind this first row,
i.e. in adjacent streets, and the associated disturbance cannot be taken into account using these equations, although the model could be developed to include impacts at properties screened from the road;

- The equations also only predict $\%HSD$ for an “isolated” section of road. The $\%HSD$ at locations where multiple roads intersect, i.e. road junctions, cannot be calculated without further modifications to the equations.
Abstract
TRL Limited was commissioned by Transport for London (TfL) to undertake a review of the noise impacts from the London Lorry Control Scheme (LLCS) which limits the use of large goods vehicles over 18 tonnes within London and is administered by London Councils. The report addresses all three Phases of the Project, as follows:
Phase 1: An initial review of possible options for amendments to the LLCS, including possible revisions to the Exempt Road Network (ERN), more rigorous enforcement of the LLCS and changes to individual vehicles. The results from this Phase identified the best option as being to focus on the identification and controlling the operation of ‘quiet’ goods vehicles.
Phase 2: Development of an in-service, standardised noise test that if applied would identify quiet large goods vehicles.
Phase 3: Consideration of the requirements for an upgraded electronic noise map of London based on sleep disturbance and a noise sensitive traffic routing tool.
The final recommendations from the study were for the introduction of a voluntary ‘London in-service noise test’ for vehicles above 18 tonnes operating in London and currently already registered under the LLCS. The test would include noise measurements when stationary and pulling away from rest. Vehicles passing the test would be awarded a ‘Reduced Noise Certificate’ which would potentially allow a wider scope of operations than permitted under the current LLCS.
Alternative methods for the management of night-time freight noise in London

TRL Limited was commissioned by Transport for London (TfL) to undertake a review of the noise impacts from the London Lorry Control Scheme (LLCS) which limits the use of large goods vehicles over 18 tonnes within London and is administered by London Councils. The report addresses all three Phases of the Project, as follows:

Phase 1: An initial review of possible options for amendments to the LLCS, including possible revisions to the Exempt Road Network (ERN), more rigorous enforcement of the LLCS and changes to individual vehicles. The results from this Phase identified the best option as being to focus on the identification and controlling the operation of ‘quiet’ goods vehicles.

Phase 2: Development of an in-service, standardised noise test that if applied would identify quiet large goods vehicles.

Phase 3: Consideration of the requirements for an upgraded electronic noise map of London based on sleep disturbance and a noise sensitive traffic routing tool.

The final recommendations from the study were for the introduction of a voluntary ‘London in-service noise test’ for vehicles above 18 tonnes operating in London and currently already registered under the LLCS. The test would include noise measurements when stationary and pulling away from rest. Vehicles passing the test would be awarded a ‘Reduced Noise Certificate’ which would potentially allow a wider scope of operations than permitted under the current LLCS.

Other recent titles from this subject area

PPR103 A new approach for evaluating the sound propagation from a moving vehicle tyre using boundary element methods. P A Morgan, G R Watts. 2007.


CT54.3 Lorries and the environment update (2002-2005)

CT52.3 Environmental impact assessment studies update (2002-2005)

CT67.4 Road surface noise update (2005–2007)