Measures to Reduce the Frequency of Over-Height Vehicles Striking Bridges: Final Report

by A Martin and J Mitchell

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MEASURES TO REDUCE THE FREQUENCY OF OVER-HEIGHT VEHICLES STRIKING BRIDGES: FINAL REPORT

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by A Martin, J Mitchell (TRL Limited)

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Executive Summary

There are nearly 2000 reported bridge strikes recorded by Network Rail for their own bridges each year (where vehicles, typically lorries or double-decker buses, try to pass under bridges that are lower than the height of their vehicles). There is an upward trend in the occurrence of recorded bridge strikes. A review of statistics for the last ten years has shown that the number of reported strikes at underlines bridges has doubled. The consequences of bridge strikes can be very disruptive to road and rail transportation systems. Traffic can be brought to a standstill for several hours while damaged vehicles are removed. Bridges under railways tend to be associated with railway embankments which create barriers across the road network. Thus the bridges become critical points on those networks and any blockage there can have widespread impact. Where railway bridges are affected, speed restrictions or prohibitions may have to be placed on the line while the bridge is inspected to confirm that it is safe for vehicles to cross... Bridge strikes also cause damage to the rail infrastructure, which has to be repaired.

The occurrence of over height vehicles hitting low bridges, i.e. those bridges with a clearance of less than 5.03 metres, has been a problem for several decades. Various solutions have been proposed, working parties have been established, legislation has been updated, and however, the problem has still not been fully resolved. TRL Limited was commissioned in 2003, by the Department for Transport, to conduct research into the bridge strike problem and find ways of reducing the incidence of bridge strikes. In particular the project has concentrated on the following issues:

- To obtain a better understanding of the reasons why drivers do hit low bridges, so as to better target action to reduce the number of incidents;
- To review the range of measures that have been taken so far to reduce bridge strikes, especially those at the frequently hit bridges;
- To assess and/or develop other ways of reducing bridge strikes;
- To provide advice to the Department for Transport (the Department) and the Bridge Strike Prevention Group (BSPG).

The report takes the following format:

Stage 1

- Literature Review
- Survey of HGV Drivers
- Network Rail Database Survey

Stage 2

- Stakeholder Consultation
- Bridge Audits
- Bridge Observation Study
- Alternative Route Mapping

Stage 3

Assessment and development of existing and new initiatives that could be introduced to reduce bridge strikes.

Stage 4

This report forms the basis of stage 4, including summaries of the previous stages and concluding comments and recommendations for future measures.

Stage 1 of this study recognised that there was a clear need to ascertain reasons why drivers fail to adhere to the warning and mandatory signs located near bridges. TRL undertook a literature review,
focus groups and a questionnaire survey to explore these issues. In Stage 1, TRL also updated the analysis undertaken in 1996 on the bridge strike incidents in the Network Rail database. Stage 2 reviewed previous research and measures that have been taken to reduce bridge strikes. This included an assessment of current measures being used to reduce bridge strikes and meetings with stakeholders to establish views and experience regarding the bridge strike problem. Stage 2 involved four main phases: stakeholder meetings, bridge audits, a bridge observation study and an assessment of alternative routes.

The findings of Stages 1 and 2 highlighted the current issues surrounding the problem of over-height vehicles striking bridges and laid a good foundation for understanding which measures are effective at tackling the problem. Various parties described their own problems and constraints, and have highlighted their own recommended solutions. The third stage of this project assessed and developed those solutions, providing an evaluation of measures, leading the research to this final stage of reflection and recommendations.

This research has identified many issues and causes of over-height vehicles striking bridges, and there is not a single overall solution. The problem is therefore a complex one and solutions may be many and varied (national and local, high cost and low cost, high impact and low impact). There are, however, three main issues that have emerged and these appear to be having a big impact on the bridge strike problem. The issues are:

- Drivers not knowing the height of their vehicles;
- Lack of provision of alternative routes at low bridges, and lack of planning of routes by hauliers;
- Inadequate signing at and on the approach to low bridges.

The following measures are recommended in the final section of this report:

**National Measures**
- Driver education;
- Measuring vehicle height;
- Alternative route symbols;
- Infra-red detection systems;
- Database of low bridges;
- Enforcements cameras;
- Driver training and behaviour observation by simulation;
- In-cab alerting systems.

**Local Measures**
- Implementation of working groups;
- Bridge audits;
- Improvements in signing.

This report provides an overview of the research carried out within this project and the reports written at each stage of the research should be referred to for more detailed information. This research has made progress in finding ways of reducing the occurrence of bridge strikes, based on information collected and knowledge gained throughout the course of the project. The most important thing now is to ensure actions are taken forward simultaneously in order to provide comprehensive solutions.
1 Introduction
This report seeks to summarise and conclude research that has been carried out by TRL Limited, studying the issues surrounding the problem of over-height vehicles striking bridges. The research has taken the form of four stages which are described below.

Stage 1
The first stage of the project tackled the issue of why drivers hit low bridges and was addressed in three ways:

- **Literature Review** - firstly a literature review was conducted, summarising the actions and progress that have already been made in the UK and abroad;

- **Survey of HGV Drivers** - secondly a confidential survey of HGV drivers was undertaken to inform the research about the behaviour and attitudes of drivers of over-height vehicles;

- **Network Rail Database Survey** - thirdly, TRL reviewed and analysed a database of bridge strikes owned by Network Rail. The study identified the type of low bridges that were most commonly hit, the type of vehicles involved and bridges that are struck on a regular basis.

Stage 2
The second stage of the project reviewed previous research and measures that have been taken to reduce bridge strikes and was undertaken in four parts:

- **Stakeholder Consultation** - 20 stakeholder meetings were undertaken to gain information on good practices that have been adopted by Highway Authorities, Bridge Owners, Haulage Companies, Bus Operators and the Police.

- **Bridge Audits** - an audit of a sample of bridges was undertaken which assessed all types of bridges including those which have a reduced number of strikes and those which are still being hit. Each bridge in the sample was visited and site details were recorded and photographed.

- **Bridge Observation Study** - A video survey was carried out on 4 bridges identified in the bridge audits. The survey filmed each approach to identify driver behaviour as they approached and passed under the bridge.

- **Alternative Route Mapping** - This involved assessing the suitability of suggested diversion routes at low bridge sites. The assessment looked at the suitability of the routes in terms of additional time and associated costs (such as fuel) that drivers would incur.

Stage 3
The third stage of the project concentrated on the assessment and development of existing and new initiatives that could be introduced to reduce bridge strikes. New and existing ideas have been reviewed and formally evaluated with a view to making recommendations in the final report.

Stage 4
This report forms the basis of stage 4, including summaries of the previous stages and concluding comments and recommendations for future measures.

1.1 Background
There are nearly 2000 bridge strikes recorded by Network Rail for their own bridges each year. There are also strikes on bridges where a road passes over another road, on footbridges, on bridges carrying underground tracks and others, but because these are the responsibility of a range of different owners, national statistics are not collected in the same way as for Network Rail. Bridge strikes can occur on all types of bridges (beam or girder bridges with flat soffits or arch bridges) and on different types of roads (busy urban networks and inter-urban roads).
The severity of strikes varies. At the bottom end of the scale, the top of the vehicle may just scrape the underside of the bridge. With other severe incidents the bridge itself may be damaged, e.g. damage to an arch or spandrel wall could affect its stability, distorting or displacing a load carrying element of a bridge could reduce the load carrying capacity of the bridge, damaging a pre-stressed concrete element carrying a live load could expose the pre-stressing steel and damaging a reinforced concrete element carrying a live load could break the reinforcement. Track movement, i.e. the horizontal or vertical alignment of the railway track, can also be affected. A severe incident also causes a physical obstruction to the passage of trains. A severe incident could also bring down a bridge completely, as has happened with some footbridges. Other severe incidents can also involve vehicles getting stuck under bridges, the backs of lorries or the top deck of buses being torn off, or a vehicle toppling over. This can cause injuries, and indeed fatalities, to vehicle occupants or passers by.

The consequences of bridge strikes can be very disruptive for traffic, which can be brought to a standstill for several hours while damaged vehicles are removed. Bridges under railways tend to be associated with railway embankments which create barriers across the road network. Thus the bridges become critical points on those networks and any blockage there can have widespread impact. Where railway bridges are affected, speed restrictions or prohibitions may have to be placed on the line while the bridge is inspected to confirm that it is safe for vehicles to cross. Under track access agreements, Network Rail is required to reimburse train operating companies for the loss of track access due to bridge strikes.

Scrape marks can be observed on most low rail bridges on the road network. Although such incidents rarely cause problems at the time, repeated scrapes can lead to extensive damage in the long term. More important though is the fact that scrapes are effectively a near miss from a serious collision and are an indication that drivers are not adhering to the warning/mandatory signs on the approach to the bridge.

All bridges under 16' 6" (5.03m) should be signed. Where signing is provided, it must be in accordance with the Traffic Signs Regulations and General Directions (TSRGD, 2002): the figure shown on the sign to indicate the available headroom should be at least 3 inches less than the measured height to allow a safety margin and should be expressed to the nearest multiple of 3 inches. The height on the sign therefore shows the safe height for a vehicle passing under the bridge. Most bridge strikes are to bridges less than 16' 6" but there have been a few instances when bridges with clearance above 16' 6" have been hit.

In the 1980s the Department of Transport set up a Bridge Bashing Working Party (BBWP) to investigate the problem and propose solutions. A wide range of measures were proposed by the Working Party, under 14 headings. For example, legislation and guidance on the provision of signs and markings to make low bridges more conspicuous, including infra-red detectors and variable signs warning over-height vehicles to turn back or divert, legislation requiring the fitting of audible warning devices to any vehicle equipped with power operated equipment over a height of 3m, legislation extending the requirement for the heights of vehicles to be marked in the cab. Most of the recommended measures were subsequently implemented but the number of bridge strikes has continued to rise. This may be partly because of increasing traffic levels and also as reporting has become more vigorous. For the last few years the Bridge Strike Prevention Group (BSPG) has taken over where the BBWP left off in bringing together the different interested parties to see what more could be done. Various ideas have been suggested, a number of these need further investigation, which is part of the reason for this project.

1.2 Aims & Objectives

The aim of this project was to find ways of reducing the incidence of bridge strikes, i.e. where vehicles, typically lorries or double-decker buses, try to pass under bridges that are lower than the height of their vehicles.

The objectives of this project are:
• To obtain a better understanding of the reasons why drivers hit low bridges, so as to better target action to reduce the number of incidents;
• To review the range of measures that have been taken so far to reduce bridge strikes, especially those at the frequently hit bridges;
• To assess and/or develop other ways of reducing bridge strikes;
• To provide advice to the Department for Transport (the Department) and the BSPG.

Stage 1 of this study recognised that there was a clear need to ascertain reasons why drivers fail to adhere to the warning and mandatory signs located near bridges. TRL undertook a literature review, focus groups and a questionnaire survey to explore these issues. In Stage 1, TRL also updated the analysis undertaken in 1996 on the bridge strike incidents in the Network Rail database. Stage 2 reviewed previous research and measures that have been taken to reduce bridge strikes. This included an assessment of current measures being used to reduce bridge strikes and meetings with stakeholders to establish views and experience regarding the bridge strike problem. Stage 2 involved four main phases: stakeholder meetings, bridge audits, a bridge observation study and an assessment of alternative routes.

The findings of Stages 1 and 2 highlighted the current issues surrounding the problem of over-height vehicles striking bridges and laid a good foundation for understanding which measures are effective at tackling the problem. Various parties described their own problems and constraints, and highlighted their own recommended solutions. Stage 3 assessed and developed those solutions, providing an evaluation of measures, leading the research to its final stage of reflection and recommendations, which can be found within this report.

This report contains summaries of findings from reports produced as part of stages 1, 2 and 3 and in places includes extra research undertaken after the stage report had been completed. It then provides some concluding comments regarding the issues that have emerged from the research and recommendations for ways to reduce the number of bridge strike incidents.

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2 Stage 1: Literature Review- Summary of Findings

The consequences of bridge strikes can be very disruptive to both road and rail transportation systems. Road traffic can be brought to a standstill for several hours while damaged vehicles are removed. There is an additional problem where railway bridges are affected as speed restrictions or prohibitions may have to be placed on the line while the bridge is inspected to confirm that it is safe for vehicles to cross. This can create considerable disruption to rail services and lead to high penalty charges to Network Rail for loss of track access by train operating companies. Bridge strikes also cause damage to the railway infrastructure, which has to be repaired. These disruptions and costs are not just applicable to rail companies; highway authorities are also suffering when footbridges and road bridges are hit.

2.1 The Size of the Bridge Strike Problem

The problem of bridge strikes was first recognised by a marked increase in the frequency of road vehicle impacts with railway bridges, in the early 1970s. As a result British Rail instigated a survey in 1972 which showed that, of some 400 cases a year, 40 were so serious that they could have caused derailment of a train (Ferguson, 1978). Consequently the most vulnerable bridges were made more conspicuous and circulars were sent out to local authorities, urging them to improve warning signs.

Horberry, Halliday and Gale (1998) in their article, “The Problem of Bridge Strikes”, analyse the issue of bridge strikes, drawing their conclusions from research carried out by the former DoT (in 1982, 1998 and 1993). The figures they report on reveal that there are over 3,400 low (less than 5.03m clearance) railway bridges crossing over roads in the UK. The problem, however, also applies to such structures as footbridges, canal bridges and roads passing over other roads as well as railway bridges. Between the early 1970s and the present day the number of bridge strikes has greatly increased from less than 300 per year reported in the 1970s to over 1700 per year from 2000 onwards.

2.2 Why Do Drivers Hit Low Bridges?

There are many possible reasons why bridge strikes occur. According to Creasey (2000) in his article entitled, “Bridge Bashing: Mind Your Head!”, and Fraser (1998), the root causes of bridge strikes are:

- Lack of signs;
- The distraction of other signs, or signs obscured by foliage;
- Signs positioned too close to bridges to enable drivers to divert;
- Warning signs may be out-of-date;
- Drivers are often unaware of their load height;
- Companies tend to hire vehicles of which they have no experience;
- Companies tend to hire agency drivers who have no experience of the vehicle;
- Road surface is bumpy or uneven and may cause the trailer to flex;
- Construction type - almost 75% of strikes occur at plate girder bridges.

According to Fraser (1998) driver error remains the principal cause of bridge strikes. However, Creasey (2000) claims that hauliers argue the blame for bridge strikes lies fifty percent with common sense and fifty percent with bad signing.

2.3 Legislation

The legislation governing how vehicles of a certain height may travel in relation to bridge safety was amended in 1997 in order to address the problem of bridge strikes. The amended regulations,
Statutory Instrument 1997 No. 530 The Road Vehicles (Construction and Use) (Amendment) Regulations 1997, deals with two issues: drivers’ knowledge of the height of their vehicle and in-vehicle automatic warning devices. It is now stated that where a vehicle’s overall height exceeds 3m, a sign indicating the vehicle's height must be displayed in the cab.

Since 1998 the regulations have also stipulated that automatic warning devices will be required where power operated high level equipment is fitted to the vehicle.

Under the 1986 Road Vehicles (Construction and Use) Regulations drivers can only be charged with careless driving if they strike a bridge. Sherrington (1997) believed that the regulations were due for a major revision as they covered weight, length and width of vehicles, but not height. He believed this would help bridge owners to claim compensation for any damage sustained, as it will place the burden of responsibility on vehicle owners for the heights of their vehicles and will provide the means of prosecution of those who fail to comply.

2.4 Advice to Others

In January 1993, a Network Management Advisory Leaflet, “Damage to Bridges by Road Vehicles, Traffic Signs at Bridges”, was published by the former DoT, giving advice to local highway authorities to try to reduce the chance of serious accidents occurring at bridges with a headroom of less than 16'6”’. The purpose of the leaflet was to ensure that these bridges are clearly and correctly signed, summarising the current advice on signing at low bridges. This information was later published by The Scottish Office as a Roads Directorate Advisory Leaflet.

2.5 Lorry Drivers

The Transport Manager's and Operator's Handbook (Lowe, 2002) gives advice on vehicle height limits, height marking and route descriptions, and where to obtain information on bridge heights for route planning, namely the AA Trucker's Atlas of Britain, which is recommended by both Network Rail and the Road Hauliers Association. The AA Trucker’s Atlas of Britain must, however, be used with some caution as it has limitations and it contains some errors.

A Bridge Bashing publicity leaflet, jointly compiled by Think! Road Safety, The United Road Transport Union, The Road Haulage Association and the Freight Transport Association, is aimed at encouraging lorry drivers to think about how tall their vehicle is before setting off on their journey.

2.6 Surveys of Drivers

In order to better understand the problem of bridge strikes, Surveys have been undertaken by various parties. Horberry, Halliday and Gale (1998) believe that there has been little previous research undertaken concerning driver behaviour in relation to low bridges and visual warnings. They believe that this area of work has great potential to significantly reduce the number of strikes occurring at low bridges.

In 1978, the former DoT undertook a survey of 497 lorry drivers in order to address the problem of over height vehicles hitting low bridges. Results of the survey are presented by Galer (1981) in a report entitled “A Survey Among Lorry Drivers About the Striking of Low Bridges”.

Although 95% of drivers interviewed claimed to know the height of their own vehicles, only 50% were accurate to within 3”.

The drivers were asked to give the meaning of various signs that would be found on the approach to a low bridge. 79% correctly understood the restricted headroom sign, 36 % correctly understood the restricted width sign, and only 31% of drivers understood that a red circle height restriction sign is mandatory.

Drivers were asked about the usefulness of displaying the vehicle height in the cab. 16% had this marked either in the cab or elsewhere on the vehicle. Many drivers thought that it would be helpful on
vehicles where the height does not vary. However there would be a practical problem of measuring the vehicle plus a variable load height.

A number of opinions on how to reduce bridge strikes by lorries were put forward, including warning gongs across the road, lanes marked under bridges, words painted across the road, rumble areas and infra-red detector systems. Galer also found that drivers wanted to be told directly whether they could pass under a bridge; this could be in the form of a sign on the road or a unit in the cab.

Fraser (1998) wrote about a small survey of haulage drivers undertaken in Glasgow in 1997. This survey was designed to obtain information about driver behaviour, procedures within the haulage industry and driver knowledge in relation to height restrictions and signing. The survey was conducted as an informal conversation with 20 lorry drivers.

This study found that 85% of drivers knew the height of their vehicle. This increase is likely to be because the height must now be displayed in the cab of the vehicle (in 1978 this was not required).

Drivers were asked if the height warning signs on low bridges were accurate in displaying the actual height of the bridge. 55% of drivers said the bridges were higher than the height indicated. When presented with circular and triangular height warning signs, only 20% of the drivers could distinguish the difference. Almost half of drivers did not know that the triangular sign existed! Every driver said that they could relate to imperial dimensions more easily than those displayed metrically.

Most of the drivers interviewed did not have an AA Truckers Atlas of Britain, although they all knew of it. 80% of drivers said their route was planned in advance; however 75% of these drivers said that their route did not take account of the location of low bridges. 30% of drivers said that at some time they had deliberately ignored a height warning sign which indicated a clearance which was less than the height of their vehicle. All drivers thought that the implementation of a spy camera system, which would record those drivers who ignore height warning signs, would act as a deterrent.

2.7 Bridge Strikes at Railway Bridges

The Department of Transport created an incident database in 1990 which contains details of 4285 bridge strikes. Strikes can range from a slight scrape, to a direct hit causing the bridge to collapse. The number of recorded bridge strikes at railway bridges has increased from 729 in 1990, to 1870 in 2004. It is not known if what appears to be a very large increase over the thirteen year period is due to an increase in the number of actual occurrences of these strikes, or whether the incidents are being reported more frequently. It may be that both are true; however the important point is that strikes are still occurring and the measures that have been introduced have not had a significant impact on reducing the incidents.

Analysis of these strikes seems to indicate that the problem largely lies with the drivers of over-height vehicles, more than the bridges themselves. Despite having some kind of advanced warning in place, or illuminating a bridge, drivers were still hitting the bridges with their over height vehicles. Almost all recorded bridge strikes were not deemed to be serious, however there were many incidents that generated repairs to the bridges and caused blocked carriageways, which would all be very costly.

High non-railway bridges also suffer great damage as a result of being struck by vehicles. There is a problem therefore with all over bridges, however only incidents involving railway bridges are currently recorded.

2.8 Solutions to the Bridge Strike Problem

Ferguson (1978) reported that the incidence of bridge strikes might also be reduced by measures such as improved signing or driver training. Many different measures have been considered by the former DTp including installation of bridge protection systems, infrared sensors and other vehicle warning systems; installation of train warning systems; reducing distractions; improved signing; and continuing publicity to drivers and hauliers.
In 1988, the Bridge Strike Prevention Group recommended to the Secretary of State, a strategy to deal with bridge strikes. Table 1 below details the 14 measures as they appear in the report: ‘A Strategy for the Reduction of Bridge Bashing: Report by a Working Party’ (1988). Details are provided, where applicable, as to whether they were deemed by the Working Party, to be low cost or high cost measures.

Table 1: Fourteen Measures To Reduce Bridge Strikes

<table>
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<td>1) Reduce number of low bridges</td>
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<tr>
<td>2) Control height of vehicles</td>
<td></td>
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<tr>
<td>3) Increase use of mandatory, instead of advisory, signs</td>
<td>LOW COST</td>
</tr>
<tr>
<td>3b) Amend regulations to allow provision without need for TRO</td>
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<tr>
<td>4) Install infra-red detectors and automatic signs at high risk bridges</td>
<td>HIGH COST</td>
</tr>
<tr>
<td>5) Improve signing and general environment around bridges</td>
<td>LOW COST</td>
</tr>
<tr>
<td>6) Construct protective beams over highway</td>
<td>HIGH COST</td>
</tr>
<tr>
<td>7) Erect crushable beams on railway bridges</td>
<td>HIGH COST</td>
</tr>
<tr>
<td>8) Install sensor system on track connected to railway signals</td>
<td>HIGH COST</td>
</tr>
<tr>
<td>10) Extend height in cab regulations</td>
<td></td>
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<tr>
<td>11) Licensing Authorities to take incidents into consideration when renewing Operators' Licences and driver licences</td>
<td>LOW COST</td>
</tr>
<tr>
<td>12) Improve securing of loads and engineering equipment</td>
<td></td>
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<tr>
<td>13) Provision of maps</td>
<td>LOW COST</td>
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<tr>
<td>14) Provision of route planning services</td>
<td>LOW COST</td>
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* - cost type not specified by the BSPG

Each of these are only likely to be cost effective if they are low-cost and / or lead to a high reduction in bridge strikes, particularly serious ones.

There are a number of other, more direct, or ‘bridge-based’ methods aimed at reducing the number of bridge strikes. Bridge-based prevention methods fall into three categories:

- Infra-red height sensors
- Locational systems
- External systems (such as arrester beams attached to a bridge or placed in advance of it)

There are also systems on the market that detect the occurrence of bridge strikes and automatically alert the appropriate authorities. Such systems typically comprise accelerometers attached to the bridge.

2.8.1 Infra-red sensors

The literature review identified a number of case studies in which infra-red sensors had been used, including bridges in the UK, Australia, and several states in the USA.

Infra-red detection devices consist of a transmitter emitting an infra-red beam which is aimed at a receiver, installed some distance in advance of the bridge. These are installed such that the beam crosses the road at a specified height above the road surface. This is usually the minimum clearance of the bridge.

If the beam is broken (by the passage of an ‘over-height’ vehicle) warning systems installed downstream of the bridge, such as flashing lights and audible alarms, are automatically triggered. The signs can also be used to advise the driver of an alternative route etc.

Attention has to be paid to the camber of the road during installation to ensure that high vehicles cannot ‘slip through’ the beam at certain positions within the carriageway. Careful consideration must be given to placing the equipment so that all approaches to the bridge are covered. The equipment
must respond to vehicles going in one direction only and must be capable of detecting an object 130 mm wide travelling through the beam at up to 45 km/h.

To be effective the transmitter and receiver must be able work in all weather conditions where vehicles can travel. It is necessary to provide the sensors with sufficiently rigid mountings to prevent false alarms due to relative movement between the transmitter and receiver.

A Department of Transport study (1988) of methods for reducing bridge strikes stated that experiments had generally established that these systems produced a substantial reduction (80 per cent or more) in the number of over-height vehicles going under bridges. Infra-red detectors were ‘regarded as the most effective signing measures available’ but expensive. Assessment was required to determine the number of high-risk bridges where installation would be cost-effective.

**2.8.2 Locational Systems**

An example of this type of strike prevention system combines the locational qualities of a global positioning satellite (GPS) system with a database containing the locations of low bridges. A small unit installed in the vehicle cab contains the GPS system and the database. As the vehicle approaches a low bridge, visual and audible warnings are activated within the cab if the vehicle is too high for the bridge.

The advantage of these types of system is that the warnings are within the cab of the vehicle and thus the driver is less likely to miss or ignore them than external road signs. However, these systems require the operator to purchase/hire and install the equipment within the vehicle, and thus the bridge is still vulnerable to high vehicles not fitted with such equipment.

If these types of systems come into play then they must cover all over bridges and not just railway bridges. The issue of dead spots, i.e. where there is no information available to the user, must also be addressed.

**2.8.3 External Physical Systems**

Protective beams placed in advance of a low bridge are often advocated as a method of protecting bridge structures. Two principal types of beam can be identified in the literature: arrester beams and barrier beams.

A study by the Department of Transport (1988) looked at the implications of erecting protective beams. It stated that, although arrester beams would minimise damage to the vehicle and danger to the occupants, such large structures on the approaches to bridges from both sides would be problematic, as well as being environmentally intrusive. Installation costs for arrester beams were estimated (in 1988) to be as much as £250,000 per bridge.

To bring an HGV to an abrupt halt, a barrier beam would have to be robust; the report suggested that it might be constructed from a steel box girder filled with concrete or a reinforced concrete beam supported on ‘sturdy’ legs. Such a structure would require significant piling works for its foundation. The costs for this type of solution were estimated (in 1988) to be at least £100,000 per bridge.

Protective beams attached to the bridge provide visual warning and help absorb the energy of an impact. These beams would not necessarily prevent strikes other than those where the driver notices the beam. In 1988 British Rail estimated the costs of such beams to be between £12,000 and £22,000 per bridge.

An alternative method of protection was suggested which was intermediate between an arrester and barrier beam. A beam less robust (and therefore cheaper) than a barrier beam could be erected some distance from the bridge; when struck by a high vehicle it would collapse, thereby alerting the driver and bringing the vehicle to a stop before reaching the bridge. At an estimated cost of £50,000 per bridge it would be far cheaper, but the report suggested that the risk posed by flying debris as the beam collapsed might render this option unacceptable.
Before any of the beams described above could be erected, some amendment of the Highway Act (1980) would be required. Horberry et al (1998) pointed out that under UK law it is illegal to obstruct the public highway by placing an obstacle (i.e. a barrier) in front of a bridge (unless it is part of the bridge structure).

2.9 Enforcement

Pure Technologies have developed a High Load Damage Surveillance System called Soundprint which allows bridge owners to record all occurrences of bridge strikes and uses video capture techniques to record the number plate of the offending vehicles. Managing the costs incurred when vehicles strike bridges is an important factor to consider in the context of the bridge strike problem. This technique could be employed by police or local authorities in order to act as a deterrent.

It is clear from the content of the literature review that there are many people with ideas as to what is causing drivers of high vehicles to hit bridges, however there is no consensus of agreement on the main contributory factors. Until the main causes are established and agreed, if they can be established, it is difficult to address the problem and find potential solutions. It may be that there is one main cause at all bridges, several causes at one bridge, or it may be that there are different causes at different bridges, depending on location, type of bridge etc.

Existing solutions to the problems seem to address different levels of the problem. Some solutions are very specific to individual causes and others cover a whole range of possible causes. For example, if it is found that drivers are not understanding or noticing the advance warning signs then a direct solution would be to attempt to design better signing (a specific cause with a specific solution). However, if it is understood that there are many contributory causes to the problem each having an influence, then it may be more appropriate to install automatic detection systems at all bridges to prevent over-height vehicles passing under the bridge. In short, the solution may be generic or specific.
3 Stage 1: Survey of HGV Drivers- Summary of Findings

3.1 Methodology

A survey of HGV drivers was designed to identify driver thoughts and actions in relation to bridge strikes and to extract the maximum amount of information from HGV drivers in an interview of acceptable duration. The questionnaire was piloted and then undertaken at 3 truck stop locations, chosen based on their locality to low bridges and HGV driver usage. 100 drivers were surveyed and the questionnaire can be found in Appendix A.

3.2 Discussion and Recommendations

3.2.1 Why Do Drivers of Over-Height Vehicles Strike Low Bridges?

This survey has provided an opportunity to investigate why bridge strikes occur and the main attributable factors to their occurrence. The survey has also given an indication of the extent of the problem as 36% of the sample stated that they (or someone they knew) had struck or scraped a low bridge when driving an HGV.

There has been much speculation as to what is the root cause of over-height vehicles striking bridges. Various factors have been suggested and based on these, a variety of measures have been put into place. This questionnaire survey was designed to address these factors and has provided an insight into the real issues behind bridge strikes. It has highlighted that there does not appear to be one single reason why bridge strikes occur. One of the final questions of the questionnaire asked what the respondents thought were the main causes of HGVs hitting low bridges. The five most frequent responses were as follows:

1. Drivers not knowing the height of their vehicles (80%);
2. Poor route planning (53%);
3. Inadequate signing (30%);
4. Drivers not believing warning signs (28%);
5. Drivers not understanding warning signs (19%).

3.2.2 Many Drivers Don’t Know the Height of their Vehicle

In this survey, 72% of drivers did not know the height of their vehicle (within 2 inches higher or lower than the measured height). Twenty percent thought their vehicle was lower than its measured height, which means they may believe they can pass under bridges which are too low. If drivers do not know the height of their vehicle then all other measures put in place (e.g. better, clearer signing, clearer alternative routes, etc.) will have little effect. The percentage of drivers who have correctly or incorrectly estimated the height of their own vehicle is shown in Figure 1.
The graph shows that only 28% of drivers surveyed correctly estimated the height of their own vehicle. If measures are introduced to ensure that drivers know the height of their vehicle, improvements in signing and alternative routes are likely to be more effective.

There are a number of measures that have been introduced to ensure that drivers know the height of their vehicle. Since 1997 the height of all vehicles over 3 metres must be displayed in the cab. This survey suggests that this has not solved the problem. The survey did show that many drivers are relying on the information in the cab to be correct (53% of respondents stated that they knew the height of their vehicle because it was displayed in the cab). However, the survey also showed that information displayed is often incorrect (or drivers are not taking a mental note of the height displayed) because more than two thirds of those who said they knew the height because it was displayed in the cab, did not correctly state their vehicle height. The survey also suggests that some respondents that use in-cab height displays, do not take the responsibility to ensure it is kept up to date (only 20% of respondents said that they measured the vehicle themselves, either that day or previously, and only 12% said the height is measured each time the load changes). There were other methods by which drivers ascertained the height of their vehicles; these included being told the height of their vehicle by someone else, or by guessing the height of the vehicle. The percentage of responses given by drivers for each of the different methods used is shown in Figure 2.
It is recommended that the correct use of accurate in-cab height displays is promoted and greater enforcement of their use is undertaken. However, an important point to consider is how accurate the in-cab height display can realistically be, as the height of the vehicle is subject to many different factors (even for fixed-height vehicles): tyre pressure, suspension adjustment, load status. It is necessary to establish whether the three inch lee-way is sufficient when bridge heights can also vary depending on different factors: road re-surfacing, width on arch bridges, signing incorrect at the start. Each of these factors can impact at the same time, and it may not be reasonable to expect drivers to take all of them into account when judging if they can pass under a bridge. In any case, it is extremely important to understand that these factors can all have an impact on the height that HGVs can safely pass under bridges and should all be taken into account. It is crucial that accuracy is maintained at all times, because relatively small differences in the height of the vehicle and/or the bridge can have a significant effect on the severity of the strike or whether one occurs at all.

In order to achieve this, all bridges should be signed correctly and all drivers should regularly measure the height of their vehicles, particularly when there has been a load change. The survey showed that 46% of the sample does not use anything to measure the height of their vehicle and 81% stated that they do not check the height of their vehicle after a load change. All of the respondents, who said that they drove variable height vehicles, used some sort of device to measure the height of their own vehicle. The percentage of drivers using each of the different types of measuring device is shown in Figure 3.

**Figure 2: Different methods used by drivers to determine the height of their own vehicles**

![Figure 2: Different methods used by drivers to determine the height of their own vehicles](image)

**Figure 3: Devices used by drivers to measure the height of their own vehicles**

![Figure 3: Devices used by drivers to measure the height of their own vehicles](image)
It is therefore recommended that drivers should be encouraged to carry a tailored measuring device (one designed for measuring variable height loads carried by lorries) and measure their vehicles each time a load changes.

**RECOMMENDATIONS:**
- Need to enforce the requirement for the in-cab height display e.g. police checks.
- Introduce fines for having incorrect height displayed.
- Ensure tailored measuring devices are easily available and low cost.

### 3.2.3 Many Drivers Don’t Understand Current Signing

In terms of signing, the principal finding of the survey is that drivers do not feel advance warning signs give them enough time to make a decision and often leave nowhere suitable to turn an HGV around. It seems drivers are more willing to risk going under the bridge, rather than attempt an awkward manoeuvre or reversing procedure in order to take an alternative route. The most popular comment given at the end of the questionnaire was that respondents would prefer signing to be further in advance of the bridge and 48% of respondents said that signing further back from the bridge would help them to make a better decision about passing under low bridges. The percentage of drivers endorsing each of a number of suggested improvements for signing low bridges is shown in Figure 4.

![Figure 4: Percentage of drivers endorsing a number of suggested improvements in low bridge signing](image)

Drivers do not generally understand the difference between mandatory and warning bridge height signs. Both signs inform drivers of a low bridge and give the safe height for passing under; provided this is understood and they are treated the same, this may not be considered a significant problem. Eighty percent of respondents said their behaviour would be the same for the warning or mandatory sign. The overall comprehension of the message, based on what height vehicle respondents said they would take through a bridge signed at 12’9”, was also quite good; only two respondents said they would take through a vehicle over 12’9”.
3.2.4 Many Drivers Ignore or Avoid Alternative Routes

This survey has shown that 88% of respondents always use alternative routes when their vehicle height is greater than the signed height on a bridge. This seems to imply that alternative routes are working relatively effectively. When asked about the acceptable length of an alternative route, most drivers said that the length did not matter, however 38% of those who don’t always take alternative routes thought that a route clearly signed at each junction would encourage them to use them in future. Figure 5 shows the responses given by drivers when asked what information would encourage them to use alternative routes in the future.

![Figure 5: Information which would encourage drivers to use alternative routes in the future](image)

There seems to be more of a problem with temporary diversions, particularly police diversions when there has been an accident on the carriageway. Thirty nine percent of respondents did say that in this situation they would check an atlas for low bridges; however a relatively large percent (28%) said they would follow the diversion and take no further action. Some of the bridge strikes reported by respondents in this survey occurred on police diversion routes. This area may need to be further investigated to find out how many bridge strikes occur on such routes; this information may be gleaned from the analysis of Network Rail’s bridge strike database.

3.2.5 Many Drivers Are Not Aware of the Bridge Strike Problem

An awareness of the problem by those in the industry is crucial if the problem is to be addressed and if the situation is to improve. It seems currently that the profile of this bridge strike issue needs to be improved.

**RECOMMENDATION:**

- Increase the recommended minimum distance an advance warning sign is placed before a low bridge.
- The last advance sign should be at the last junction before the restricted bridge or at any other industrial outlet between there and the bridge.

**RECOMMENDATIONS:**

- Alternative routes should be clearly signed along the route.
- Police should ensure that vehicles are not diverted on routes with low bridges or give a low bridge warning if necessary.
raised, not only to HGV drivers, but also to employers and owners of HGV companies. It was found that 75% of respondents do not receive any guidance from their employer on how to avoid hitting low bridges. However, the consequences of striking a bridge are quite severe, as just under half of respondents said they would either be sacked or suspended if they had a recorded bridge strike. The problem appears to be in the lack of guidance given to HGV drivers; the transferring of knowledge from employer to employee. Drivers need to be given adequate training in order that they do not find themselves in a situation where they are dismissed from their job.

**RECOMMENDATIONS:**
- Employers should be encouraged to provide written guidance on how to avoid hitting bridges.
- A marketing campaign should be launched raising the profile of the bridge strike problem: leaflets, articles in press, posters at truck stops, etc.
- Training on how to avoid bridge strikes should be part of applying for an HGV licence.
- Questions on bridge height signing should be included as part of the HGV driver theory test.

### 3.3 Vehicle Height Survey

TRL has undertaken recent work (outside the scope of this project) which has involved conducting a number of surveys, carried out across the UK, to investigate the proportion of high-sided vehicles on the road with a height of 10 feet or over. Approximately thirty surveys in total were carried out.

The surveys that took place on ‘A’ roads were selected on the basis of having high volumes of traffic, but this was not the case for the other road classifications. There were considerably more surveys carried out on ‘B’ or ‘C’ or unclassified roads than on Motorways or ‘A’ roads. However, surveys on Motorways or ‘A’ roads tended to be for longer periods of time.

Each site was surveyed for a different amount of time, ranging from little more than an hour, to six hours or more. Surveys took place at various times of day, though all of them took place between 7.00am and 7.00pm. The results across all road classifications were aggregated for the purpose of the graph below, without any weighting applied to represent the differing volumes of traffic on each road type, or the length of time the surveys were carried out. Although these surveys and the methodology for collating the results were not ideally suited to this project, the methodology for gathering vehicle heights could be adapted for future use.

To gather the vehicle height data, a laser scanner was used, so that no disruption was caused to the traffic, or any change in road user’s behaviour. The laser scanner is able to capture thousands of data points a minute in such a way that the data can be re-visited and the 3 dimensional scenarios recreated and viewed from almost any angle.

The graph shown in Figure 6 gives a distribution of heights for vehicles 10 feet or over and details the number of bridges at each bridge height. The information on the number of bridges has been collected from The AA Trucker’s Atlas and therefore only covers known bridges on both A and B roads.
In total, almost 10,000 vehicles taller than 10 feet were observed during the surveys, with the peak in the height distribution occurring at approximately 13 feet, or 4 metres. Some vehicles (0.14%) were observed to be taller than 16 feet. This graph provides the heights of only a sample of bridges and vehicles and therefore only gives an indication of the overlap between the distributions. By identifying the proportion of vehicles and bridges at each height, the graph provides an indication of the heights at which a conflict between a vehicle and a bridge is most likely to take place. The graph shows that there are a large number of vehicles with a height of 13 feet and an average number of bridges at this height, and thus a potential conflict. However, the bridges below this height are also at risk of collision from vehicles of this height. The greatest proportion of bridges is approximately 16 feet in height. Although there are more bridges at this height, they do not pose as much risk as lower bridges because there are fewer vehicles that could come into conflict with these bridges.

As discussed, this graph is only indicative as it has been compiled using a small and unrepresentative sample of vehicles and only a sample (albeit representative) of bridges. In order to gain information that is more conclusive, it would be necessary to conduct comprehensive height surveys for vehicles and to compile and use a database listing every bridge in the UK that may be at risk from vehicle strikes.

3.4 Truck Simulator survey

In order to supplement the information collected in the initial HGV Driver Survey, particularly regarding drivers’ understanding of unsigned bridges, TRL conducted a further questionnaire survey. Truck drivers, undertaking training in the TRL truck simulator, were asked to complete a short questionnaire related to low bridges. The questions were adapted from the HGV Driver Theory Test Handbook and the questionnaire can be found in Appendix B.

Drivers were asked the following three questions:

1) Unless otherwise shown, what is the minimum height of an unsigned bridge?

2) When a vehicle is over 3 metres tall, it is a legal requirement to display the height of the vehicle in the driver’s cab. In your experience, is this in-cab height display always accurate?
3) The height of your vehicle is 3.7 metres (12 feet). What action should you take on the approach to this bridge?

   a) Keep to the centre of the arch and give way to oncoming traffic
   b) Drive through slowly, keeping to the left of the marked limits
   c) Keep to the centre of the arch and take priority over oncoming traffic
   d) Drive through quickly, keeping to the left of the marked limits

Respondents were asked if they knew the minimum height of an unsigned bridge. Figure 7 shows the spread of responses to this particular question.

**Figure 7: Percentage of respondents giving minimum height values for an unsigned bridge**

Nearly 50% of all respondents correctly stated that the minimum height of an unsigned bridge is 16’ 6”.

Drivers were also asked about their own experiences regarding the accuracy of the in-cab height display, which is a legal requirement for vehicles over 3 metres tall. Table 2 gives the total number of forced choice responses for each category.
Table 2: Accuracy of the in-cab height display

<table>
<thead>
<tr>
<th>Accurate</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Always</td>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>Usually</td>
<td>9</td>
<td>38</td>
</tr>
<tr>
<td>Sometimes</td>
<td>7</td>
<td>29</td>
</tr>
<tr>
<td>Rarely</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>Never</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Over 60% of respondents said that the in-cab display was either always or usually accurate. It is of some concern that 37% of respondents said that the in-cab display was only accurate on some occasions or it was rarely accurate.

Drivers were also given a scenario where both the height of their vehicle and signing on an arch bridge was given. With this information supplied they were asked what action they should take on the approach to this bridge. Table 3 gives the total number of each of their forced choice responses.

Table 3: Action on approach to an arch bridge

<table>
<thead>
<tr>
<th>Action</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Keep to the centre of the arch and give way to oncoming traffic</td>
<td>20</td>
<td>87</td>
</tr>
<tr>
<td>Drive through slowly, keeping to the left of the marked limits</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Keep to the centre of the arch and take priority over oncoming traffic</td>
<td>3</td>
<td>13</td>
</tr>
<tr>
<td>Drive through quickly, keeping to the left of the marked limits</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

3.5 Variable load survey

It was found in the original HGV Driver Survey, that driver’s of variable load vehicles were under represented. It was therefore decided to undertake an additional survey which involved measuring and checking the heights of variable load vehicles only. Vehicles were measured in the lorry park of a motorway service area over a 7 hour period and in total, 32 vehicles were measured.

Figure 8 shows the distribution of the type of vehicle measured in the sample. Low loaders\(^2\) and flatbeds\(^3\) vehicles make up the largest proportion of the sample; however car transporters are also highly represented.

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\(^2\) Low loaders are very low to the ground with ramps for vehicles to drive onto e.g... Cranes, tractors, large machinery, and are usually artic.

\(^3\) Flatbeds are higher with or without sides; they can be rigid or artic. They often carry large girders, roof beams, bricks etc.
In addition to measuring the height of each vehicle, survey staff checked the height displayed in the vehicle cab in order to check for its accuracy. Of the 32 vehicles measured, 5 did not have their height displayed at all (some were foreign drivers) and 2 were measured under 3 metres and therefore are not legally required to display their height; this leaves a sample of 25 vehicles. Of all the vehicles measured, 52% were correctly displaying the height of their vehicle in the cab, and these tended to be the car transporters (see Figure 9). The flatbed vehicles and low loaders tended not to display an accurate height in their cab.

Figure 9: Vehicles Displaying the Correct Height in the Cab, by Vehicle Type

Figure 10 shows the accuracy of the in-cab height display based on vehicle height. Based on this small sample, it appears that taller vehicles are more likely to have their correct height displayed in the cab.

Figure 10: Vehicles Displaying the Correct Height in the Cab, by Vehicle Height
3.5.1 Concluding Comments

From this sample of vehicles, it can be seen that overall,

- Five (out of 32) vehicles were not displaying a height at all, two of which were foreign drivers.
- Nearly half (12 out of 25) of those vehicles displaying a height in their cab, were displaying an incorrect height.
- Car transporters tended to be better at displaying a correct height, than flatbed vehicles and low loaders.
- Within this sample, taller vehicles tended to have a correct height displayed in the cab.
4 Stage 1: Network Rail Database Survey- Summary of Findings

4.1 Summary

The Network Rail database contains data for all recorded incidents. Within the database there were 12,829 incidents involving bridges over highways, occurring during a 93 month period between 1st October 1995 and 3rd July 2003.

Excluding the part year data (1995 and 2003), the total number of incidents recorded at these bridges was 11,471, giving an annual average of 1,639 incidents.

There were 3131 uniquely identifiable (‘named’) bridges in the database. The number of incidents per named bridge ranged from 1 to 113. Most bridges (1719, 55%) were only struck once during the 93 month period; 436 (14%) bridges were struck twice; 216 (7%) bridges were struck on three occasions and 760 (24%) bridges were struck 4 or more times. Of these 760 bridges, 109 bridges have been struck 21 times or more.

The greatest number of low bridge incidents occurred in Southern Region (23%), with 17% in the Midlands region. The average number of incidents per bridge per year varied from 0.41 to 0.60 across the Network Rail regions.

Bridge height data was known for 6,742 incidents. The majority of incidents occurred at low bridges with signed heights between 13 and 15 feet. The presence of advance warning signs was only recorded for 65% of all 12,829 incidents.

Vehicle type information was known for 8,199 incidents. Approximately 50% of these incidents involved heavy good vehicles. The most common reason given for an HGV striking a low bridge was drivers ignoring or disregarding the warning or hazard of the low bridge.

The difference between the height of each vehicle involved and the low bridge which it struck were calculated. For 788 incidents it was thought that the vehicle involved was higher than the bridge signed height. For the majority of these strikes the difference was less than half a metre. However for 30 incidents the difference was recorded as being over one metre.

Bridge construction was known for 2,458 of the named bridges. A total of 6,947 incidents occurred at girder/beam construction bridges, which gives an average of 0.60 incidents per bridge per year. For arch bridges the average number of incidents per bridge was slightly lower at 0.46. There were only 3 known truss design bridges in the database and each was struck on one occasion only.

Although a large number of strikes occur each year, relatively few cause sufficient damage to require repair or cause obstruction to the highway. However, for each reported bridge strike a low speed limit is imposed on the rail line which can lead to considerable cost and disruption to services. Repairs to bridges were reported to be necessary for only 608 (5%) of the 12,829 incidents. Material from the bridge was reported to fall in 1,429 (11%) incidents and the highway was blocked for 1,737 (14%) incidents.

In terms of human life, fortunately most incidents have resulted in no casualties, with only 25 of the 12,829 incidents resulting in casualties of which only 5 were Fatal or Major casualties.

4.2 No. of Strikes and No. of Bridges

In order to gain an understanding of which bridges are at the most risk of being struck, the numbers of strikes that have occurred at certain bridges (established in the Network Rail database) have been plotted against the number of bridges of a particular height. Currently, there is no complete record of all low bridges in the UK, therefore the population of bridges was taken from the AA Trucker’s Atlas, which covers A and B roads only. Figure 11 has been produced to given an indication only of the ‘at risk’ bridges, and would need to be plotted against the whole population of bridges to be entirely accurate. It shows that by far the most problematic bridges are those measured at 7’6”, followed by
bridges at 10’ and 10’9”. Generally, the taller bridges, i.e. those bridges with a height of greater than 13’ 0” tend not to have a high strike rate.

Figure 11: No. of strikes per bridge
4.3 Mandatory vs. Warning Signs

The results of the HGV Driver Survey showed that most drivers do not understand the difference between warning and mandatory signs: 28% admitted not knowing the difference and another 56% answered incorrectly. This starts a debate into whether there is just cause to continue signing bridges in these two different ways. Can the use of mandatory signs be discontinued (particularly when they were introduced as a tool for the police to prosecute but there is little evidence to suggest that they ever do)? The drivers were also asked how their behaviour might differ when faced with the two signs; 80% stated that their behaviour would be the same for both signs. Interestingly, 7.5% (of the remaining 20%) said that they would be more cautious when passing the triangular warning sign.

Ideally the Network Rail Database, which contains records of strikes over the past 6 years, would be used to determine patterns at bridges and it would be possible to identify bridges where signing has changed from warning to mandatory and note whether the trend in number of strikes has changed (either for better or worse). The installation dates of mandatory signs are not readily available (and to seek this information is outside the scope of this project) therefore it has not been possible to conduct this type of analysis.

It is possible to take from the database the type of signing present at each bridge strike, and it has been found that 39.6% of bridges strikes involved bridges with mandatory signing and 49.8% involved warning signs. It is, however, known that there are more bridges with warning signs than mandatory signs therefore this could be just a representation of the sample.

If a decision is to be reached on the effectiveness of the warning and mandatory system, it is recommended that a sample of bridges be analysed, as described above, in terms of their change to mandatory signing and the number of strikes consequently received (compared with historical data). If the changeover dates could be established it would be a relatively simple process to check the dates against the trends already established in the Top 100 bridges (see TRL Stage 1 Report: PR/T/151 03). It would be necessary to find changeover dates for approximately three years ago in order to see trends three years before and after installation.
5 Stage 2- Summary of Findings

5.1 Stakeholder Meetings Summary

The bridge strike problem has existed for many years now, and it is hoped that by drawing together the experiences of relevant affected parties, a start can be made in tackling some of the important issues. It became very apparent through meeting with the various stakeholders that in most cases there was a distinct lack of communication between them. A ‘joined up’ approach in all authority areas and particularly at problematic bridges is highly recommended. Localised working parties with regular meetings or correspondence including local authorities, Network Rail and the police would be an effective way to begin to tackle the problem. This would aim to encourage information sharing and possible cost sharing (when implementing measures).

Implementing these working parties may help resolve some of the problems reported during the various stakeholder meetings, such as funding, reporting of strikes, lack of communication, ownership of the problem (responsibilities), and gaining access to Network Rail information.

With regards to the various measures implemented at bridges, costly measures such as VMS triggered signing, in-cab audible warnings, gantries with chains/gongs etc. are only ever used as a last resort, or when a problem is very apparent. The were various opinions concerning when vehicle activated signs should be used, for example most local authorities thought that they should only be used where there are appropriate diversion routes or places where HGVs can turn round, whilst other stakeholders thought that even when there is nowhere for the HGV to go it is better to stop them hitting the bridge (they can be reversed up the road if necessary).

The bridge strike offenders were usually thought to be vehicles carrying variable height loads and with foreign drivers. The police stated that they found it hard to prosecute foreign drivers.

The provision of alternative routes was a major area of discussion across many of the meetings: haulage companies, bus operators and the police suggested that there should be more and better signed alternative routes. Local authorities however, reported difficulties in prescribing these routes due to issues such as other low bridges in the vicinity, unsuitable residential roads and a lack of origin-destination information for HGVs using the roads.

Haulage companies did not always perceive the problem of bridge strikes to be significant to them and the extent to which they took measures to prevent their drivers from striking a bridge varied considerably. They did admit to the in-cab height displays being often inaccurate and agreed with the TRL HGV Driver Survey that found that many drivers do not understand the difference between mandatory and warning height signs. Most, however, did provide training that involved bridge strike awareness; this training was usually given on induction to the company.

5.2 Bridge Audits Summary

Bridge Audits were carried out at twenty two selected sites with low bridges, where a large number of bridge strikes had occurred.

For each site, the presence of, and the correctness of advance warning signing was recorded, both on the approaches to and in the vicinity of the bridge. Good signing practices were observed at some sites, where mandatory signs were mounted on bright yellow backing boards to make them more conspicuous. Some sites had large amounts of signing on the approach to the bridge, including junctions. However, some bad practice was also observed. At one site there was insufficient advance signing on a road with a very high traffic flow. At several sites the road on the approach to the bridge was lined with trees which could cause obscuration problems for the warning signs, including variable message signs, when the trees are in leaf. Obsolete signs that are no longer in the Traffic Signs Regulations and General Directions (TSRGD) were also observed. At one site with a very low bridge (9’ 9”) none of the approach warning signs indicated the distance from the bridge. On several sites with arch bridges the approach warning signs have not indicated that it was an arch bridge.
Alternative route signing was also observed at eight of the twenty two bridges. However, none of these eight bridges had a comprehensive alternative route signing from all directions. The correct warning sign incorporating the arch bridge symbol was not used for some of the arch bridges.

For each site, the condition of the signs, both on the approach to, and at the bridge were observed. At many of the bridges the signs were found to be in poor condition. Chevron panels were either missing from the top of some of the girder bridges or were broken. At several bridges, graffiti was present, either on the side of the bridge or on the sign face. Many of the signs were also found to be in bad condition; old, dirty or covered in algae.

At some sites specific measures were employed in an attempt to reduce the frequency of a bridge strike or to limit the damage caused by a potential strike. These measures included automatic detections systems, variable message signs (VMS), impact protection beams, road markings on the approach to the bridge, enlarged signs and the words ‘LOW BRIDGE’ painted on the side of the bridge.

5.2.1 Electronic Warning Signs

Several sites used VMS and there were problems identified both in the location of these signs, in some cases being too close to the bridge and problems of foliage obscuring the signs. An analysis was conducted on the sites within the audit that used VMS, in order to see if there had been any improvements since the VMS had been installed. Five sites within those that were audited used VMS: Latchmere Road, Tulse Hill, Wrecclesham, Orpington and Staines (Chertsey Road). Of those, only three had been installed in the last five years (within the timeframe of the Network Rail database): Latchmere Road, Tulse Hill, and Wrecclesham. The date of implementation was established and a before and after comparison was conducted, using the strike information recorded in Network Rail’s database. The information obtained at Latchmere Road and Tulse Hill was inconclusive due to the recent installation of the signs and lack of strikes before implementation; however the start of a possible pattern can be seen at Wrecclesham where the number of strikes has decreased. The following graph Figure 12 shows the decrease in strikes since May 2002 when the sign was installed.

5.3 Bridge Observation Study (Video Survey) Summary

The type of large goods vehicle using the route under the low bridge was analysed for each of four survey sites (Langley, Latchmere Road, Lower Sydenham and Wilton). For each site the greatest proportion of large goods vehicles recorded were in the C1 category, i.e. medium sized rigid lorries.
of at least four tonnes. For a 12’ 9” bridge in Langley there were also a significant proportion of tipper trucks and flatbed low loaders. For a 14’ 0” bridge in Wilton there were a significant number of articulated lorries recorded in the C + E, category, i.e. an articulated lorry with a maximum authorised mass of at least 18 tonnes (18000kgs). For all sites the total number of heavy vehicles recorded for each of the other categories was relatively small.

The percentage of heavy goods vehicles in the total traffic flow during any fifteen minute observation period varied between sites. For a 12’ 6” bridge in Latchmere Road, the highest percentage of HGVs recorded was 7% in the eastbound direction and 8% in the westbound direction. For the bridge in Wilton the highest percentage of HGVs recorded was 19% in both the northbound and southbound directions.

When analysing the behaviour of large vehicles in the vicinity of a bridge, for three out of the four sites, large vehicles had a tendency to either straddle or cross the white lines under the bridge. For all sites there were instances where large goods vehicles passed under the bridge with only a very small clearance, less than a foot on several occasions and only several inches on one occasion. For the 13’ 0” bridge in Sydenham there appeared to be no clearance at all when a large vehicle passed under the bridge, although no apparent damage was observed.

5.4 Alternative Route Mapping Summary

A paper exercise was carried out to design alternative (diversion) routes at bridges which currently do not have signed diversions. The twenty seven bridges used for this particular exercise were taken from the sample of bridges examined in the bridge audits.

The process of selecting a diversion route involved locating a low bridge on a large scale map, identifying a possible diversion route to avoid the bridge, measuring both the length of a route under the low bridge and the equivalent possible diversion route, calculating the difference in distance between these two routes, which was used to calculate any additional costs for an HGV driver to follow the diversion route.

Some difficulties were encountered when following this procedure which included problems in identifying particular features on a route which may make it unsuitable, such as road width or traffic calming measures or road geometry, such as steep gradients. For some of the low bridges there were other low bridges in the same vicinity which caused problems in finding a suitable alternative route. There was no information on traffic flows for a particular route.

A number of recommendations were made when planning an alternative route for a low bridge:

- A high vehicle Origin-Destination survey should ideally be carried out before starting the process of selecting a possible diversion route.
- A diversion route should be correctly signed to TSRGD with sufficient signing on all possible approach routes and, if at all possible, at every road intersection until the end of the diversion route.
- The introduction of symbols such as a diversion symbol (e.g. yellow diamond or HV) at junction points on a diversion route should be considered.
- VMS should be used if possible and situated in an appropriate location (at a sufficient distance from the bridge) to allow vehicles to follow a diversion route.
- Diversion routes in urban areas should avoid narrow streets through residential areas including schools, etc. Diversion routes in rural areas should avoid narrow country lanes to prevent any conflict with other vulnerable road users, such as cyclists, horses and pedestrians.
5.5 Stage 2 Summary and Conclusions

Stage 1 considered why bridge strikes occur and the main factors that can be attributed to their occurrence, by consulting with HGV drivers. The aim of Stage 2 has been to take a holistic approach bringing together the experiences of other affected parties and examining bridges for current problems and potential measures. Stage 2 has highlighted many different issues which all relate to the problem of over-height vehicles striking bridges, and they mostly involve various stakeholders working together to help reduce the problem.

It became very apparent, when talking to the various stakeholders, that there was a strong need for a ‘joined up’ approach in trying to tackle this problem. For each problematic bridge there are various affected parties who are likely to have an interest in reducing the number of incidents that occur. These could include: local authorities, Network Rail, the police, prominent local haulage companies, owners of industrial estates, local residents. Regular meetings and correspondence between such an Interest Group would be an effective way to begin to tackle the problem and would facilitate the sharing of information, cost, resources, knowledge and expertise. Implementing these working parties may help resolve some of the problems reported during the various stakeholder meetings, such as funding, reporting of strikes, lack of communication, ownership of the problem (responsibilities), and gaining access to Network Rail information.

The bridge audits and observation studies led to the conclusion that problematic bridges should incorporate more advance warning signs. These signs need to be clear and conspicuous, and very importantly they need to provide the driver with adequate time to make a decision. Many of the bridges viewed in the audit did have signing at the last available point of turn, i.e. at the last junction point before the bridge, however the experience of the haulage companies, the bus operators and bridge audits concluded that drivers need enough time to contemplate their next move. It is not always practical for an HGV driver to pull over at the side of the road to check a map; therefore it is more appropriate for them to be given two or three chances at various junction points to take other routes or roads. The signs they are presented with must be clear about where the hazard is located and wherever possible the driver should be shown an alternative route. Consideration should also be given to the use of mandatory signs at arch bridges. Current practice can involve erecting four signs on one bridge (two different heights, signed in both imperial and metric). The use of mandatory signing enables metric and imperial measurements to be included on the same sign, which reduced sign clutter and therefore enhances clarity.

The lack of provision of alternative routes has been found to be a key factor in this study. The bridge audits revealed that only 8 out of 22 bridges had some form of signed alternative route. A theme seemed to be emerging where frequently struck bridges were often without a signed alternative route. However, it must be accepted that there are locations where alternative routes are not readily achievable (e.g. due to other low bridges and unsuitable roads), they should be considered wherever possible, and every effort should be made to make routes available to HGV drivers.

Results from the HGV Driver Survey, found that drivers suggested more alternative routes should be available in order for them to make better informed decisions about how to avoid low bridges. Drivers wanted clearly defined routes, with destinations signed at junction points along the route (or use of symbols) and Haulage companies re-iterated this point in the Stakeholder meetings in the early part of Stage 2. Introducing clearly defined alternative routes at problematic bridges (particularly where the route is not always obvious) may go some way to reducing the number of strikes.

The use of symbols at junction points on alternative routes should be considered (e.g. diamond or triangle); these are already used for temporary diversions or holiday routes and could be adapted for use on High Load Routes. There may also already be signed high load routes which could be used, for example in Salisbury there is a high load route already signed with yellow diamonds which coincidentally provides an alternative route to the A36 bypassing the most hit arch bridge in the UK.
In summary the three main findings from Stage 2 are:

1. The need to create Interest Groups or Working Parties for individual problematic bridges;
2. The need for more advance and clearer signing at problematic bridges;
3. The need for clearly signed alternative routes (wherever possible).
6 Stage 3- Summary of Findings

A series of measures which could be implemented have been considered in the Stage 3 report. These measures have emerged through Stages 1 and 2 of this research and have been evaluated on this basis. The views and experiences of all the various stakeholders have been taken into account: HGV drivers, hauliers, local authorities, Network Rail, the police and bus companies. Results from the literature review, findings from the analysis of Network Rail’s database and the bridge audits have also informed the basis for discussing each measure. It has not been possible to trial any measure at current problematic bridges, as this is outside of the scope of this project, however it is recommended that this be undertaken at problematic bridges, as before and after surveys (these would be long term evaluations and would need to be undertaken over a number of years).

Stage 3 was not intended to give detailed recommendations, rather it serves to set out the various measures discovered through the first part of the research and provide an objective evaluation of each of the measures.

The measures, which have been described fully in the Stage 3 report, are summarised here:

### 6.1 Improvements for Stakeholders

<table>
<thead>
<tr>
<th>Measure</th>
<th>Minimum Requirement</th>
<th>Maximum Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Groups</td>
<td>Local Authorities and Network Rail to work in partnership at problematic bridges.</td>
<td>Working Groups to be set up including all relevant stakeholders e.g. Local Authority (Highway and Structures), Network Rail, Police, Local Haulage Companies, affected neighbouring Local Authorities etc.</td>
</tr>
<tr>
<td>Bridge Audits</td>
<td>Local Authorities should check all signs and re-measure the height of all bridges, on a regular basis.</td>
<td>Local Authorities should periodically conduct a full review of the bridges in their area, in terms of their relative risk of being struck. This should also include an action plan detailing what measures need to be undertaken.</td>
</tr>
</tbody>
</table>
## 6.2 Improvements at the Bridge

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bridge Markings</td>
<td>Markings on both side of the bridge could involve using different types of hatching arrangements using different colours.</td>
</tr>
<tr>
<td>Lane Markings</td>
<td>Permanent white lane markings, as specified in the Traffic Signs Manual Chapter 5, could be put on the road surface in both directions on the approach to the bridge.</td>
</tr>
<tr>
<td>Road Markings</td>
<td>Road markings conforming to diagrams 1010, 1014 and 1024.1 (The Traffic Signs Regulations and General Directions, 2002) and maintained to a high standard should be used for all arch bridges.</td>
</tr>
<tr>
<td>Chevrons</td>
<td>Chevrons on bridges conforming to diagram 530.2 (The Traffic Signs Regulations and General Directions, 2002) should be used for all low bridges, except for arch bridges (where chord markings conforming to diagram 532.2 should be used).</td>
</tr>
<tr>
<td>Lighting Signs</td>
<td>Lighting the warning or mandatory signs on the approach to the bridge.</td>
</tr>
<tr>
<td>Lighting the markings on the road surface</td>
<td>Dynamic road signs and markings using LED technology is currently under development by Philips Electronics N.V.</td>
</tr>
<tr>
<td>Integral protective beams</td>
<td>Protective beams placed in advance of the bridge to make contact with the vehicle and alert the driver before contact is made with the bridge.</td>
</tr>
<tr>
<td>Chains</td>
<td>Chains can be hung from the underside of the bridge.</td>
</tr>
<tr>
<td>Infra-red beams and accelerometers</td>
<td>AEA Technology Rail has developed a system <em>(BashChex)</em> using infra-red beams and accelerometers on the bridge to detect an over height vehicle striking the bridge.</td>
</tr>
<tr>
<td>GATSO cameras</td>
<td>GATSO cameras can be positioned at appropriate locations in the vicinity of the bridge, so that they are trained on a vehicle number plate.</td>
</tr>
<tr>
<td></td>
<td>Possibility of re-branding them as Safety Cameras and could therefore link to Safety Partnerships.</td>
</tr>
<tr>
<td>Digital cameras with infra-red lighting</td>
<td>The AEA Technology Rail <em>BashChex</em> system has cameras, which include infra-red lighting and can be trained on the vehicle number plate to allow the vehicle number plate to be identified, even in darkness.</td>
</tr>
<tr>
<td>Electronic detection system</td>
<td>Infra-red detection systems, which warn drivers of an impending bridge strike by several different methods, such as variable message signs, flashing lights and audible alarms. The variable message signs can also be used to advise the driver of an alternative route.</td>
</tr>
<tr>
<td>Rebuilding the bridge</td>
<td>Demolishing and completely rebuilding the bridge, to increase the clearance for high sided vehicles.</td>
</tr>
<tr>
<td>Lowering the road</td>
<td>Lowering the road surface to increase the clearance for high sided vehicles.</td>
</tr>
<tr>
<td>Closing the road</td>
<td>Close the road to all traffic, except maybe pedestrians and cyclists where appropriate.</td>
</tr>
</tbody>
</table>
### 6.3 Improvements in Signing

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric heights</td>
<td>Metric heights should be shown for all bridges on main roads and routes that are used frequently by foreign drivers.</td>
</tr>
<tr>
<td>Larger warning and mandatory signs</td>
<td>Larger signs could be located both on the approach to, and on the bridge. Larger signs should be used, where appropriate, up to a maximum of 1500mm.</td>
</tr>
<tr>
<td>Mounting signs on rectangular yellow backing board</td>
<td>Mandatory signs could be mounted on a rectangular yellow backing board and located both on the approach to, and on the bridge.</td>
</tr>
<tr>
<td>Design of new advance direction sign incorporating diversion symbol</td>
<td>A yellow diamond / triangle diversion symbol currently used for temporary diversions, or HV (for High Vehicles) could be used on an advance direction sign.</td>
</tr>
</tbody>
</table>
| Advance mandatory signing                    | All advance mandatory signing for non-arch bridges situated on main routes used by foreign drivers should also be signed in both imperial and metric measurement.  
                                       | All non-arch bridges should have at least one advance mandatory sign on each approach at the last point of diversion before the low bridge. |
| Repeater signs                               | Repeater signs should also be used with the provision of an alternative route.                                                               |
| Height restriction with indication of an alternative route signs | The use of the sign to diagram 818.4 (mandatory height limit ahead with indication of an alternative route) should be encouraged.            |
| Advance warning of height restriction signs  | At non-arch bridges the use of sign to diagram 818.3 (mandatory height limit at low bridge ahead) should be used, even when diversion signing has been provided, to give an advance warning of the height restriction. |
| Approach signing for arch bridges            | Both approaches to an arch bridge should be signed using signs to diagrams 531.1 and 531.2                                                |
| Variable message signs                       | Variable message signs (VMS) should be used for advance signing for all low bridges and should be situated in appropriate locations.         |
6.4 Intelligent systems

<table>
<thead>
<tr>
<th>Measure</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>Telematics - Geo-fencing</td>
<td>Enables users to electronically define and programme the co-ordinates of a specific landmark, such as a low bridge, into a vehicle mounted tracking unit which automatically sends an alert to the driver that it has crossed the geo-fence (i.e. the boundary).</td>
</tr>
<tr>
<td>Bridgewatch system</td>
<td>A device, which is based around an integrated GPS system, that creates both a visible and an audible warning in a driver’s cab if the vehicle is in close proximity to a low bridge.</td>
</tr>
<tr>
<td>BRIDGESAFE system</td>
<td>A system, which is available as a radio frequency application, that provides a series of both visual and audible warnings to drivers as they approach a low bridge.</td>
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</table>

6.5 Improvements in Driver Education/Awareness

<table>
<thead>
<tr>
<th>Measure</th>
<th>Minimum Requirement</th>
<th>Maximum Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Driver Training</td>
<td>Design handouts on the dangers of low bridges which would be distributed to major haulage companies for use when training drivers.</td>
<td>Design a complete training programme which can be run by employers to train drivers in how to avoid low bridges, measuring the height of their vehicle, what to do if they get stuck at a bridge and what to do if they strike a bridge.</td>
</tr>
<tr>
<td>Promote use of measuring devices</td>
<td>Use the media to promote the use of measuring devices, via haulage associations.</td>
<td>n/a</td>
</tr>
<tr>
<td>Driver education in road signs</td>
<td>Produce literature detailing the signs related to heights of low bridges, to be distributed to haulage companies.</td>
<td>Include other information, such as expected behaviour at certain signs and include more questions on bridge height signing in the HGV Driver Theory Test.</td>
</tr>
<tr>
<td>General Publicity Campaign</td>
<td>Raise the awareness of the bridge strike problem via leaflets, posters, articles in magazines etc.</td>
<td>Within the material produced, not only inform them of the issues but provide advice to drivers and operators about the actions they can take to help reduce the problem.</td>
</tr>
<tr>
<td>Use truck simulation to train drivers</td>
<td>Encourage large companies to send their drivers on training sessions at a truck simulator.</td>
<td>Incorporate truck simulator training on bridge strike awareness into the HGV Driver theory test.</td>
</tr>
</tbody>
</table>
7 Stage 4- Final Conclusions

This research has identified many issues and causes of over-height vehicles striking bridges. The problem is therefore a complex one and rather than one overall solution, solutions may be many and varied (national and local, high cost and low cost, high impact and low impact). There are, however, three main issues that have emerged and these appear to be having a big impact on the bridge strike problem. The issues are:

- Drivers not knowing the height of their vehicles;
- Lack of provision of alternative routes at low bridges, and lack of planning of routes by hauliers;
- Inadequate signing at and on the approach to low bridges.

7.1 Driver Knowledge of Vehicle Height

There is much evidence to suggest that drivers do not know the height of their vehicle. This evidence comes from previous research (Galer, 1981) and research carried out within this project (HGV driver survey, stakeholder consultation, survey of variable height vehicles). In fact, 80% of drivers interviewed in TRL research thought that the main cause of vehicles striking bridges is that drivers do not know the height of the vehicle they are driving (Martin and Freeman, 2003).

The situation does not appear to be getting any better, as it has not improved since Galer’s research in 1981. Galer (1981) found that although 95% of respondents said they knew the height of their vehicle, only 12% gave the exact height, with only 38% correct within 2 inches either side of the measured height. TRL’s research in 2003 demonstrated that only 28% of respondents either knew the exact height of their vehicle or were correct within 3 inches either side of the measured height. This research seems to show that drivers are becoming increasingly unaware of their vehicle height, which might be a factor in why bridges are being struck more often. What is particularly concerning is that the TRL survey showed that 20% of the drivers interviewed underestimated their vehicle height which puts them at a great risk of striking a bridge (their vehicle is taller than they realise). It may be argued that drivers do not need to remember the height of their vehicle because it is now displayed in their cab; however research also shows that this height display is rarely accurate.

Galer’s survey was conducted in 1981 before legislation was introduced which now requires a height to be displayed in the cab of any vehicle over 3 metres, and therefore unsurprisingly found that only 16% had the height marked somewhere on or in their vehicle. Naturally, since the legislation was introduced in 1997, most vehicles have a height displayed in their cab; however the survey of variable height vehicles conducted by TRL (2004) showed that only 48% of vehicles had the correct height displayed. According to the drivers surveyed by TRL, 57% were relying on the height display to inform them of the height of their vehicle. If this display is incorrect this will inevitably cause them a problem when confronted with advance warning of a low bridge which displays the safe height to pass under.

TRL research involved asking drivers and employers whether they felt that in-cab displays were always kept up to date, and the response was that they are often not correct. Many of the Operators thought that the displays were rarely correct, despite being aware of the legislation which requires them to be accurate. Thirty seven percent of drivers also thought that the display was sometimes or rarely correct. This information leads to the conclusion that there needs to be enforcement of the current legislation in order to increase compliancy; currently there is no incentive for the display to be accurate.

Tailored measuring devices are currently rarely used, with only 5% of the TRL survey sample using a device built especially for measuring vehicles. An ordinary tape measure is used by 42%, which could explain inaccuracies in the in-cab display, but most importantly, 46% are not using anything to measure the height of their vehicle. The majority (81%) do not re-check the height when their load changes, most of them were driving a fixed height vehicle, but they are not taking into account differences in height when their load has been removed (effects of vehicle suspension). However,
36% said that they sometimes drive a variable height vehicle, where it is more vital that they re-measure their vehicle. These findings highlight the need for tailored measuring devices to be made available to all drivers. In order to encourage their use, they should be cheap to buy and forcefully marketed to ensure a good take-up.

7.2 Alternative Route: Provision and Planning

The provision of alternative routes and the need to better plan routes has been highlighted from the outset of this research with requests for more signed routes and admissions of bad practice from the HGV driver survey, the focus group and the stakeholder consultations. The bridge audits highlighted the need for better signed alternative routes. The lack of provision of alternative routes was the second most common reason for vehicles striking bridges, according to the opinion of drivers interviewed by TRL in the HGV driver survey.

The research explored and conducted within this project has found that drivers are usually responsible for planning their own routes (rather than the employer) and rarely take account of low bridges. The literature review highlighted, in a pilot study conducted by Fraser in 1998 that despite 80% of drivers claiming they plan their routes, 75% of this planning does not take into account low bridges. TRL’s HGV driver survey showed that the most popular method for planning routes is a standard road map, though the second most popular method is the use of the Trucker’s Atlas. Two approaches can therefore be taken: acknowledge that drivers do not take into account low bridges in their route planning and therefore provide signed alternative routes at the sites themselves, or take action to encourage drivers to plan with low bridges in mind. It is recommended that both options are explored and that the problem is tackled from both angles for maximum effect.

Drivers in the TRL HGV driver survey were very positive about the notion of alternative routes. Most (88%) of drivers said they already use alternative routes; however there do not appear to be many signed routes at low bridges. Of the 22 bridges identified for the bridge audits, only 8 had some kind of signing for an alternative route. The majority (58%) of the drivers in the survey also said that the length of the route did not matter, which indicates that they might be used if they were adequately signed. The drivers in the focus groups that TRL conducted (2003) also agreed that given enough notice of a low bridge and a signed diversion, they would take the alternative route. Drivers, haulage companies and bus companies did say that they wanted a clearly signed route at each junction along the diversion and were positive about the idea of using symbols.

Local authorities were consulted by TRL in stage 2 of this project, and they gave the general impression that they find it difficult to implement signed alternative routes, and therefore make little attempt, even at known ‘problematic’ bridges. Designing a route is not always straightforward and many things have to be taken into account, including other low bridges in the vicinity, weight and width restrictions and origin and destination information for the HGV traffic. However, if these problems can be overcome, the benefits of having a signed alternative route are likely to outweigh the initial investment of designing the route.

Local authorities were also concerned about sign clutter and gave this as a reason for not putting signed routes in place. This is a consideration, however again, the benefits of implementing these routes must be weighed against these disadvantages and of course careful consideration should be given as to the placement of the signs and the TRL recommendation of using symbols on existing direction signing could ease this problem.

7.3 Signing of Low Bridges

In order to react to a low bridge, drivers must have good advance warning and accurate signing. This research has shown that drivers currently can not be relied upon to plan their routes sufficiently, to avoid low bridges. Whilst this aspect needs to be worked on, it means that drivers are relying on signs to give them information about hazards on their route, which means that it is even more important that the signs are well maintained, give adequate warning and help drivers to decide which route to choose instead.
Background research to this project has found that many people feel that the signing of low bridges is not performing the function it should be. Creasey (2000) wrote about the views of hauliers and suggested that hauliers believe that half the blame for bridge strikes lies with bad signing; he quotes Brenda Taylor (employer) who argues that signs are too close to the bridge and drivers need a lot more notification. Inadequate signing was the third most common reason why vehicles strike bridges, according to drivers interviewed by TRL in the HGV driver survey.

As part of this research, TRL have conducted an analysis of Network Rail’s incident database, which records reported incidents at rail bridges. These analyses were conducted in 1996 and again in 2003 and both sets of analysis show a problem with bridge signing. The results of analysing the 1996 records highlighted that although at most of the bridges struck there was some kind of advance warning, at 62% of cases, visibility was very poor. This could have been due to obscuration, faded signs, sign clutter etc. Only 65% of bridges involved in strikes were recorded as having some kind of advance warning signs when the analysis was repeated in 2003 (a significant drop from the 86% in 1996). The 2003 analysis also showed that many of the bridges being struck are those that are not illuminated and do not have distinctive paintwork.

The TRL HGV driver survey results are consistent with the remarks by Creasey and Taylor above; drivers wanted more signing, further in advance of the bridge. Nearly half of the drivers interviewed thought that signing further in advance of the bridge would help them make a better decision as to whether to continue on their route. Members of the focus group thought that existing signing usually appears too late and they have nowhere to turn around.

Throughout the stakeholder consultations conducted by TRL (2004) signing became a prevalent issue. HGV company employers also thought that signing is a problem; they would like to see bigger signs, lit up, more of them and again further in advance of the bridge. The police that were consulted were also in agreement and would like to see more careful consideration given to the placement of signs, so that they are in the direct line of sight for the driver.

The bridge audits that were undertaken by TRL (2004) revealed many problems with the signing at low bridges: signs that do not comply with regulations, signs that were badly maintained, missing signs and inconsistencies in signing. Local authorities are concerned with sign clutter and so often reluctant to erect more signs at or on the approach to low bridges. Again, the balance needs to be sought between having more signs and taking action to address the bridge strike problem. There was a general lack of procedures in place for maintaining low bridge signs, and height signs are rarely checked to make sure they are still displaying the correct height.

Ultimately it is important that signs are clear, conspicuous, and accurate, and provide the driver with adequate time to make an informed decision about whether to continue along their planned route.
8 Stage 4- Final Recommendations

This section details TRL’s recommendations for future action. The research that has been conducted within this project has informed TRL on the issues involved in dealing with the problem of over height vehicles striking bridges. TRL have consulted with many different affected parties (local authorities, HGV drivers, haulage companies, the police, bus companies, etc) and investigated issues such as:

- Past research into the bridge strike problem;
- Driver understanding and behaviour;
- Patterns in the occurrence of bridge strikes;
- Understanding of the problem by stakeholders;
- Quality of signing and;
- Implementing alternative routes.

The results of these investigations have enabled TRL to build a picture of the current situation and identify particularly problematic areas that need further attention. It is important that the results of this research are developed into a work plan and that the priority of the actions be determined. It is thought that the BSPG (Bridge Strike Prevention Group) may have a better understanding of likely timescales for implementing certain measures or overseeing particular further research, however an indication of a priority level is given by each recommendation.

The Stage 3 Report (PR/T/058/04) provided an evaluation of various different measures that could be undertaken in order to combat the seemingly rising number of bridge strikes. This section of final recommendations draws on those evaluations and highlights measures that should be taken forward. Not all of the measures considered in Stage 3 will be recommended here, only those of greatest value, though some of those in the previous may still be of some benefit.

8.1 National Measures

<table>
<thead>
<tr>
<th>STEP</th>
<th>ACTION</th>
<th>PRIORITY LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Develop an awareness campaign aimed at drivers and operators educating them in the issues relating to signed and unsigned bridges. Within the material produced, not only inform them of the issues but provide advice to drivers and operators about the actions they can take to help reduce the problem. The production and distribution of the material must be carried out in conjunction with an awareness campaign. Use shock tactics by showing photos of incidents.</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>Information booklets have already been designed for HGV drivers and Operators which is a very positive step, however it is vital that the information provided in these booklets is disseminated effectively; they must be distributed as widely as possible e.g. placed at Service Stations, free with relevant journal publications, sent to local HGV companies near problematic bridges. It is</td>
<td>High</td>
</tr>
</tbody>
</table>
### MEASURING VEHICLE HEIGHT
Drivers should have access to a tailored measuring device in order to accurately know the height of their vehicle.

<table>
<thead>
<tr>
<th>STEP</th>
<th>ACTION</th>
<th>PRIORITY LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Develop a lightweight, tailored measuring stick, particularly for drivers with variable height vehicles. Cost is an issue to drivers and operators therefore encourage market competition to keep costs low.</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>Use the media to promote the use of measuring devices, via haulage associations, relevant publications and ad campaigns.</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Introduce a method of enforcing the accuracy of in-cab height displays, for example it could be included within spot checks of vehicle ‘O’ licences and weight restrictions. Drivers should receive a penalty, such as a fine for displaying incorrect information.</td>
<td>High</td>
</tr>
<tr>
<td>4</td>
<td>The provision and accuracy of in-cab height indicators, for fixed height vehicles, should be checked in the MOT test.</td>
<td>Medium</td>
</tr>
</tbody>
</table>

### ALTERNATIVE ROUTE SYMBOLS
Symbols, such as yellow triangles or diamonds, should be used on advance direction signs in order that drivers can follow the symbol until they are back on the familiar route.

<table>
<thead>
<tr>
<th>STEP</th>
<th>ACTION</th>
<th>PRIORITY LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Encourage use of these symbols which will aid drivers when they take an alternative route. Symbol could be yellow diamond/triangle or the letters HV. Network Rail should identify priority sites where such symbols might be of immediate benefit.</td>
<td>High</td>
</tr>
</tbody>
</table>
Possible design of new information sign (with use of blue background) using the words “Vehicles over [X] High Follow [symbol]”.

<table>
<thead>
<tr>
<th>STEP</th>
<th>ACTION</th>
<th>PRIORITY LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Encourage use of VMS to direct over-height vehicles on to an alternative route, as well as just using it to inform them that they are too high for the bridge ahead. VMS must have a default message when they are not working. There is also a need for a good maintenance contract in place, including an emergency response, for maintaining these systems.</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>Consider use of pictograms to help foreign drivers.</td>
<td>Low</td>
</tr>
</tbody>
</table>

**INFRA-RED DETECTION SYSTEMS**
Infra-red systems warn drivers of an impending bridge strike by several different methods, such as variable message signs, flashing lights and audible alarms. The variable message signs can also be used to advise the driver of an alternative route.

**DATABASE OF LOW BRIDGES**
Collect information on all low bridges in the UK in order to develop a national bridge database- which may in the future incorporate an incident recording system.

**ENFORCEMENT CAMERAS**
Enforcement cameras could be positioned at appropriate locations in the vicinity of the bridges with mandatory signs, so that they are trained on a vehicle number plate.
The British Transport Police usually only deal with rail incidents, whilst local police deal with road traffic incidents. Further investigate the potential role of the British Transport Police and Crown Prosecution Service in prosecuting offenders of bridge strikes using information collected from enforcement cameras.

Further consultations should be made with companies that manufacture bridge strike detection systems in order to establish methods of collecting number plate data.

<table>
<thead>
<tr>
<th>STEP</th>
<th>ACTION</th>
<th>PRIORITY LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>The British Transport Police usually only deal with rail incidents, whilst local police deal with road traffic incidents. Further investigate the potential role of the British Transport Police and Crown Prosecution Service in prosecuting offenders of bridge strikes using information collected from enforcement cameras.</td>
<td>Medium</td>
</tr>
<tr>
<td>4</td>
<td>Further consultations should be made with companies that manufacture bridge strike detection systems in order to establish methods of collecting number plate data.</td>
<td>Low</td>
</tr>
</tbody>
</table>

| SIMULATION TOOLS |
| Use of CD-ROM based software or life size truck simulators to simulate driving situations that incorporate low bridges. |

<table>
<thead>
<tr>
<th>STEP</th>
<th>ACTION</th>
<th>PRIORITY LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Develop bridge strike training sessions using a truck simulation tool. This could be used as part of the HGV driver test, or could be used by HGV companies to provide ongoing training to their employees. This could take the form of desktop applications (which could be sent to companies for drivers to undertake at employer offices) truck simulation in a realistic environment (such as TruckSim). Incentives could be given to drivers or operators for attending the training e.g. reduced insurance premiums.</td>
<td>Medium</td>
</tr>
</tbody>
</table>

| IN-CAB ALERTING SYSTEMS |
| Enables users to electronically define and programme the co-ordinates of a specific landmark, such as a low bridge, into a vehicle mounted tracking unit which automatically sends an alert to the driver that it has crossed the geo-fence (i.e. the boundary). |

<table>
<thead>
<tr>
<th>STEP</th>
<th>ACTION</th>
<th>PRIORITY LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Currently there is no uniformity in the telematics systems used in lorries, therefore it would be difficult to encourage the use of systems such as Bridgeclear. It is suggested that the use of telematics systems be monitored, so that when there is sufficient usage of these systems, investigations take place on suitability of including low bridge alerting systems. There are plans to introduce lorry user charging which would make telematics boxes compulsory in all lorries- this may be a good time to explore the use of low bridge alerting systems. There needs to be a national controlled database of maximum safe headrooms.</td>
<td>Low</td>
</tr>
</tbody>
</table>
8.2 Local Measures

WORKING GROUPS
Local Authorities, Network Rail and other relevant stakeholders to work in partnership at problematic bridges.

<table>
<thead>
<tr>
<th>STEP</th>
<th>ACTION</th>
<th>PRIORITY LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Implement working groups at problematic bridges which would include the local highway authority and Network Rail as a minimum, but also other relevant stakeholder’s e.g. Police, local haulage companies, affected neighbouring local authorities, etc. The parties would work together, sharing information, ideas and costs in order to try to reduce the number of strikes occurring at the bridge. This could be managed centrally, by DfT in terms of a demonstration project that tackled a number of the most hit bridges (e.g. the top ten in the Top 100 bridges taken from Network Rail's system of strike recording). The project would show how these partnerships can work, which would encourage other authorities to use this method. All bridges on the South Circular Road (A205) in London should be included in any working party as this particular road contains some of the most hit bridges in the country.</td>
<td>High</td>
</tr>
</tbody>
</table>

BRIDGE AUDITS
Local Authorities (or agencies on behalf of local authorities) should check all signs and re-measure the height of all bridges, on a regular basis using a check sheet (see Appendix C).

<table>
<thead>
<tr>
<th>STEP</th>
<th>ACTION</th>
<th>PRIORITY LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>When a bridge is considered to be a problem because it is being continually hit, it is important that the bridge owner and the authority responsible for signing it understand what they can do to reduce the problem. This research has highlighted problems with signs and markings at bridges, therefore it is suggested that a checklist be made available to local authorities as a way of evaluating and prioritising the action they need to take. A checklist has been produced and can be found in Appendix C.</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>Local Authorities should periodically conduct a full review of the bridges in their area, in terms of their relative risk of being struck. The checklist in Appendix C may also be useful for this process. These regular audits should also include an action plan detailing what measures need to be undertaken.</td>
<td>High</td>
</tr>
</tbody>
</table>
SIGNING
A high level of accuracy should be maintained in signing, both on the bridge and in advance of the bridge, however particular attention should be directed to advance mandatory signing, repeater signs and alternative route signing.

<table>
<thead>
<tr>
<th>STEP</th>
<th>ACTION</th>
<th>PRIORITY LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Advance mandatory signing: All non-arch bridges should have at least one advance sign of a mandatory restriction on each approach at the last point of diversion before the low bridge.</td>
<td>High</td>
</tr>
<tr>
<td>2</td>
<td>All arch bridges should have at least one advance sign on each approach at the last point of diversion before a bridge.</td>
<td>High</td>
</tr>
<tr>
<td>3</td>
<td>Repeater signs: Repeater signs should also be used with the provision of an alternative route.</td>
<td>High</td>
</tr>
<tr>
<td>4</td>
<td>Advance height restriction sign, with indication of an alternative route: The use of the sign to diagram 818.4 (mandatory height limit ahead with indication of an alternative route) should be encouraged.</td>
<td>High</td>
</tr>
<tr>
<td>5</td>
<td>All low bridges should be correctly signed. Priority should be given to those bridges where no signs are currently provided.</td>
<td>High</td>
</tr>
</tbody>
</table>
8.3 BSPG Action Plan

The Bridge Strike Prevention Group (BSPG) meets twice a year to discuss measures to reduce the number of over-height vehicles striking bridges. As part of this they have developed an action plan which has been put on hold pending the results of this research. TRL have been asked to comment on the outstanding actions of this plan, with the knowledge acquired from their research. In order that good progress is made on carrying out the actions detailed in the plan, it is recommended that a sub-committee be established with key members of the BSPG. This sub-committee could meet more regularly than the BSPG and those within the group would have individual responsibilities for specific actions, thus ensuring that actions are taken forward.

The following table details the current action plan and suggestions from TRL where applicable.

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>ACTION</th>
<th>TRL COMMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improving availability of information about bridge heights</td>
<td>BSPG to explore options and feasibility of developing and maintaining national database of bridge heights that would be widely accessible. If practical to promote/facilitate implementation of the same.</td>
<td>This definitely needs to be developed and needs a champion- someone to be responsible for implementing and someone (or a group) to be responsible for maintaining it. This could be an add-on to ESDAL in the future, but no direct plans at the moment.</td>
</tr>
<tr>
<td>Improved information on driver behaviour</td>
<td>DTLR to consider commissioning further research to monitor driver behaviour at vulnerable bridges. This should include monitoring the effectiveness of signs indicating that camera surveillance is operating at a particular bridge. As part of this, DTLR also to consider the implications of Data Protection Act requirements, and of further adding to existing signing.</td>
<td>We have looked at driver behaviour at bridges, however there were no instances of surveillance cameras being used in any of the bridges studied in the audits.</td>
</tr>
<tr>
<td>Improved enforcement</td>
<td>BSPG to consider scope for more effective action against offenders. To issue information and advice for police, CPS and court officials on the economic and other damage caused by bridge bashing and the powers available to deal with drivers who ignore mandatory height prohibition signs. BSPG to explore the practicality and cost-effectiveness of using cameras to enforce mandatory height restrictions.</td>
<td>Need further investigation into Network Rail and local highway authorities funding the equipment and maintenance and whether BTP (British Transport Police) can be involved in prosecution; some police think it is a good idea but would need extra resources to prosecute. See recommendations.</td>
</tr>
<tr>
<td></td>
<td>CPS to collect data on prosecutions involving bridge strikes.</td>
<td></td>
</tr>
<tr>
<td>OBJECTIVES</td>
<td>ACTION</td>
<td>TRL COMMENT</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Higher penalties</td>
<td>Failure to comply with mandatory height signs attracts a fixed penalty and discretionary disqualification, but even if enforcement were to be improved it isn’t clear that the penalties are a sufficient deterrent, or that magistrates would impose the maximum penalty available. BSPG to explore with relevant authorities the scope for increasing the level of penalties.</td>
<td>TRL comment not appropriate due to legislation requirements.</td>
</tr>
<tr>
<td>Improved driver education</td>
<td>DTLR to issue updated “Know Your Traffic Signs” for commercial vehicle drivers. BSPG to consider other options for improving driver training and education.</td>
<td>TRL have recommended an awareness campaign.</td>
</tr>
<tr>
<td>Development of cost-effective warning devices</td>
<td>So far no system has been developed to the stage where it could offer a cost-effective or foolproof solution. BSPG to consider whether it could play any further useful role in facilitating the deployment of such systems, e.g. evaluation of effectiveness?</td>
<td>Using the Network Rail database, it has not been possible to efficiently determine the effectiveness of warning devices such as VMS. A separate study would need to address this (see suggestions for further work below).</td>
</tr>
<tr>
<td>Development of devices for measuring vehicle/ load heights</td>
<td>BSPG to consider feasibility of running a design competition for a portable height measurer.</td>
<td>No need for competition, just need a lightweight, compact, cost effective model. Need to approach an engineering company with the specific requirements, and consult with haulage companies for buy-in.</td>
</tr>
<tr>
<td>Consider options for improving information about incidence and severity of bridge strikes</td>
<td>It has become more difficult to identify areas requiring attention because of changes in the way the Network Rail database is maintained, which mean that there is less information available about the vehicles striking bridges and their place of origin. Also, damage is frequently caused by vehicles that manage to get through or away from the bridge and escape without being identified. BSPG to keep options for collecting information under review, especially in light of proposed changes in Network Rail.</td>
<td>No other way to record at the moment, so emphasis on Network Rail. Tighten up on the way NR record strikes e.g. consistency in how they record bridge heights, and accuracy of strike reporting.</td>
</tr>
</tbody>
</table>
### OBJECTIVES
Changes to legislation to allow Network Rail and other bridge owners to recover costs that are not presently recoverable

### ACTION
DTLR to consider whether there is any legislation proposed which might provide an opportunity to include appropriate provisions to make costs recoverable which cannot be recovered under existing legislation.

### TRL COMMENT
TRL comment not appropriate.
8.4 Recommendations for Further Work

8.4.1 Bridge Audits

A programme of bridge audits should be carried out, as a national project, at problematic bridges, i.e. those bridges with a high number of strikes. An agency independent of the highway authority should conduct the audits and report on actions that should be carried out by the highway authority (e.g. replacing or adding signs). The agency employed should have a good understanding of the regulations and therefore would have the appropriate knowledge to identify incorrect signing.

To assist in these audits, the bridge audit checklist in Appendix C would be of great benefit. When carrying out an audit, the latest version of TSRGD should also be available to check that all of the fixed signs observed on the approaches to the bridge, and on the bridge and diversion signs, conform to the regulations. The checklist could also be used by local authorities themselves when carrying out their own self assessments.

This work could be carried out as part of a demonstration project which would tackle the most problematic bridges, encouraging local authorities and Network Rail to work in partnership with each other and other interested/affected parties.

8.4.2 Trial of measures

A trial could be conducted where remedial measures, for example improvements in signing, could be introduced at problematic bridges. A ‘before and after’ survey of the number of strikes at a particular bridge could be conducted using bridge strike data from the National Rail database.

For non-arch bridges, improvements in signing could include the use of black and yellow chevron markings on either side of the bridge to make the bridge more conspicuous, or mounting mandatory signs, both on the approaches to the bridge and on the bridge, on yellow rectangular backing boards, to improve sign conspicuity. Reflectorised chord markings could be installed on each side of arch bridges to make the bridge more conspicuous, or lane markings, conforming to the regulations, could be painted on the road surface to guide high sided vehicles under the centre of the arch.

Variable message signs (VMS) could be installed before the last point of any possible diversion before a low bridge. For low bridges where there are still a large number of strikes despite the presence of VMS (which may be due to the sign being obscured by other vehicles, foliage or other signs) it may be worthwhile to trial VMS on both sides of the road.

It would be important to consider other influential factors in this kind of survey. For any particular bridge there may not be a simple correlation between, for example any signing improvements and a reduction in the number of strikes. Other factors may affect the number of strikes, such as a change of land use in the vicinity of the bridge, or changes in traffic flows and these would need to be monitored throughout the term of the study. Results would need to be examined over a suitable time period and it is suggested that a period of at least 5 years before implementing a preventive measure and a period of 5 years after be used.

8.4.3 TruckSim

TRL has recently introduced the UK’s first dedicated truck driving simulator which provides the opportunity to investigate the key issues in driver behaviour when confronted with low bridges including the practicality and benefits of improved signage, etc with no risk. Following creation of appropriate scenarios and scenery the simulator would enable measures to be evaluated, crucially, without damage to equipment or the actual bridges themselves.

Use of the TRL owned laser scanner could also provide the potential to integrate real scenarios into the simulator software. It is suggested that this approach be used to diagnose the actual key factors in
bridge strikes (particularly driver behaviour), evaluate potential solutions and create training scenarios to improve driver behaviour and their assessment of risk.

8.4.4 **Effectiveness of Mandatory Height Signs**

Investigations could be carried out, in the case of non-arch bridges with a high incidence of bridge strikes, where warning signs on the approaches to the bridge and on the bridge itself have been replaced with mandatory signs. For any particular bridge, a ‘before and after’ survey of the number of strikes would be conducted using bridge strike data from the National Rail database. Again there may be other factors to consider and these would need to be monitored throughout the study.

8.4.5 **Vehicle Height Distributions**

To inform future decisions on where to concentrate efforts on reducing the problem of bridge strikes, it would be useful to have a good idea of the distribution of vehicles heights on roads in the UK. The graph shown in Section 3.3 on page 16 of this report (Figure 6), gives an indication based on a very small and probably un-weighted sample (and was provided as part of a separate TRL project). To gather the data, TRL used its laser scanner which can capture the activity that is taking place in any particular location such that distances can be measured, for instance, without causing any disruption to the traffic, or any change in road user’s behaviour. It would be useful to collect a truly representative sample of vehicle heights, which would enable more focussed analysis of risk in terms of the number of bridges in the UK, the number of known strikes and the proportions of vehicles at particular heights.
9 Acknowledgements

The work described in this report was carried out in the Transport Systems Unit of TRL Limited. The authors are grateful to Ian Burrow who carried out the quality review and auditing of this report, the Department for Transport and the Bridge Strike Prevention Group for their guidance and assistance, and the stakeholders that took part in the consultation in Stage 2:

- Lincolnshire County Council (Grantham)
- London Borough of Lewisham (Lower Sydenham)
- Kent County Council (BSPG representative)
- Nottinghamshire County Council (Tollerton)
- WS Atkins (Wilton, Salisbury)
- Slough Borough Council (Langley)
- Transport for London (Latchmere Road)
- Swindon Borough Council
- Network Rail (Southern Region)
- Surrey County Council
- Handyskips
- Millbank Trucks Limited
- Waitrose
- Christian Salvesen
- Ashridge Plant Hire
- Thamesdown Transport (Swindon)
- Guildford Country Liners
- TfL (Surface Public Transport)
- Surrey Police
- Taplow Traffic Police
10 References


TSO (2002). The Traffic Signs Regulations and General Directions, 2002

Appendix A: HGV Driver Survey
SURVEY OF HGV DRIVERS

Good morning / afternoon. I am from the Transport Research Laboratory and we are currently carrying out a survey of HGV drivers to investigate your driving experiences on behalf of the Department for Transport. I noticed that you have driven an HGV here today and was hoping that you may be willing to answer a few questions in relation to route planning and signing around low bridges. It should take no more than 20 minutes and any answers that you give will be treated in confidence and used for statistical purposes only. Neither your details or your company details will be recorded in this survey.

If driver agrees to participate: While I ask you a few questions, would you be happy for my colleague to take some measurements of your vehicle? She/he will not record any information to identify the vehicle itself.

Q1 How long have you been driving HGVs?

___________________ years  ___________________ months

Q2 In total, how many miles per year do you drive an HGV for work purposes?

___________________ miles  ___________________ km

(if respondent wishes to answer in km)

Q3 Using the categories shown overleaf, please tick the HGV types that you regularly drive in the first column, and then the one you drove here today in the second.

(Hand questionnaire to respondent and respondent to complete the table overleaf)
<table>
<thead>
<tr>
<th>Vehicle Type</th>
<th>Rigid</th>
<th>Drawbar</th>
<th>Articulated</th>
</tr>
</thead>
<tbody>
<tr>
<td>CURTAINSIDER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TILT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Box Van (incl. stepframe)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reefer (Fridge)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TANKER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TANK CONTAINER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAR TRANSPORTER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EJECTOR/ WALKING FLOOR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BULK TIPPER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FLATBED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIVESTOCK</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>LOW LOADER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RECOVERY VEHICLE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GLASS CARRIER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OTHER</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Q4 Which of the following best describes your employment as an HGV driver?

(read out and tick one box only)

- Owner/operator (own vehicle only)
- Owner of trucking company (2 or more HGV drivers employed)
- Agency driver
- Employed by large company (10 or more HGV drivers employed)
- Employed by small company (less than 10 HGV drivers employed)

Q5 What is the height of the vehicle that you arrived in today?

(fill in spaces or tick box if respondent does not know)

___________ m ___________ cm ___________ ft ___________ inches (Go to Q6)

Don’t know (Go to Q7)

Q6 How do you know the height of this vehicle?

(read out separately and tick ALL that apply)

- The height of the vehicle is displayed in the cab (Go to Q8)
- You measured the vehicle before using it today (Go to Q7)
- You had measured the vehicle previously (Go to Q7)
- You were told its height by someone else (Go to Q7)
- Guessed or judged its height without measuring (Go to Q7)
- ‘Just know’ (Go to Q7)

Q7 Is the height of the vehicle displayed in the cab?

Yes (Go to Q8)

No (Go to Q8)

Don’t know (Go to Q8)
Q8  Do you or a colleague use any of the following devices to measure the height of this vehicle?
   (read out and tick all that apply)

   Digital HGV measuring device   (Go to Q9)
   Non-Digital HGV measuring device (Go to Q9)
   Tape measure (or other manual measuring tool) (Go to Q9)
   Other (please specify)           (Go to Q9)

   Do not use anything to measure the height of the vehicle  (Go to Q9)

Q9  Is the height of your vehicle measured every time the load changes?

   Yes                        (Go to Q10)
   No                         (Go to Q10)
   Not applicable/Load does not change (Go to Q10)
   Don’t know                 (Go to Q10)

Q10 Have you heard of the ‘Truckers’ Atlas/Guide’?

   Yes                        (Go to Q11)
   No                         (Go to Q12)

Q11 Do you have access to a ‘Truckers’ Atlas/Guide’?
   (Read out and tick all that apply)

   Yes, I own a copy           (Go to Q12)
   Yes, my employer has a copy (Go to Q12)
   Yes, from a different source (please specify) (Go to Q12)

   No                         (Go to Q12)
Q12  (Show card A)
When driving an HGV for work purposes, how often do you drive routes that you are unfamiliar with?

Never  (Go to Q14)
Rarely  (Go to Q13)
Sometimes  (Go to Q13)
Regularly  (Go to Q13)
Always  (Go to Q13)

Q13  Before making a journey that you are unfamiliar with, how do you plan your route?
(Read out and tick all that apply)

Local knowledge  (Go to Q14)
Advice from colleague/friend  (Go to Q14)
Directions provided by employer  (Go to Q14)
Direction from person at destination  (Go to Q14)
Use a website  (Go to Q14)
Use a Truckers’ Atlas  (Go to Q14)
Use a standard road map/atlas  (Go to Q14)
Other (please specify)  (Go to Q14)

I never plan my route  (Go to Q15)

Q14  (Show card A)
How often does your route-planning take into account low bridges?

Never  (Go to Q15)
Rarely  (Go to Q15)
Sometimes  (Go to Q15)
Regularly  (Go to Q15)
Always  (Go to Q15)
Q15  
(Show card B)

What differences exist in the meaning of these two signs?

(Go to Q16)

Q16  
(Show card B)

How would your behaviour differ when confronted by these two different signs?

(Go to Q17)

Q17  
(Show card C)

These are examples of signs describing alternative routes.

(Show card A)

If your vehicle is higher than the signed bridge height, how often do you follow the alternative route?

- Never  (Go to Q18)
- Rarely  (Go to Q18)
- Sometimes  (Go to Q18)
- Regularly  (Go to Q18)
- Always  (Go to Q20)

Q18  Why would you not follow a signed alternative route?

(Go to Q19)
Q19  Which of the following information would encourage you to take a signed alternative route to avoid a low bridge?
(Read out and tick all that apply)

- Length of alternative route
- Clearly Signed route at each junction
- Symbols to mark the alternative route
- Location of the bridge (e.g. Sandhurst)
- Other (please specify)

__________________________________________________________

Nothing would encourage you to take an alternative route

Q20  What is the maximum number of miles that you would accept a permanent alternative route to add to your overall journey distance?

___________________ miles ___________________ km
(if respondent wishes to answer in km)

Doesn't Matter

Q21  Which of the following would you do if diverted onto a temporary alternative route due to an accident or other unforeseen situation on the route ahead?
(Read out and tick all that apply)

- Follow the diversion without checking the route to be taken
- Check alternative route on atlas/map but do not check for low bridges
- Check atlas/map for low bridges on the alternative route
- Phone employer for guidance/information
- Phone person at destination for guidance/information
- Other (please specify)

__________________________________________________________
Q22  Do you think that signs displayed at low bridges provide enough information to make a 
safe decision to pass under the bridge?  
(Use show card D if respondent needs an example)

Yes  (Go to Q24)  
No  (Go to Q23)

Q23  What other information would help you to decide whether to pass under the bridge?

(QGo to Q24)

Q24  (Show card A)  
In your opinion, how often are signed bridge heights accurate?  

Never  (Go to Q25)  
Rarely  (Go to Q25)  
Sometimes  (Go to Q25)  
Regularly  (Go to Q25)  
Always  (Go to Q26)

Q25  Do you think that signed height is usually lower or higher than the actual bridge height?

Higher  (Go to Q26)  
Lower  (Go to Q26)  
Some are higher and some are lower  (Go to Q26)

Q26  What is the maximum height of vehicle that you would attempt to drive under a bridge 
signed with a height of 12’9”” (3.9m)

___________ m  ___________ cm  ___________ ft  ___________ inches
Q27 Would your answer to Q26 depend on any other factors?
(Prompt if necessary: Would your behaviour change depending on the situation?)

Yes  (Go to Q28)
No   (Go to Q29)

Q28 What are these factors?
(DO NOT read out, tick all responses provided and record how they would change)

Mandatory, Circular sign    (Go to Q29)
_________________________________________________________
Triangular, Warning Sign    (Go to Q29)
_________________________________________________________
When load changes on a rigid vehicle    (Go to Q29)
_________________________________________________________
When load changes on a Low Loader     (Go to Q29)
_________________________________________________________
Other (please specify)     (Go to Q29)

Q29 Do you prefer bridge height signs to provide measurements in...?

Metric (metres)    (Go to Q30)
Imperial (feet)    (Go to Q30)
Both               (Go to Q30)
No preference      (Go to Q30)

Q30 What is the maximum height of vehicle you can safely take under an unsigned bridge without first checking your route with the local highway authority?

___________ m  ___________ cm  ___________ ft  ___________ inches

Don’t know
Q31 Do you think that all bridges should be signed, irrespective of their height?

Yes (Go to Q32)

No (Go to Q32)

Q32 How much information or guidance have you received from your employer on how to avoid hitting low bridges?

None (Go to Q34)

A little (Go to Q33)

A lot (Go to Q33)

Q33 What information or guidance was provided?

Q34 What would your employer do if you hit a low bridge with your HGV? (Read out and tick all that apply)

Sack you (Go to Q35)

Suspend you pending an enquiry (Go to Q35)

Fine you/remove other financial privileges (Go to Q35)

Nothing (Go to Q35)

Other (please specify) (Go to Q35)

Don’t know (Go to Q35)

Q35 Have you, or anyone you know, ever struck or scraped a low bridge when driving an HGV? (Prompt: we are interested in ANY instances, they can include minor scrapes)

Yes (Go to Q36)

No (Go to Q38)
Q36  How many incidents have you, or anyone you know, had?

___________________

Q37  Can you please describe the two most recent incidents..?

(a) What happened?
   Incident 1
   Incident 2

(b) How did it happen?
   Incident 1
   Incident 2

(c) What happened as a result?
   Incident 1
   Incident 2

(Go to Q38)

Q38  What do you think are the main causes of HGVs hitting low bridges?
    (Read out and in column A tick all that apply, and in column B tick what the respondent thinks is the main cause)

    A       B

    Inadequate signing
    Driver not knowing vehicle height
    Drivers not understanding signs
    Drivers not believing signs
    Poor route planning
    Other (please specify)

________________________________________________________

(Go to Q39)
Q39  Would you be more careful about passing under a low bridge if the following enforcement measures were in place?  *(Read out and tick all that apply)*

Yes  No

Driver receives fine following a bridge strike  
Driver receives points on license following a bridge strike  
Video surveillance cameras situated at the bridge

Q40  Do you think that automatic in-cab warning devices are effective in warning drivers of a low-bridge on the route ahead?

Yes  *(Go to Q42)*  
No  *(Go to Q41)*  
Do not know of such devices  *(Go to Q43)*

Q41  Why do you think that they are not effective?

*(Go to Q42)*

Q42  How much would you be willing to pay to for an automatic in-cab warning device?  *(Read out and tick all that apply)*

Nothing  *(Go to Q43)*  
Less than £50  *(Go to Q43)*  
£51 to £100  *(Go to Q43)*  
£101 to £150  *(Go to Q43)*  
£151 to £200  *(Go to Q43)*  
More than £200  *(Go to Q43)*
Q43  Do you think that infra-red detector systems linked to electronic message signs are an effective method of warning an HGV driver that his/her vehicle is too high to pass safely under a bridge on the route ahead?

Yes  (Go to Q45)
No  (Go to Q44)
Do not know of such devices  (Go to Q45)

Q44  Why do you think that they are not effective?

Q45  How old are you?

Q46  INTERVIEWER: Please note respondent's sex

Male  (Go to Q47)
Female  (Go to Q47)

Q47  Do you have any further comments about anything that you have been asked about during this interview?
Appendix B: Truck Driver Survey
Theory Questionnaire

Driver-ID:

1. Unless otherwise shown, what is the minimum height of an unsigned bridge?

   metres

   OR

   feet

   inches

2. When a vehicle is over 3 metres tall, it is a legal requirement to display the height of the vehicle in the driver’s cab. In your experience, is this in-cab height display always accurate?

<table>
<thead>
<tr>
<th>Tick One</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Always</td>
</tr>
<tr>
<td>b) Usually</td>
</tr>
<tr>
<td>c) Sometimes</td>
</tr>
<tr>
<td>d) Rarely</td>
</tr>
<tr>
<td>e) Never</td>
</tr>
</tbody>
</table>

3. The height of your vehicle is 3.7 metres (12 feet). What action should you take on the approach to this bridge?

<table>
<thead>
<tr>
<th>Tick One</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Keep to the centre of the arch and give way to oncoming traffic</td>
</tr>
<tr>
<td>b) Drive through slowly, keeping to the left of the marked limits</td>
</tr>
<tr>
<td>c) Keep to the centre of the arch and take priority over oncoming traffic</td>
</tr>
<tr>
<td>d) Drive through quickly, keeping to the left of the marked limits</td>
</tr>
</tbody>
</table>
Thank you very much for completing this part of the questionnaire.

TRL are currently investigating the problem of vehicles hitting bridges, a research project for the Department for Transport. We appreciate the time you have taken to complete the questions above regarding low bridges. Your personal details will not be recorded for use with this project. If you have any other useful comments regarding the problem of vehicles hitting bridges, please write them in the box below.

COMMENTS:
Appendix C: Bridge Audit checklist
## BRIDGE AUDIT CHECK SHEET

<table>
<thead>
<tr>
<th><strong>Bridge Location</strong></th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Signed height (feet /inches)</strong></th>
<th>[Current Signed Height]</th>
<th>[Height After Re-Measuring]</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Date of audit</strong></th>
<th></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Advance signing</strong></th>
<th></th>
</tr>
</thead>
</table>

- **Signing:**
  - *Is it there?*
  - *Is it Adequate?*
  - *Is it in the right place?*

  **Comments:**

<table>
<thead>
<tr>
<th><strong>Is the bridge signed on its approach from both directions?</strong></th>
<th>YES/NO</th>
<th><strong>Comments:</strong></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Is advance signing used at junction points on the approach to the bridge?</strong></th>
<th>YES/NO</th>
<th><strong>Comments:</strong></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>What signs have been used?</strong></th>
<th><strong>List:</strong></th>
</tr>
</thead>
</table>

- **Consider the following:**
  - *Warning or mandatory signs (non-arch bridges: diagrams 530, 629.2, 629.2A and 818.3)*;
  - *Warning signs (arch bridges: diagrams 530, 531.1 - with arch bridge symbol and 531.2)*.

<table>
<thead>
<tr>
<th><strong>Do the signs conform to the current regulations (TSRGD, 2002)?</strong></th>
<th>YES/NO</th>
<th><strong>Comments:</strong></th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th><strong>Are the signs in good condition?</strong></th>
<th><strong>Comments:</strong></th>
</tr>
</thead>
</table>

- **Consider the following:**
  - *Cleanliness;*
  - *Damage;*
  - *Graffiti;*
  - *Obscured.*
<table>
<thead>
<tr>
<th>Question</th>
<th>YES/NO</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is there unacceptable sign clutter?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is it appropriate to consider adopting measures to make the signs more conspicuous (e.g. rectangular yellow backing boards)?</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td><strong>Signing at the bridge</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are warning or mandatory signs located on both sides of the bridge?</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>Does the signed height at the bridge agree with that shown in the AA Truckers Atlas of Britain? (if applicable)</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>What signs have been used?</td>
<td>List:</td>
<td></td>
</tr>
<tr>
<td>Consider the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Warning or mandatory signs (non-arch bridges: diagrams 530, 629.2 and 629.2A);</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Warning signs - arch bridges (diagrams 530 and 531.1);</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Chevrons - non arch bridges (diagram 530.2);</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Chord markings - arch bridges (diagram 532.2);</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Road markings - non arch bridges;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Lane and road markings - arch bridges (diagrams 1010, 1014 and 1024.1).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do the signs conform to the current regulations (TSRGD 2002)?</td>
<td>YES/NO</td>
<td></td>
</tr>
<tr>
<td>Are the signs in good condition?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consider the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Cleanliness;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Damage;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Graffiti;</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
- Obscured;
- Condition of H bars (arch bridges only).

<table>
<thead>
<tr>
<th>Question</th>
<th>YES/NO</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is there unacceptable sign clutter?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is it appropriate to consider adopting measures to make the signs more conspicuous (e.g. rectangular yellow backing boards)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is it appropriate to consider using markings on the bridge? e.g. ‘LOW BRIDGE’</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Provision of Alternative Route**

<table>
<thead>
<tr>
<th>Question</th>
<th>YES/NO</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is there a signed alternative route?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the alternative route suitable for high vehicles?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What signs have been used? Consider the following:</td>
<td></td>
<td>List:</td>
</tr>
<tr>
<td>Primary route direction signs (diagrams 2002, 2003 and 2027);</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non – primary route direction signs (diagrams 2107, 2108 and 2132);</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Informatory signs (diagrams 818.3 and 818.4).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do the signs conform to the current regulations (TSRGD, 2002)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the signs in good condition? Consider the following:</td>
<td></td>
<td>Comments:</td>
</tr>
<tr>
<td>Cleanliness;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damage;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graffiti;</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obscured.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there unacceptable sign clutter?</td>
<td>YES/NO</td>
<td>Comments:</td>
</tr>
<tr>
<td>Use of Specific Measures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is it appropriate to consider the use of Variable Message Signs (VMS)?</td>
<td>YES/NO</td>
<td>Comments:</td>
</tr>
<tr>
<td>Consider the following:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- <em>Use on approach as warning or diversion signing;</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- <em>Location;</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- <em>Functioning correctly;</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- <em>Free from foliage.</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is it appropriate to consider the use of Automatic detection systems (with cameras)?</td>
<td>YES/NO</td>
<td>Comments:</td>
</tr>
<tr>
<td>Is it appropriate to consider the use of Impact protection beams on bridge?</td>
<td>YES/NO</td>
<td>Comments:</td>
</tr>
<tr>
<td>Is it appropriate to consider the use of other forms of detection systems (e.g. chains)?</td>
<td>YES/NO</td>
<td>Comments:</td>
</tr>
<tr>
<td>General Considerations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. of reported strikes in previous 12 months</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date of last bridge strike.</td>
<td></td>
<td></td>
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<tr>
<td>Amount of HGV traffic passing under bridge.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Any weight restrictions on the route under the bridge.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjacent land use.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence and location of any other low bridges nearby.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scope for a high sided vehicle to manoeuvre, i.e. turn around in the vicinity of the bridge.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>--------</td>
<td></td>
</tr>
<tr>
<td>General bridge condition, in particular structural weaknesses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are there distracting advertisements on the approaches to the bridge?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the lighting adequate for the signs and at the bridge?</td>
<td></td>
<td></td>
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</tbody>
</table>