Department for Transport

# Managing the accidental obstruction of the railway by road vehicles

February 2003

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Department for Transport
Great Minster House
76 Marsham Street
London SW1P 4DR
Telephone 020 7944 3000
Internet service www.dft.gov.uk



Further copies of this report are available from:

Department for Transport
PO Box 236
Wetherby
West Yorkshire
LS23 7NB
Tel: 0870 1226 236
Fax: 0870 1226 237
Email: dft@twoten.press.net

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# contents

# Introduction

On 28 February 2001 a vehicle came off the M62 motorway at Great Heck, near Selby, ran down the railway embankment and onto the East Coast Main Line, where it was struck by a passenger train. The passenger train was derailed and then struck by a freight train travelling in the opposite direction. 6 passengers and 4 staff on the trains were killed. The driver of the vehicle was found guilty of causing the deaths of 10 people by dangerous driving. The Deputy Prime Minister commissioned early reports about the crash from the Health and Safety Executive (HSE) and TRL Ltd (formerly the Transport Research Laboratory). HSE's report made clear that the accident was considered to have resulted from a highly unlikely and unpredictable chain of events. TRL's report showed that the safety barriers met the requirements of the national standard.

The Deputy Prime Minister was also concerned about the general issues this crash raised about the accidental incursion of road vehicles onto the railway. He asked the Health and Safety Commission (HSC) to convene a working group to look at the circumstances of incidents where vehicles have blocked rail lines and whether there are features in common that might have been preventable. Their report *'Obstruction of the railway by road vehicles'* ISBN 07176 2294 0 was published on 25 February 2002. Copies are available from HSE books price £5.00 or to download at www.hse.gov.uk/railway/obstruct.pdf.

At the same time the Deputy Prime Minister asked the Highways Agency to review its standards for near side safety barriers. Their report *'To review the standards for the provision of nearside safety fences on major roads'* was also published on 25 February 2002 and copies are available to download at www.highways.gov.uk.

These two reports contained 19 separate recommendations to Government. This report has been produced in response to those recommendations and sets out the steps we consider should be taken jointly by railway infrastructure authorities and highway authorities to manage the risk of the accidental incursion of road vehicles onto the railway. The steps have been drawn up by working groups containing representatives from the railway infrastructure authorities, highway authorities, Railway Safety, the Health and Safety Executive, the British Transport Police, the Welsh Assembly Government, the Scottish Executive, the Northern Ireland Roads Service, the Department for Transport and the Highways Agency. The members of the working groups are listed in appendix 1 of this report.

Chapter 1 outlines the process the working groups consider should be followed in order to manage the accidental incursion of the railway by road vehicles. The contacts listed in appendix 2 have been closely involved and volunteered to advise on the use of the various forms in this report.

Chapter 2 is the protocol for apportioning responsibility and costs of improvements made at locations where roads maintainable at public expense meet, cross or run close to railways. The protocol does not cover level crossings. This protocol meets the sixth recommendation in the HSC report. It was drawn up by the members of working group 1 and has been ratified by representatives of the main road and rail authorities. We commend it to other authorities as a model when considering what might be required on the infrastructure for which they are responsible.

Chapter 3 is the proforma to rank the risk at the sites for which you are responsible. Form 1a was produced by the CSS (formerly the County Surveyors Society), the Highways Agency and Network Rail (formerly Railtrack) to assess single carriageway roads over railways. Form 1b was produced by the Highways Agency, CSS and Network Rail to assess motorway and dual carriageway roads over railways. Form 2 was produced by Network Rail, CSS and the Highways Agency to assess all roads neighbouring railways. All three proforma are available on the DfT website www.roads.dft.gov.uk/roadnetwork/bridgesites/index.htm. Many authorities have already assessed the risk at the sites for which they are responsible. These forms may look a little different to the ones they used, but their substance is the same as the earlier versions. There is no need to reprioritise sites.

The risk prioritisation forms will have helped identify the high priority sites and the low priority sites on your network. You may well have already carried out mitigation work on the high priority sites. It is likely, however, that there will be a number of sites where the risks are not clearcut. These sites may well benefit from the second stage assessments set out in Chapter 4 that was developed by the second working group and TRL. The copy of form 3 on the DfT website is ready for use and will automatically calculate the cost-effectiveness of measures at individual sites. The risk prioritisation tools and the second stage risks assessments meet the first recommendation of the HSC report and recommendations f and g of the Highways Agency report. This chapter also contains guidance developed by a third working group, with technical support from TRL, about measures that might help mitigate the risk of the accidental incursion of road vehicles onto the railway. This meets the fifth recommendation of the HSC report.

The second and third recommendations of the HSC report were that more and better data should be collected about the accidental incursion of the railway by road vehicles. It has been agreed that from 1 April 2003 British Transport Police will record the data about road/rail incidents, including those at level crossings, on a proforma. This will be supplemented by data about the road itself and collated by Railway Safety. The proforma will be available, with instructions about its completion, on the DfT website.

The Highways Agency is taking forward recommendations a, b, c, d, e, h, i, j and k of their report. This report meets recommendation l. To steer the standards the Agency has established a Technical Project Board with members from design consultants, road and rail design experts, the devolved administrations, barrier manufacturers and their trade association and road and rail safety experts. A consultant has been commissioned to assist with the preparation of the revised barrier standard, which will be circulated widely for consultation.

Action is outstanding on recommendation 4 and on recommendation 7 of the HSC report. The Department will obtain information annually about the progress of work to manage the accidental incursion of the railway by road vehicles. In 2006 the Department will seek the views of the main parties involved in the drawing up of the protocol on responsibility and costs in order to review its operation.

The Department for Transport is extremely grateful to the members of the groups, and the organisations they represent, for the hard work and time they have devoted to the production of this report.

Department for Transport

February 2003

# chapter one: The process of managing road/rail interfaces

This document offers guidance on how highway authorities and rail authorities can demonstrate that they have ranked sites where roads cross or run alongside railways according to their relative risk and that they have considered how to manage that risk. It includes everything authorities should need to manage risk.

Chapter 2 is the protocol ratified by the Local Government Association and Network Rail setting out the apportionment of responsibility and costs of improvements made at locations where roads meet, cross or run close to railways. Chapters 3 and 4 set out how to rank risk at all sites and assess the scope for treatment at the higher ranked sites. Scoring spreadsheets and guidance on their use accompany these chapters.

The advice emphasises the need for consistency in assessing rail interfaces with roads. The scoring spreadsheets make this easier to achieve. The guidance also indicates the level of justifiable expenditure for sites reaching different scores in the initial risk ranking process. The guidance is based on the combined judgement and expertise of a group of experts from both road and rail sectors. The ranking scores produced are designed to allow risks to be compared; they should not be treated as accurate measures of safety risk.

Final decisions on the need for, and type of, treatment (and, therefore, the appropriate level of expenditure) rest with highway and rail authorities. They should not rule out the possibility of action at any site.

## 1.1 Background

The report (Health and Safety Commission, 2002) following the rail incursion at Great Heck in February 2001 recommended that the Department for Transport develop guidance on the application of measures to manage risk where roads meet, cross or run close to railways.

This guidance is most relevant to:

- road bridges over railways;
- roads running alongside railways; and
- cul de sacs ending at railways.

It covers all classes of road. It does not, in general, cover level crossings.

Recent data suggests that, on average, incidents where vehicles end up on rail tracks at these sites will kill one train occupant every 10 years and one vehicle occupant every two and a half years.

A two-part assessment process is recommended. This process should start by ranking the risk at every site, followed by an assessment of the cost effectiveness of measures to reduce risk at the higher scoring sites. Many sites in Britain will have been ranked already.

**STEPS TO RECORD RISK AND DECIDE TREATMENT**

- Read the explanatory notes (Chapter 1)
- Read the guidance notes relating to the risk ranking tool (Chapter 3)
- Obtain scores for the railway factors (on forms 1a, 1b and 2) for all sites
- Define a screening programme, starting with sites with the highest rail factor scores
- Visit sites and complete forms 1a, 1b or 2. Use scores to establish whether the sites need further assessment
- For overbridge sites with an initial score of more than 90, rescore form 1a or 1b for each corner of the site separately
- Record scores for audit records on sites that don't need further assessment
- Read guidance notes on assessing the scope for treatment at a site (Chapter 4)
- Where sites qualify for more assessment, obtain more detailed information based on the guidance, include a site diagram, and record scores and all other relevant information
- Complete the mitigation spreadsheet (form 3) by identifying, costing, assessing the effectiveness of and selecting appropriate measures
- Recommend action, taking account of local views, budget and benefit
- Record all findings and decisions and set date for a review

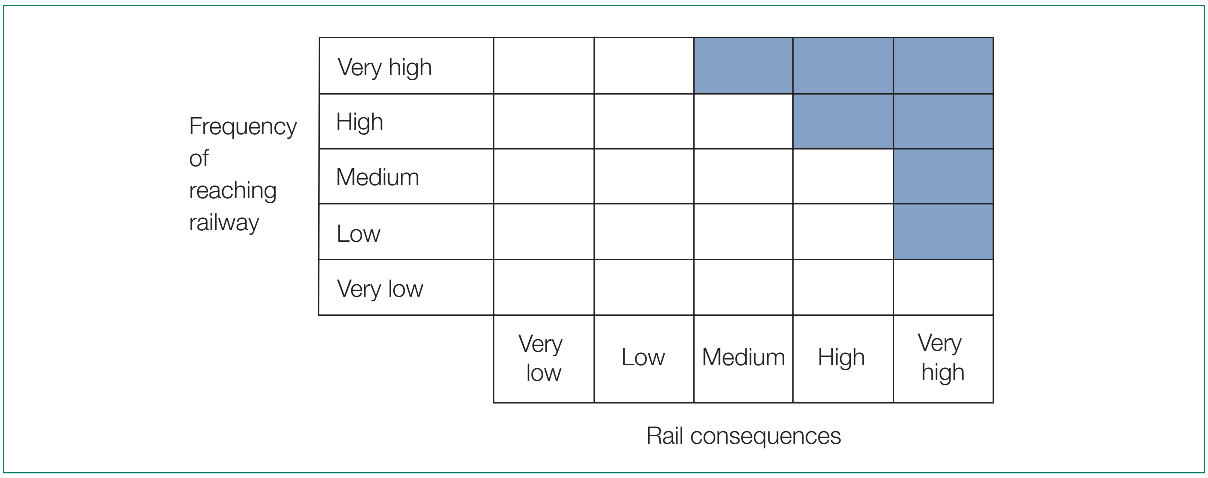
## 1.2 Ranking sites to assess comparative risk

All sites should be inspected and a record of their comparative risk made using a consistent scoring sheet for each road/rail interface (forms 1a, 1b or 2). This will provide an audit record.

The scoring system highlights the highest risk areas. The assessment then considers the potential sources of the risk and the appropriate treatment (form 3).

There are three factors that combine to give the level of risk at a particular location – the frequency of vehicles leaving the road (average number of occasions a year), the probability of the containment failing to prevent the vehicle reaching the railway line, and the consequences in terms of death and injury if a vehicle reaches the line. The combination of high probability of a vehicle reaching the rail line, and a high likelihood of injury if this occurs, leads to the highest level of risk ranking. The risk matrix at Figure 1.1 illustrates this.

### Fig 1.1 Risk matrix – sites for treatment likely to lie in shaded area



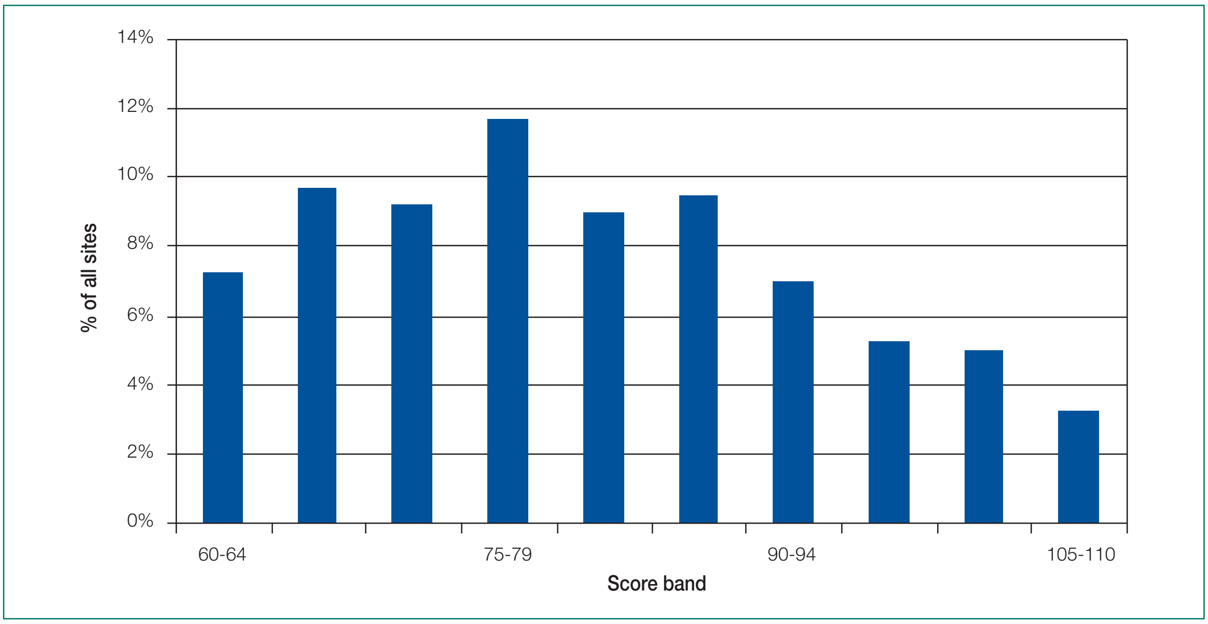

Authorities should use the same general scoring process for all roads, but Chapter 3 includes separate scoring spreadsheets for overbridges and for neighbouring sites (forms 1 and 2, respectively). There are separate overbridge scoring spreadsheets for single carriageway roads (form 1a) and for motorways and dual carriageway roads (form 1b). These take account of the different characteristics at these sites.

Authorities should give top priority to inspecting sites where there have been recent incursions or which have high rail or road traffic flows. Authorities can get rail score information for all sites from the relevant railway authority.

The highway authority should make sure that it scores all its sites and the railway infrastructure authority should have the opportunity to comment on the scores. Joint inspection may be appropriate.

Each highway authority is likely to identify a wide distribution of risk over all its sites. Figure 1.2 shows a typical distribution of the higher scores that might be expected based on information from all sites within one region.

**Fig 1.2 Typical distribution of scores**




## 1.3 Assessing scope for treatment

The initial risk scoring identifies the worst potential outcome at each site. So the first stage of assessing treatment (Chapter 4) is to work out at which part of the site the worst outcome might occur.

Vehicles usually leave the road in one of the following situations:

- a driver fails to negotiate a bend or is tired or inattentive. In the extreme case, a driver who has fallen asleep or is taken ill may make little attempt to recover the situation;
- a conflict between vehicles causes one to swerve or results in a collision. In the latter case speeds are likely to be reduced before leaving the road.

The engineer will need to judge whether vehicles are likely to leave the road at the site, and what the vehicle paths would be.

Information on the following factors should be considered:

- road gradient – general, and local to bridge – and its effect on visibility;
- presence and severity of bends;

- likely excess speed of traffic (in any circumstances);
- potential conflicts;
- warning signs or road markings;
- unstimulating environments that might exacerbate problems of driver fatigue;
- potential influence of traffic at nearby junctions;
- width and structure of the verge/hard shoulder, to assess the potential effect on vehicles;
- presence of, and further scope for, safety fencing; and
- any provision for pedestrians and cyclists nearby.

The engineer needs to identify the most likely points at which vehicles might leave the road, taking account of the factors above. He or she should then assess whether vehicles leaving at this point could be contained. The engineer should take account of any existing information on vehicles leaving the road or accident damage at the site.

Identifying the worst parts of the site is likely to be most important when considering containment. The site type diagrams (Figures 4.1 – 4.4) give some indication of the areas to assess. They also show the areas around these sites where there may be higher likelihood of vehicles reaching the railway. The engineer will need to judge what part of these areas to consider at each site, taking into consideration the landscape and traffic conditions. Where the engineer marked containment as deficient on the initial scoring spreadsheet (form 1a, 1b or 2), it is important that he or she should record how much of the site this relates to.

Authorities should normally consider a level of containment sufficient to stop a car from reaching the rail line. Higher levels may be needed on roads with a high percentage of HGVs, or where HGVs might be manoeuvring near the site. Standard fencing will be less effective if a vehicle strikes it at an angle greater than 20 degrees.

Obstacles along the vehicle's likely route will influence the likelihood of containment. For example, trees, bushes, road signs, lighting columns, ditch or drainage features, and also the slope of the ground beyond the road's edge could prevent incursion. It will be useful to judge in two parts the likelihood of vehicles reaching the railway. First, is there a path through which a vehicle could penetrate the roadside boundary? And secondly, having done so, is it likely to continue onto the railway, whether upright or on its side?

The engineer should record this information and the conclusions from it in a brief report, together with a site map or diagram showing the areas he or she considers to be at risk.

## 1.4 Deciding how much to spend

The HSC report *'Obstruction of the railway by road vehicles'* reaches the following conclusions:

- risk is small in relation to other elements of railway risk and tiny in relation to other elements of road risk, but it is nonetheless worth considering ways of reducing it;
- schemes to reduce risks of road vehicles ending up on railway lines should not leapfrog other road and rail safety initiatives that would yield bigger safety improvements; and
- at many locations there may be nothing more to be done beyond what is already in place.

Sites where containment is clearly inadequate and the probability of injury to train occupants is high are likely to score 100 or over in the initial ranking (on forms 1a, 1b or 2). Road authorities should seriously consider building a safety fence at these sites that is appropriate to the type of site, the level and type of traffic.

Many sites scoring less than 100 may also warrant some treatment. Risk here should be reduced to a level that is as low as reasonably practicable. The key is deciding the right level of investment to meet this principle. If a low cost measure would obviously benefit a site, then the highway authority should consider it regardless of the ranking score.

At many locations there may be no practical measures to be taken beyond what is already in place.

In order to provide guidance on levels of spend, the total level of risk and its likely distribution between different types of site has been considered at a national level.

The HSC report shows that on average, 0.1 train occupants and 0.4 vehicle occupants die in Great Britain every year as a result of accidental incursions onto Network Rail's railway lines (excluding accidents at level crossings).

The measures that are most likely to be implemented to prevent road and rail fatalities and injuries are either safety fencing, or changes in road marking, signing or traffic management. Fencing can be assumed to have a life of 20 years but road markings or signing may last for less than five years.

For the purpose of the calculation below, the Department for Transport has estimated that an overall maximum investment of £32 million[1] can be justified to minimise the risk at all road/rail sites in Great Britain. It is expected that road and rail authorities will, jointly, consider the risk at individual sites and make judgements about the appropriate amount to spend at them. This expenditure is directed primarily at good asset management and will not contribute significantly to road casualty reduction.

1 All prices and costs given in this document are for 2002.

The distribution of risk between sites used in this document is based on information from a sample of sites inspected in 2001 and 2002. There are an estimated 6,500 sites where public road bridges cross railways, including London Underground and private rail lines. The number of sites needing assessment where roads neighbour railways is less clear. A figure of 2,000 has been assumed in this document.

Figure 1.3 summarises how these numbers might give an estimate of the total expenditure justified at bridges with different ranking scores. However, these are guideline figures only because:

- differences in regional costs will mean that lower amounts may be appropriate at many sites in the country;
- engineering judgement will influence what treatments are appropriate at particular sites; and
- the risk ranking tool is imprecise.

For sites other than those with very high scores (100 or more on forms 1a, 1b or 2), the expenditure should be assessed alongside other road and rail safety needs. Authorities might consider such sites for treatment at the same time as other planned site improvements or maintenance programmes.

**Fig 1.3 Indicative spend per site**

| Risk ranking score | Comparative risk | % of sites | No. of sites | % of total risk | Estimated maximum total investment (£ millions) | Indicative spend per site (£000) |
|---|---|---|---|---|---|---|
| ≥105 | 1300 | 3 | 250 | 73.5 | 24 | 30 – 200 |
| 100-104 | 230 | 5 | 425 | 21.7 | 7 | 5 – 30 |
| 95-99 | 40 | 5 | 425 | 3.8 | 1 | 1 – 5 |
| 90-94 | 7 | 7 | 600 | 0.9 | < 0.1 | < 1 |
| 85-89 | 1 | 9 | 760 | 0.2 | < 0.1 | < 0.2 |
| 80-84 | 0.2 | 9 | 770 | <0.1 | < 0.01 | < 0.2 |
| <80 | 0.03 | 62 | 5,270 | <0.1 | < 0.01 | < 0.2 |
| All | | 100 | 8,500 | 100 | 32 | |

## 1.5 Assessing effectiveness

The pack includes a mitigation spreadsheet (form 3) to help engineers choose cost effective measures. There is further information on typical costs and effectiveness of measures in Chapter 4 of this document.

Engineers should enter their estimates of the cost and suitability of a range of measures at each site. The spreadsheet then gives the relative cost-effectiveness for different measures.

Where possible, engineers should use and record their own judgement of the effectiveness of potential measures at each site. The total costs of implementing measures at a site will also depend on local conditions, and whether the whole site has to be treated or only one approach.

The spreadsheet (form 3) also, as each measure is selected, re-calculates the estimated effectiveness of unselected measures, and calculates the estimated effectiveness of all the selected measures together.

Examples using the mitigation spreadsheet (form 3) can be found in the detailed guidance notes with the spreadsheet (Chapter 4).

## 1.6 Follow up actions

### Documentation of scores

Network Rail has a database of all risk ranking scores for sites on their lines. London Underground Ltd holds similar scores for their sites. Highway authorities should notify the appropriate railway infrastructure authority whenever they introduce safety measures following risk ranking.

Highway authorities should keep their own record of documentation relating to risk ranking and follow up assessment decisions, for audit purposes.

Before any major planned changes on either road or rail at these sites, authorities should reassess the site under the proposed new conditions.

### Review

Action should be taken to follow the protocol recommendation that arrangements need to be in place to maintain and evaluate the effectiveness of the measures.

# Protocol for apportioning responsibility and costs of improvements made at locations where roads maintainable at public expense meet, cross or run close to railways (except level crossings)

## Introduction

After the road/rail accident at Great Heck, Selby, on 28 February 2001 the Secretary of State for Transport agreed to the 19 recommendations from the Health and Safety Commission and the Highways Agency about how best to mitigate as far as possible against similar accidental incursions in the future. This mitigation included a joint programme of work by highway authorities and rail infrastructure authorities to prioritise and assess the risk of a vehicle leaving the road and getting onto the railway at the sites for which they were responsible. They would then need to jointly consider and agree what measures, if any, might be appropriate and effective in helping to reduce the risk of this happening.

It was not part of the 19 recommendations, but it seems sensible that highway authorities and railway infrastructure authorities should investigate jointly any incidents that occur in the future.

This protocol has been agreed between representatives of the highway authorities and the railway infrastructure authorities to clarify who should be responsible for doing what and paying for what, as recommended by the Health and Safety Commission. It should be used in conjunction with the guidance produced by the Department for Transport, CSS, LoTAG, Network Rail, LUL, Railway Safety and others to assess the risk of a vehicle leaving the road and getting onto the railway and measures which might provide cost effective mitigation at those sites.

DfT will review the effectiveness of the protocol and the progress of the programme of risk assessment work at an appropriate time after the various recommendations of the HSC and HA have been put in place.

# Responsibilities

This protocol was necessary because the legal responsibility to assess the risks and provide any mitigation measures to prevent accidental incursions by road vehicles onto railway property falls jointly on a highway authority and a railway infrastructure authority.

The Health and Safety at Work etc Act 1974 (HSWA), with its related regulations, imposes a general duty on employers to protect the health and safety not only of their employees but also of others affected by their operations (i.e. including the general public not using railways). Implicit in the HSWA, and explicit in the Management of Health and Safety at Work Regulations 1999, is a requirement for every employer to make a suitable and sufficient assessment of risk. This assessment must cover risks to employees and anyone else potentially affected by the conduct of the employer's activities. The purpose is to manage health and safety risks down to the lowest reasonably practicable levels. Railway companies have a duty to assess risks and to take any reasonably practicable steps to reduce them. "Reasonably practicable" is assessed by agreeing the value used of preventing a fatality. This value is published annually in the Railway Group Safety Plan. Once necessary actions have been identified through the risk assessment process, railway companies have a legal obligation to carry them out.

There are differing views on whether highway authorities have a similar legal duty. Highway law has its roots in common law and authorities generally have powers rather than duties. The Highways Act 1980 puts on highway authorities a duty to maintain the highway (Section 41), which is usually understood to mean that they should ensure the safe passage of road users. They also have a duty under Section 39(3) of the Road Traffic Act 1988 to study road traffic accidents and to take such measures as they consider appropriate to prevent them.

It may be difficult for a railway infrastructure authority to fulfil its duties under the Health and Safety at Work Act if the reasonably practicable steps it identifies need to be taken on land outside the railway boundaries, where it has no authority to take action. The action may be on land where the highway authority has the power to take action but may not have a precise legal duty. Furthermore, the railway infrastructure authority may not be in a position to consider the overall effect on road safety of any measures proposed.

This protocol sets out what has been agreed about the responsibilities of the highway authorities and the railway infrastructure authorities in this matter, and who should pay for what.

# The stages in the risk mitigation process

**1. Risk Ranking and Risk Assessments**

- Lead – highway authority.
- Costs – each side (highway authority and railway infrastructure authority) pick up own costs.

### 2. Preparation of scheme specification for mitigation measures

- Lead – if measures are those associated with highways (e.g. barriers, traffic calming), highway authority. If measures are those associated with railways, railway authority.

- Costs – each side (highway authority and railway infrastructure authority) pick up own costs.

### 3. Land (if needed)

- Lead – if measures are those associated with highways (e.g. barriers, traffic calming), highway authority. If measures are those associated with railways, railway authority.

- Costs – provide free of charge if land owned by highway authority or railway infrastructure authority. If land has to be purchased, costs (including legal and administration charges) should be met 50% by the highway authority and 50% by the railway infrastructure authority and a sensible decision made about ownership based on whose land it adjoins. It is probably preferable to acquire the land, but if this cannot be done, permission to use it will need to be acquired, and costs involved in that should be met 50% by the highway authority and 50% by the railway infrastructure authority. If permission to use the land is acquired, the arrangements for maintaining any measures installed, and who will pay for this, will need to be agreed at the same time.

### 4. Procurement of works

- Lead – if measures are those associated with highways (e.g. barriers, traffic calming), highway authority. If measures are those associated with railways, railway authority.

- Costs – each side (highway authority and railway infrastructure authority) pick up own costs.

### 5. Physical works

- Lead – in general, the highway authority should take the lead for road measures and the railway infrastructure authority should take the lead for rail measures.

- Costs – including costs of contractors and utilities and associated costs such as accommodation works. 50% paid by the highway authority and 50% paid by the railway infrastructure authority. Costs directly related to the railway, such as track possession, should be paid by the railway infrastructure authority and costs directly associated with the road, such as road closures, should be paid by the highway authority.

### 6. Supervision of work

- Lead – if railway related (railway safety and possessions, etc) railway infrastructure authority. If highway related, highway authority.

- Costs – each party meets own costs.

### 7. Future inspection, maintenance, replacement and evaluation of effectiveness

- Lead – this needs to be decided at the outset on a site by site basis. Generally, whoever owns the land will be responsible for keeping the measures in good working order. If the land remains in the ownership of a third party, arrangements for taking the lead in organising maintenance will need to be agreed during the acquisition of the interest in the land to enable measures to be installed (stage 3 above). If the measures are highway related, this might well be the highway authority. If they are railway related, it might well be the railway infrastructure authority.

  Evaluation of the effectiveness of the mitigation measure(s) should be done jointly as part of a stocktaking review after they have been in place for 3 years.

- Costs – whoever owns the land will be responsible for costs. If the land remains in the ownership of a third party, it is suggested that maintenance be funded 50% by the highway authority and 50% by the railway infrastructure authority.

## Dispute resolution

If the highway authority and railway infrastructure authority cannot within 3 months agree on any issue, they should first refer the matter to their head office if they have one (e.g. Network Rail and Highways Agency) or to their representative organisations (e.g. CSS – formerly the County Surveyors Society – or the London Technical Advisors Group – LoTAG) to try to reach an amicable agreement. If a resolution cannot be reached within 3 months, they may refer the matter to DfT, the Welsh Assembly Government or the Scottish Executive (as appropriate) who, with independent advisors such as Railway Safety, HSE and the Institution of Civil Engineers, will find a solution.

**Notes**

The protocol covers only those roads maintainable at public expense. Railway infrastructure providers may wish to use it as the basis for negotiations with those responsible for roads and bridges that are not maintainable at public expense, particularly those over which the public has a right of way.

It is a framework agreement, which sets out the general principles. There may need to be small changes to deal with the circumstances at individual sites.

The term “lead” means responsibility for initiating and managing work and ensuring that progress is recorded.

Not all stages will be appropriate in every instance.

# chapter three: Ranking risk at all sites

## 3.1 Background

The Department for Transport (DfT) developed this risk ranking from a series of meetings with both highway and railway engineers. It provides a means of ranking bridge sites in terms of catastrophic risk.

We tested the system at bridges considered subjectively to fall into high risk and tolerable risk bands, to make sure that the risk ranking is practicable on site. We initially intended it to tackle the risk of vehicle incursions from roads that are the responsibility of local highway authorities. We have tried to keep it as simple as possible throughout, to prevent differing interpretation of the factors.

We have developed three risk ranking tools, covering:

- single carriageway roads on bridges over railways;
- motorways and dual carriageway roads on bridges over railways; and
- roads which neighbour railways and present a feasible chance of incursion.

We have developed these tools jointly with railway and roads representatives, including specialists on road and rail safety and structures. We have tested them extensively before publication and the results have been broadly consistent with the:

- judgement of the individuals involved in developing the risk ranking tools; and
- relative risk at each site as perceived by the highways and railways specialists involved.

The risk ranking is not an end in itself. Nor will it identify precisely what precautions may be needed at a particular bridge. It is merely intended to identify sites that have the highest ranked risk in comparison with other bridges. This will allow a highway engineer to explore the practicability of further risk mitigation, in conjunction with the railway infrastructure controller (chapter 4).

The following notes give an insight into how the ranking developed, by explaining the background and importance of the factors we have used and by offering guidance on how to score the factors.

**General Note**

Throughout the ranking, the assessor should use only the values indicated on the overbridge site scoring spreadsheet. Where a site falls between two scores, or a score is not available, use the higher or maximum score for the factor. This ensures that unintentional factoring does not affect the final calculation, so the engineer always considers the worst case situation.

We recommend that highway authorities create a central database of both the individual factor scores and the total for each location. This will establish a threshold for carrying out detailed risk assessment and also a level at which they should carry out mitigation works. Local variations in scoring will also become apparent, which may result in changes to the risk-ranking model.

Setting a precise threshold is a longer-term aim. It must not prevent highway authorities from acting on a high risk ranking.

# Form 1a Single carriageway road vehicle incursion risk ranking

## 3.2 Overall scoring and subsequent actions

You get the overall score for a bridge by **adding all 14 factors together**. As a guide, an increase of two in a score for any of the factors or for an overall risk score implies a doubling of the risk, so 6 is twice as bad as 4, and 12 is eight times worse than 6. This gives a wide range of risk values. A score of 90 implies that the risk is approximately a million times greater than a score of 50.

The scoring regime assumes that no factor needs a score of zero, as even the best protection still allows a slim chance of a vehicle or debris finishing on the line. This may be for instance due to a vehicle becoming airborne.

Assessors should rank bridges according to score. They should assess the highest scoring bridges in more detail to see how they can be improved. As a guide, scores of 100 or more are significant (in relative terms) and scores of 70 or more would suggest that highway authorities should at least consider the practicability of improvements. This does not rule out simple and cost effective improvements at bridges that score less than 70.

As a guide, two highway authorities have proposed physical works at bridges, which score 99 and 100 respectively using the current scoring sheet. After road approach protection they will score 76 and 77.

Bridges that score one for either factor 1 or 5 need no further action unless the engineer identifies simple low cost works on site. However, the assessor should still complete the scoring sheet to show that they have evaluated the site and to record the present situation.

We recommend that highway authorities create a central database of both the individual factor scores and the total for each location. This will establish a threshold for carrying out detailed risk assessment and also a level at which they should carry out mitigation works. Local variations in scoring will also become apparent, which may result in modifications to the risk ranking model.

Setting a precise threshold level is a longer-term aim. It must not prevent highway authorities from acting on a high risk ranking.

# 3.3 Factors

### 3.3.1: Road approach containment

This factor is used to consider the possibility of a road traffic accident (RTA) resulting in a vehicle or debris continuing along the road approach side slope and then onto the track. It is also used to consider a vehicle or debris gaining access either side of the parapets in a cutting.

Where containment varies on each approach side slope, (that is, at each of the four corners), assessors must consider the worst case. In particular, they should consider containment immediately adjacent to parapet ends and score the factor accordingly. For example, good containment on a road approach up to 3m from the parapet, but with no protection in the 3m section, would be marked 24.

**Score 1 for acceptable containment (safety fence, heavily wooded road approach slopes, buildings or brick walls 450 mm or thicker)**

The scorer should assess whether a fence takes account of normal design parameters. For instance, a safety fence is not designed to resist perpendicular loading at a Z bend over a railway bridge.

"Heavily wooded" means trees of more than 500mm girth at spacing of less than 2m. Buildings on approaches or brick/masonry walls in good condition, 450mm or greater in thickness, to be scored as 1.

Where the road speed is not greater than 30mph, the scorer may include Trief safety kerb in this category.

Virtually zero chance of a road vehicle penetrating the containment, or evading the end of it.

**Score 12 for inadequate containment (inadequate safety fence, lightly wooded road approach slopes or brickwork minimum 225 mm thick)**

At this score, the safety fence is being expected to provide containment perpendicular to its face, or it meets a standard now superseded, or it is a non-standard type.

Trees are of less than 500mm girth and/or spacing of 2m or more. Brick/masonry walls in good condition are a minimum of 225mm thick.

Some sites have several layers of protection, each of which would be inadequate on its own, but which together offer a reasonable level of containment. For example, a pedestrian safety barrier at the kerb edge combines with a close-boarded fence on concrete posts at the boundary.

Perceived chance of vehicle evading or penetrating a fence or trees.

**Score 24 for non-existent containment (including post rail/wire fencing)**

At this score, road approach slopes have no fencing or only post/wire or post/rail fencing.

There is no significant vegetation (trees or bushes less than 250 mm girth and/or at spacing greater than 2m).

High chance of a vehicle that leaves the highway continuing at undiminished speed.

### 3.3.2: Road alignment (horizontal)

Road width and horizontal alignment are important, as a wide straight road with passing clearance for two oncoming vehicles is an obviously lower risk than a narrow road where one vehicle has to give way. The curved approaches increase the chance of an accident due to reduced sighting distance and reaction time.

"Road width" is the width of road surface, disregarding any footpath or verge.

### 3.3.3: Road alignment (vertical)

Blind summits reduce the sighting and reaction distance for two oncoming vehicles meeting at a bridge with restricted clearance. Assessors should determine visibility on straight road hump backs in accordance with the Design Manual for Road and Bridges, TD 9/93.

### 3.3.4: Actual speed of approaching road traffic

The faster approaching road traffic is going, the greater the risk of an accident. Speed also contributes to the effect of the accident. The faster a vehicle is travelling, the further it (and any debris) may travel afterwards.

Assessors should use actual speed figures, measured on site. Where these are not available, they should evaluate speeds during the site visit. Assessors should disregard signed and designed speeds. Experience indicates that actual speeds may be much higher.

### 3.3.5: Site topography

This factor involves subjectively assessing the likelihood of a vehicle, or substantial parts of it, or its load, reaching the track following a RTA which breaches any containment in factor 1. The assessor should consider:

- gradient of the side slope;
- distance from toe of cutting slope to the nearest track;
- track bed being higher or lower than field level next to approach slopes;
- proximity of track to ends of parapets;

- increased risk of incursion due to skew effects at obtuse corners;
- height of deck above track level; and
- possibility of vehicle becoming airborne.

This factor does not include any risk assessment of sections of parapet being displaced onto the track following a RTA. We consider this in factor 8.

### 3.3.6: Site specific hazards increasing the likelihood of a RTA

Because it is not practicable to have a simple risk ranking which considers all possible hazards, we decided to include a factor so that the assessor can take account of additional hazards that may increase the risk of a RTA. These include (but are not limited to):

- steep descent on road approach and adjacent access tracks;
- lay-bys;
- bus stops;
- car parking; and
- cafes and shops.

All of these may lead to conflicting or unusual traffic movements.

**Score 1** for no obvious hazard.

**Score 5** for a single minor hazard, such as a field gate, lay-by or bus stop.

**Score 9** for multiple minor hazards or a single major hazard, such as a school, hospital or factory entrance, leading to conflicting traffic movements.

Assessors should consider traffic speeds, and the distance of hazards from parts of bridge approaches susceptible to road vehicle incursion. A frequently used field gate 10m from a relatively unprotected wall on a narrow high speed road would score higher than one 100m away on a lightly used, wider road.

### 3.3.7: Site specific hazards increasing the consequences of the RTA

Again, due to the difficulty of including all possible hazards, we have included a factor so that the assessor can take account of them. These include, but are not limited to, exposed pipelines, water mains and so on that are:

- attached to the bridge structure;
- adjacent to the bridge approaches; or
- parallel with the railway tracks.

Risk increases where there is more than one pipeline.

Some railway infrastructure is likely to worsen the effects of an accident. Some, such as switch and crossing work or junctions, are a derailment hazard. Others are likely to increase the severity of an accident if hit by a derailed vehicle. These include station platforms, bridge piers and abutments and tunnel portals within 800m (half a mile) of the bridge site. Disregard overhead line masts within this factor.

**Score 1** for no obvious hazard.

**Score 3** for a single hazard, such as a gas main, oxygen pipe and so on.

**Score 5** for multiple hazards and/or railway infrastructure likely to increase the severity of an accident.

### 3.3.8: Parapet resilience

Parapet resilience (containment) is important because the effect of an accident will be less if the parapet can keep crashed vehicles on the bridge deck. On multi-track routes a parapet may limit the effects of any RTA to the outer tracks.

Modern welded steel half through bridge decks offer containment to at least P6 standard. Earlier riveted steel/wrought iron half through decks score higher, due to the possibility of rivet or deck corrosion.

Where the parapet is in poor condition due to age, corrosion or existing accident damage, assessors should raise the score to at least the next category.

Refer to BD 52/93 *The Design of Highway Bridge Parapets* for details of parapet types.

**Score 1** for P6 parapet, or welded steel half through bridge deck.

**Score 2** for P1 to P5 parapet, or riveted steel/wrought iron half through bridge deck.

**Score 5** for 450mm thick brickwork parapet.

**Score 7** for 340mm thick brickwork parapet.

**Score 11** for cast iron or corrugated sheet parapet.

### 3.3.9: Road verges and footpaths

Road approaches and bridge decks with wide footpaths or verges reduce the risk of RTAs, as they give drivers extra width to take avoiding action and offer the psychological comfort of a wider gap to steer through. At sites where pedestrian safety barriers have been provided, factor should be marked on the distance between barrier and kerb edge.

### 3.3.10: Road signage and markings

Adequate road signage and markings help to warn strangers to an area that a hazard exists. But their effects are limited and the consensus view is that regular road users may ignore signage and markings. This makes locals more likely to crash. For this reason signage is generally considered to be of lower importance in the ranking procedure.

**Score 1** for signage/markings considered fit for purpose and which are clean and clearly visible, or are not considered to be needed at the location.

**Score 2** for non-existent, inadequate, or obscured signage/markings, at a location where they are considered necessary.

**NOTE** Assessors should notify the highway authority of a score of 4 for early action, regardless of the perceived risk at the location based on the total score from all factors.

### 3.3.11: Volume of road traffic

Road traffic volume increases the probability of a RTA. This model was developed using the number of HGVs per day, but assessors may apply any measure of recorded traffic flow, subject to similar weighting. HGVs and farm traffic are more likely to be involved in an accident on narrow roads, as they reduce the passing space for oncoming traffic.

This factor may need upwards adjustment to the next category where local conditions such as the presence of a quarry increase traffic, but may not be reflected in the original survey figures.

Assessors may use the following vehicles per day figures where the highway authority cannot provide traffic volumes in HGVs.

**Score 1** for 0 to10 HGVs per day (<200 vehicles per day)

**Score 2** for 11 to 100 HGVs per day (<2,000 vehicles per day)

**Score 3** for 101 to 500 HGVs per day (<7,150 vehicles per day)

**Score 4** for 501 to 1,000 HGVs per day (<12,500 vehicles per day)

**Score 5** for over 1,000 HGVs per day (>12,500 vehicles per day)

The highway authority will provide traffic figures.

### 3.3.12: Permissible line speed and track alignment

We consider this to be important because derailments are more likely on high-speed routes. We have included the curve factor due to the increased chance of derailment on curves and the reduced opportunity for the train driver to brake.

Scoring reflects the increased chance of derailment with increased speed, or curvature, and also that the effects of the accident worsen with speed.

On routes with more than two tracks and where the parapet resilience in factor 8 scores 2 or less, we consider that, unless other circumstances indicate otherwise, assessors should only consider the speed of the outer lines. The assumption is that the parapets would contain any crashed vehicle and only the outer tracks would be affected.

We have included speed categories higher than present operating speeds so that assessors can use the model on the Channel Tunnel Rail Link and other high speed routes. It also allows ranking where speed enhancement schemes are being considered.

Details of line speeds are available from the railway infrastructure authority. This may be Network Rail, London Underground Ltd, NEXUS (Tyne and Wear PTE), a preserved railway operator or some other infrastructure authority.

The site inspection will establish whether the line curves.

### 3.3.13: Type of rail traffic

The type of rail traffic can affect the severity of a railway incident following a RTA in a number of ways. The five categories below are a development of work to assess the risk from signals passed at danger (SPADs). This includes the likelihood of derailment and the crash resistance of different rolling stock types.

Though a route may be considered to be used primarily by one of the lower risk categories below, if more than five higher risk trains use the route a day, assessors should include it in the higher scoring group. For example, the East Coast Main Line north of York is principally a loco hauled passenger route for high speed trains and IC225s, but it also carries sliding door Sprinters and some dangerous goods traffic, so it scores 5.

**Score 1** for freight only routes not carrying dangerous goods, such as petrol. These are considered the least risk, as generally there is less chance of derailment. Also substantially fewer casualties are possible.

**Score 3** for loco hauled passenger trains, to include push-pull services such as high speed trains and IC225s and similar. These have a reduced risk of derailment as they are loco hauled and have better crash resistance than lighter rolling stock. The significant number of possible injuries, however, increases risk.

### Score 5 for sliding door multiple units (max speed 100 mph), and/or dangerous goods freight trains

Modern diesel and electric sliding door multiple units (Sprinters, EMUs) and trains carrying dangerous goods increase risk. This is due to the high number of possible casualties following any explosion or fire.

### Score 7 for slam door multiple units and sliding door multiple units (maximum speed greater than 100 mph)

This is because older slam door trains have less structural integrity than modern ones and passengers in the leading vehicles of modern higher speed multiple units are at greater risk of death or injury.

### Score 11 for light rail

Lightweight passenger trains, as operated by NEXUS (Tyne and Wear Metro), are at greatest risk. This is due to the high number of possible casualties and the increased chance of derailment of a light rail vehicle, compared with conventional multiple unit or loco hauled services.

Light rail does not include preserved railways operating under a Light Railway Order. You should assess these against the types of vehicles they normally operate.

The railway infrastructure authority will confirm the types of traffic likely to use a route.

### 3.3.14: Volume of rail traffic

The more trains use a route, then obviously the greater the chance of one being involved in the aftermath of a RTA. The railway infrastructure authority will provide usage figures for a particular route.

Network Rail will provide figures from its NETRAFF system. NETRAFF will give information for each track at a location, split into passenger/freight movements. Assessors should first score the total for the location. This applies even at multi-track sites, where the assessor is only looking at the outer tracks in factor 12, due to acceptable parapet containment in factor 8. The information by track, split into passenger/freight movements, may be useful later when carrying out a more detailed risk assessment.

# Form 1a Single carriageway road vehicle incursion risk ranking

| Factor | Options | Score | Factor | Options | Score |
|---|---|---|---|---|---|
| f1 (See Note A) | **Road Approach Containment**<br>Score 1 for acceptable (safety fence and/or heavily wooded side approaches, buildings or brick wall thicker than 450mm)<br>Score 12 for inadequate (imperfect fencing and/or medium/lightly wooded approaches, 225mm thick brick wall)<br>Score 24 for non-existent (No fencing, or only post and rail/wire, no signficant vegetation) | | f8 | **Parapet Resilience**<br>Score 1 for P6 parapet or welded steel half through type<br>Score 2 for P1 to P5 parapet or rivetted steel/wrought iron half through type<br>Score 5 for 450mm brickwork/masonry parapet<br>Score 7 for 340mm brickwork/masonryparapet<br>Score11 for cast iron or corrugated sheet parapet | |
| f2 | **Road Alignment (Horizontal)**<br>Score 1 for straight road with at least 7.3m carriageway<br>Score 3 for straight less than 7.3m carriageway or curved at least 7.3m carriageway<br>Score 7 for curved road less than 7.3m carriageway<br>Score 10 for reverse curves less than 7.3m carriageway | | f9 | **Road Verges and Footpaths**<br>Score 1 for at least 2m both sides<br>Score 2 for at least 1m both sides<br>Score 3 for one or both verges less than 1m | |
| f3 | **Road Alignment (Vertical)**<br>Score 1 for level or constant grade<br>Score 2 for slight hump back<br>Score 3 for hump back where vehicles are inter-visible<br>Score 5 for hump back where vehicles are not inter-visible | | f10 (See Note D) | **Road Signage/Carriageway Markings**<br>Score 1 for signage/markings fit for purpose and clearly visible, or not needed<br>Score 4 for unfit, non-existent or obscured signage/markings, where considered to be required | |
| f4 | **Actual Speed of Approaching Road Traffic**<br>Score 1 for <10mph<br>Score 3 for <30mph<br>Score 5 for <50mph<br>Score 7 for <70mph<br>Score 9 for >70mph | | f11 (See Note E) | **Volume of Road Traffic**<br>Score 1 for 0 to 10 HGVs (<200 vehicles) per day (generally green lane or farm access)<br>Score 2 for 11 to 100 HGVs (<2000 vehicles) per day (generally unclassified)<br>Score 3 for 101 to 500 HGVs (<7150 vehicles) per day (generally C or B class)<br>Score 4 for 501 to 1,000 HGVs (<12500 vehicles) per day ("Other Strategic" roads)<br>Score 5 for Over 1,000 HGVs (>12500 vehicles) per day (generally "Primary Routes") | |
| f5 | **Site Topography**<br>Score 1 if vehicle/debris very unlikely to foul track<br>Score 4 if vehicle/debris unlikely to foul track<br>Score 6 if vehicle/debris can be reasonably expected to foul track<br>Score 8 if vehicle/debris likely to foul track<br>Score 10 if vehicle/debris very likely to foul track | | f12 (See Note F) | **Permissible Line Speed and Track Alignment**<br>Score 1 for straight track up to 45mph<br>Score 4 for straight track up to 75mph or curved up to 45mph<br>Score 8 for straight track up to 90mph or curved up to 75mph<br>Score 12 for straight track up to 100mph or curved up to 90mph<br>Score 16 for straight track up to 125 mph or curved up to 100mph<br>Score 20 for straight track up to 140 mph or curved up to 125mph<br>Score 24 for straight track above 140 mph or curved above 125mph | |
| f6 (See Note B) | **Site Specific Hazards Increasing Likelihood of RTA**<br>Score 1 for no obvious hazards<br>Score 5 for single site specific hazard<br>Score 9 for multiple minor hazards, or single major hazard (e.g. school, hospital or major factory access) | | f13 (See Note G) | **Type of Rail Traffic**<br>Score 1 for Non-Dangerous Goods Freight<br>Score 3 for Loco-Hauled Stock<br>Score 5 for Sliding Door Multiple Units (up to 100mph) or Dangerous Goods Freight<br>Score 7 for Slam Door Multiple Unit or Sliding Door Multiple Units (over 100 mph)<br>Score 11 for Light Rail (see definition in guidance notes) | |
| f7 (See Note C) | **Site Specific Hazards Increasing Consequences of Event**<br>Score 1 for no obvious hazards<br>Score 3 for single site specific hazard<br>Score 5 for multiple site specific hazards and/or Railway infrastructure likely to increase severity of an incident | | f14 | **Volume of Rail Traffic**<br>Score 1 for seldom used route (fewer than 500 trains per year)<br>Score 3 for lightly used route (501 to 3,000 trains per year)<br>Score 5 for medium used route (3,001 to 10,000 trains per year)<br>Score 8 for heavily used route (10,001 to 50,000 trains per year)<br>Score 12 for very heavily used route (more than 50,000 trains per year) | |
| | | | | | **Total** |

Note A Score f1 on the basis of the corner of the bridge with the least containment.
Note B Site specific hazards increasing the likelihood of an RTA include the following features in proximity to the bridge: farm access, road junction, private driveway, lay-by, bus stop, school, hospital, etc.
Note C Site specific hazards increasing the consequences of the event include the following features in proximity to the bridge: exposed gas or chemical pipelines, etc.
Railway infrastructure likely to increase severity of incident to include pointwork, platforms, bridge piers and abutments and tunnel portals etc within 800m (½ mile) of structure.

Note D If Score =4 sign / road marking deficiencies to be brought to attention of Highway Engineer
Note E Equivalent traffic flows for all vehicle types may be subsituted, depending upon the units of measurement used by the relevant highway authority.
Note F If f8 scores 2 or less, score f12 on the basis of outermost tracks of a multi-track railway
Note G If f8 scores 2 or less, score f13 on the basis of outermost tracks of a multi-track railway
Note H Volume of rail traffic to be provided by Railway Infrastructure Controller, see guidance notes.

# Form 1b Motorway and dual carriageway road vehicle incursion risk ranking scoring spreadsheet

## 3.4 Overall scoring

You get the overall score for a bridge by **adding all 14 factors together.**

As a guide, an increase of two in a score for any of the factors or for an overall risk score implies a doubling of the risk, so 6 is twice as bad as 4, and 12 is eight times worse than 6. This gives a mid range of risk values. A score of 90 implies that the risk is approximately a million times greater than a score of 50.

The scoring regime assumes that no factor needs a score of zero, as even the best protection still allows a slim chance of a vehicle or debris reaching the railway line.

Assessors should rank bridges according to score. They should assess the highest scoring bridges in more detail to see what improvements can be made. The maximum possible score is 143. As a guide, scores of 100 or more are significant and scores of 70 or more would suggest that highway authorities should at least consider improvements. This does not rule out simple and cost effective improvements at bridges that score less than 70.

Bridges that score one for factor 1 (road approach containment) combined with a score of 1 for factor 5 (site topography) and a score of two or less for factor 8 (vehicle parapet resilience) require no further action. However the assessor should still complete the scoring sheet to show that they have evaluated the site and to record the present situation.

## 3.5 Factors

### 3.5.1 Road approach containment

This factor is used to consider the possibility of a road traffic accident (RTA) resulting in a vehicle or debris continuing along the road approach side slope and then onto the track. It is also used to consider a vehicle or debris gaining access either side of the safety barriers and transitions prior to the vehicle parapet in a cutting.

Where containment varies on each approach, (that is, at each corner of the bridge) assessors must consider the worst case.

### Score 1 for very high containment

This means that there is a very high containment barrier (H4a) of adequate length with appropriate transition to a normal containment safety barrier (N2), in accordance with the European standard BS EN 1317 and the Highways Agency's interim requirements for road restraint systems (IRRRS). These should either be continuous or used in conjunction with a very high containment level vehicle parapet. See factor 8.

Assessors should particularly consider the "length of need" for high containment safety barriers and/or vehicle parapets on high-speed roads. The "length of need" is the length reasonably required to prevent a vehicle from reaching the railway. Road engineers are likely to meet "the length of need" either by using a very high containment level parapet and transition or continuous high containment barriers.

Assessors should only include sites in this category where the length of high containment protection is reasonably likely to prevent any vehicle reaching the track from either a wide approach angle (containment) or a shallow approach angle (length).

### Score 6 for normal containment

This score covers sites with normal containment safety barriers of adequate length, fully complying with current European standards and the IRRRS, and connected to a normal containment level (formerly P5 type) parapet in accordance with the requirements for non-proprietary safety barriers.

### Score 12 for approach safety barriers of normal containment that are sub-standard, defective, damaged or too short

These sites have safety barriers that do not comply with current European standards. This is either as a result of poor original installation, deterioration, damage, settlement or any other significant defect, or because they are too short.

### Score 24 for no effective vehicle restraint system or very low containment, non-standard walls, fences or barriers

Here there is a high probability of an errant vehicle continuing at the same speed and/or angle.

### 3.5.2: Road alignment (horizontal and vertical)

Road width and horizontal and vertical alignments are important, but are unlikely to be a significant feature of high-speed major roads. Length of sight lines are important, as blind summits and bends can reduce sighting and reaction times. Assessors should determine inter-visibility on straight road humpbacks and bends in accordance with the '*Design Manual for Roads and Bridges*', TD 9/93.

Assessors should consider using the single carriageways ranking tool for major roads with speed restrictions or with narrow widths and poor alignments.

### 3.5.3: Sleep-related vehicle accidents (SRVAs)

Recent research has identified a number of RTAs caused by drivers falling asleep. These are known as sleep-related vehicle accidents or SRVAs. The study found that SRVAs are relatively common on high-speed major roads. Proportions ranged from 16 per cent to 30 per cent of all reported fatal, injury and damage only accidents.

In a recent study of SRVAs, the highest proportion was found on a featureless, unlit stretch of the M40 in rural Warwickshire. The research indicated that SRVAs are independent of traffic density, but there are some identifiable characteristics that lead to clusters of these accidents. Availability of service areas did not seem to affect SRVAs. But the study found clusters of SRVAs on slow right hand bends and towards the end of a long route.

For example, run-off accidents were clustered on the eastbound carriageway of the eastern end of the M180 and A180, but there was no such cluster on the westbound carriageway. SRVAs were also found to occur on slow left hand bends. Most major roads have a central reservation safety fence, which heavy goods vehicles (HGVs) may broach thereby posing a particular risk of incursion on to railway lines. (See note 11: Traffic volume.)

### 3.5.4: Actual speed of approaching road traffic

This ranking tool is intended for use on fast roads where higher traffic speeds increase both the likelihood and the effect of an accident. This is due to the distance over which the vehicle and debris may travel after the accident, and/or the capability of the vehicle restraint system.

If possible, assessors should use actual speeds taken from site measurements. If these are not available, they should estimate the speed at medium traffic density and note it on the scoring sheet. Assessors should consider traffic density when measuring traffic speed, as these two factors can be interdependent, producing an unreliable figure.

### 3.5.5: Site topography

The assessor should consider how far an errant vehicle leaving a high-speed road would travel. This may be affected by the:

- gradient of the side slope;
- distance from toe of cutting slope to the nearest track;

- height of the track bed in relation to the field level next to the approach slopes;
- proximity of the track to ends of the vehicle parapets;
- increased risk of incursion due to skew effects at obtuse corners;
- height of the deck above track level;
- likelihood of the vehicle becoming airborne;
- skid resistance of the ground between the road and the railway line; and
- presence of shrubbery between the road and the railway line.

This factor is not intended to include any assessment of the risk associated with parts of the vehicle parapet being displaced onto the track. We consider this in factor 8.

### 3.5.6: Site specific hazards increasing the likelihood of a RTA

Analysis of accident data suggests that RTAs on major, high-speed roads are clustered near junctions or other areas, which can lead to conflicting or unusual traffic movements or vehicles changing lanes. The following are all likely to increase the frequency of RTAs:

- junctions;
- lane drops;
- service areas; and
- lay-bys.

Assessors should generally consider the distance of a hazard from the bridge approach when scoring this factor. Raise the score by one band for sites prone to long periods of bad weather, such as exposed moorland.

### 3.5.7: Site specific hazards increasing the consequences of the event

These include, but are not limited to, exposed pipelines, water mains and so on, that are:

- attached to the bridge structure; or
- adjacent to the bridge approaches; or
- parallel with the tracks.

Risk increases where there is more than one pipeline.

Some railway infrastructure is likely to worsen the consequences of an accident. Some, such as switch and crossing work or junctions, are a derailment hazard. Others are likely to increase the severity of an accident if hit by a derailed vehicle. These include station platforms, bridge piers and abutments and tunnel portals within 800m (half mile) of the bridge site. Disregard overhead line masts within this factor.

### 3.5.8: Parapet resilience

Parapet resilience (containment) is important because the effect of an accident will be less if the parapet can keep crashed vehicles on the bridge deck. On multi-track rail routes a parapet may limit the effects of any RTA to the outer tracks.

Refer to IRRRS for details of parapet types.

The type of parapet will also, by definition, specify the height and the infill. This will, in turn, determine the likelihood of debris from the bridge fouling the track.

### 3.5.9: Hard shoulders, edge strips, road verges and footpaths

Road approaches and bridge decks with hard shoulders, edge strips and/or wide footpaths or verges reduce the risk of RTAs, as they give drivers extra width to take avoiding action and to regain control of their vehicles.

### 3.5.10: Quality and effectiveness of edge markings and raised rib markings

Edge markings, raised rib markings (sometimes called “rumble strips”) and reflective road studs (sometimes called “cats eyes”) on the nearside edge of major roads alert drivers to their position. They should help to reduce the risk of vehicles leaving the nearside of major roads. There is some evidence that adequate, well-maintained raised rib markings can be particularly effective in overcoming run-off accidents where fatigue is a factor. However, assessors need to check their condition.

### 3.5.11: Volume of road traffic

Heavy road traffic has been shown to increase the likelihood of a RTA. We measure traffic flow for major high-speed roads with high volumes of traffic in vehicles per day (vpd). On average HGVs make up about 10 per cent of the traffic on motorways and all-purpose trunk roads and are involved in about seven per cent of RTAs. However, the mix of traffic may add to the risk of vehicle incursion, particularly in relation to containment (see 3.5.1: Road approach containment). Assessors should increase the score by one band if HGVs form 12 per cent or more of total traffic.

### 3.5.12: Permissible line speed and track alignment

We consider this to be important because derailments are more likely on high-speed routes. We have included the curve factor due to the increased chance of derailment on curves, and the reduced braking distance if the curve obscures the vehicle and/or debris on the track from the train driver’s view.

Scoring reflects the increased chance of derailment with increased speed, or track curvature, and also that the consequences of the accident worsen with speed.

**The operating speed categories allow assessors to use the model for the Channel Tunnel Rail Link and other high-speed routes, and where speed enhancement schemes are being considered.**

Details of line speeds are available from the railway infrastructure authority. This may be for example Network Rail, London Underground Ltd, NEXUS (Tyne and Wear PTE), a preserved railway operator or other infrastructure authority.

The site inspection will establish the existence of curvature.

### 3.5.13: Type of rail traffic

The type of rail traffic can affect the severity of a railway accident following a RTA in a number of ways. The five categories below are a development of work to assess the risk from signals passed at danger (SPADs). This includes the likelihood of derailment and the crash resistance of different rolling stock types.

Though a route may be used primarily by one of the lower risk categories below, if more than five higher risk trains use it each day, assessors should include it in the higher scoring group. For example, the East Coast Main Line north of York is principally a loco hauled passenger route for high speed trains and IC225s, but it also carries sliding door Sprinters and some dangerous goods traffic, so it scores 5.

**Score 1 for freight only routes**, not carrying dangerous goods such as petrol. These are considered the least risk, as generally there is less chance of derailment. Also substantially fewer casualties are possible.

**Score 3 for loco hauled passenger trains**, to include push-pull services such as high speed trains and IC225s and similar. These have a reduced risk of derailment as they are loco hauled and have better crash resistance than lighter rolling stock. The possible number of injuries, however, increases the risk.

**Score 5 for sliding door multiple units (max speed 100mph), and/or dangerous goods freight trains**

Modern diesel and electric sliding door multiple units (Sprinters, EMUs) and trains carrying dangerous goods increase risk. This is due to the high number of possible casualties following any explosion or fire.

**Score 7 for slam door multiple units and sliding door multiple units (maximum speed greater than 100 mph)**

This is because older slam door trains have less structural integrity than modern ones and passengers in the leading vehicles of modern higher speed multiple units are at greater risk of death or injury.

### Score 11 for light rail

Lightweight passenger trains, as operated by NEXUS (Tyne and Wear Metro) are at greatest risk. This is due to the high number of possible casualties and the increased chance of derailment of a light train, when compared with a conventional multiple unit or loco hauled service.

Light rail does not include preserved railways operating under a Light Railway Order. You should assess these against the types of vehicle they normally operate.

The railway infrastructure controller will confirm the types of traffic likely to use a route.

### 3.5.14: Volume of rail traffic

The more trains use a route, then obviously the greater the chance of one being involved in the aftermath of a RTA. The railway infrastructure authority will provide usage figures for a particular route.

Network Rail will provide the figures from its NETRAFF system. NETRAFF will give information for each track at a location, split into passenger/freight movements. Assessors should first score the total for the location, even at multi-track locations.

# Form 1b Motorway and dual carriageway road vehicle incursion risk ranking scoring spreadsheet

| Factor | Options | Score | Factor | Options | Score |
|---|---|---|---|---|---|
| f1 (See Note A) | **Road Approach Containment**<br>Score 1 for Very High Containment (H4a) vehicle restraint system (safety barrier or extended vehicle parapet etc.) of adequate length.<br>Score 6 for Normal Containment (N2) vehicle restraint system of adequate length or compliant with "length of need".<br>Score 12 for sub-standard, defective or damaged or inadequate length approach safety barriers (See Note A)<br>Score 24 for non-existent or significantly sub-standard vehicle restraint system. | | f8 (See Note 4) | **Vehicle Parapet Resilience**<br>Score 1 for Very High Containment (H4a) vehicle parapet or equivalent<br>Score 2 for a Normal Containment (N2) parapet (of either 1.25 or 1.5 m height) or a sub-standard parapet protected by a normal containment safety barrier<br>Score 3 for a Normal Containment (N2) parapet (of 1 m height)<br>Score 5 for an unprotected 450mm brickwork/masonry vehicle parapet<br>Score 7 for an unprotected 340mm brickwork/masonry vehicle parapet<br>Score 11 for an unprotected defective or sub-standard vehicle parapet | |
| f2 | **Road Alignment (Horizontal & Vertical)**<br>Score 1 for full standard sight stopping distance (ssd), full width lanes, straight and constant grade<br>Score 3 for full standard ssd, some curves and undulations but standard horizontal and vertical alignments<br>Score 7 for sub-standard ssd or narrow, sub-standard vertical and horizontal alignments | | f9 | **Hard Shoulders, Edge Strips, Road Verges and Footpaths**<br>Score 1 for full width hard shoulder (>3.0m) and 1.5m or greater verge<br>Score 2 for reduced hard shoulder (3.0m<2.5m) or 1m edge strip and 1.5m or greater verge/footpath measured at the narrowest point<br>Score 3 for narrow hardshoulder (< 2.5m) or edge strip and verge/footpath less than 2m measured at the narrowest point | |
| f3 | **Sleep-Related Vehicle Accidents**<br>Score 1 for no obvious risk factor<br>Score 3 for site on featureless rural road with the minimal services and/or minimal distractions for drivers at the side of the road<br>Score 5 for a bridge on a sweeping right hand bend, sweeping left hand bend with no central reserve safety barriers or a site at the end of a long route (e.g. eastbound of eastern end of M20 or southbound of southern end of M3 etc.)<br>Score 9 for a combination of any of the above factors | | f10 (See Note D) | **Carriageway Markings**<br>Score 1 for edge markings, rumble strips and "cats eyes" in accordance with current standards<br>Score 4 for non-existent, inadequate or obscured markings, worn, buried or over painted rumble strips at a location where considered to be required | |
| f4 | **Actual Speed Of Approaching Traffic**<br>Score 1 for 50 – 60<br>Score 3 for 61 – 70<br>Score 6 for > 70 | | f11 (See Note E) | **Combined Volume of Road Traffic on both Carriageways**<br>Score 1 for < 20,000 vehicles per day (vpd)<br>Score 2 for 21,000 – 40,000 vpd<br>Score 3 for 41,000 – 60,000 vpd<br>Score 5 for 61,000 – 120,000 vpd<br>Score 8 for Over 120,000 vpd | |
| f5 | **Site Topography**<br>Score 1 if vehicle/debris very unlikely to foul track from the bridge approach<br>Score 4 if vehicle/debris unlikely to foul track from the bridge approach<br>Score 6 if vehicle/debris can be reasonably expected to foul track from the bridge approach<br>Score 8 if vehicle/debris likely to foul track from the bridge approach<br>Score 10 if vehicle/debris very likely to foul track from the bridge approach | | f12 | **Permissible Line Speed and Track Alignment**<br>Score 1 for straight track up to 45mph<br>Score 4 for straight track up to 75mph or curved up to 45mph<br>Score 8 for straight track up to 90mph or curved up to 75mph<br>Score 12 for straight track up to 100mph or curved up to 90mph<br>Score 16 for straight track up to 125 mph or curved up to 100mph<br>Score 20 for straight track up to 140 mph or curved up to 125mph<br>Score 24 for straight track above 140 mph or curved above 125mph | |
| f6 (See Note B) | **Site Specific Hazards Increasing Likelihood of RTA**<br>Score 1 for no obvious hazards<br>Score 5 for single site specific hazard<br>Score 7 for multiple minor hazards, or single major hazard (e.g. junctions, steep slopes, sharp bends)<br>Score 9 for multiple major hazards | | f13 | **Type of Rail Traffic**<br>Score 1 for Non-Dangerous Goods Freight<br>Score 3 for Loco-Hauled Stock<br>Score 5 for Sliding Door Multiple Units (up to 100mph) or Dangerous Goods Freight<br>Score 7 for Slam Door Multiple Unit or Sliding Door Multiple Units (over 100 mph)<br>Score 11 for Light Rail (see definition in guidance notes) | |
| f7 (See Note C) | **Site Specific Hazards Increasing Consequences of Event**<br>Score 1 for no obvious hazards<br>Score 3 for single site specific hazard<br>Score 5 for multiple site specific hazards and/or Railway infrastructure likely to increase severity of an incident | | f14 | **Volume of Rail Traffic**<br>Score 1 for seldom used route (fewer than 500 trains per year)<br>Score 3 for lightly used route (501 to 3,000 trains per year)<br>Score 5 for medium used route (3,001 to 10,000 trains per year)<br>Score 8 for heavily used route (10,001 to 50,000 trains per year)<br>Score 12 for very heavily used route (more than 50,000 trains per year) | |
| | | | | | **Total** |

Note A This factor is to be considered in conjunction with f5 Site Topography to determine the "length of need".

Note B Site specific hazards increasing the likelihood of an RTA include the following features in proximity to the bridge: interchange, road junction, lay-by, emergency service vehicle recesses, lane drops and no hard shoulder etc. Consideration should be given to increasing the score by two if there is no adequate carriageway lighting.

Note C Site specific hazards increasing the consequences of the event include the following features in proximity to the bridge: exposed gas or chemical pipelines, etc. Railway infrastructure likely to increase severity of incident to include pointwork, platforms, bridge piers and abutments and tunnel portals etc within 800m (½ mile) of structure.

Note D If Score = 4 road marking deficiencies to be brought to attention of maintaining authority.

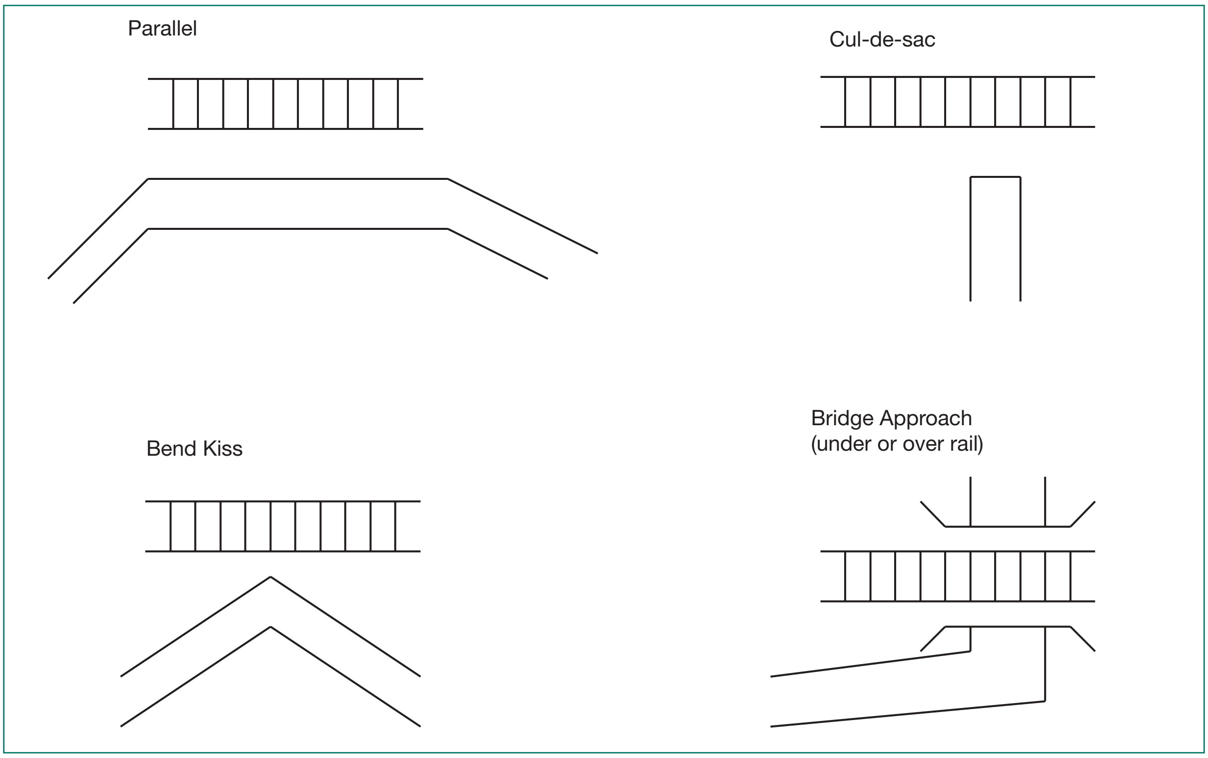
Note E The percentage of HGVs on major roads is typically about 10%, consideration should be given to increasing the score for a disproportionately higher level of HGVs on the route.

Note F Line speed, volume and type of rail traffic to be provided by Railway Infrastructure Controller, see guidance notes.

# Form 2 Neighbouring road vehicle incursion risk ranking

## 3.6 Definition of a neighbouring (or parallel) site

For the purpose of risk ranking, a neighbouring (or parallel) site covers four basic circumstances. The sketches below best explain these:




Highway authorities should assess any site where there is a feasible chance of incursion.

Assessors should consider each distinct section of the site separately. Distinct sections would include the convergence and divergence points and there could be separate sections within a parallel site if there was a significant change to the landscape.

## 3.7 Overall scoring and subsequent actions

You get the overall score for a section by **adding all 14 factors together**. As a guide, an increase of two in a score for any of the factors or for an overall risk score implies a doubling of the risk, so 6 is twice as bad as 4, and 12 is eight times worse than 6. This gives a wide range of risk values. A score of 90 implies that the risk is approximately a million times greater than a score of 50.

Remember that even the best protection still allows a slim chance of a vehicle or debris finishing on the line. This may be due to a vehicle becoming airborne.

Assessors should rank sites according to their highest scoring section. They should assess the highest scoring sites in more detail to see how they can be improved. As a guide, scores of 100 or more are significant (in relative terms) and scores of 70 or more suggest that highway authorities should at least consider improvements. This does not rule out simple, cost-effective improvements at sites that score less than 70.

**Sections that score one for any of the factors 1, 2 or 3 need no further action**. However, the assessor should still complete the scoring sheet to show that they have evaluated the site and to record the present situation.

## 3.8 Factors

The first three factors depend very much on the physical characteristics of the road/rail interface, so we use a matrix to convert the factor into a score.

### 3.8.1: Relative level of road and rail

If the railway is a long way above the road up a steep slope, then there is no realistic chance of an incursion. Incursions become more likley if the road is level with or higher than the railway.

Drivers can lose control of a vehicle travelling downhill, increasing its chance of reaching the line. Drivers travelling uphill could inadvertently accelerate once the ground becomes level or begins to slope downward from the road to the railway. This alters the effectiveness of bunds and ditches. Where the score is a letter, use the matrix below to convert it into a number.

**Score A for rail more than 3m above road with slope steeper than 1:2**

**Score B for rail less than 3m rise above road or on slope less than 1:2**

**Score C for rail and road level**

**Score D for rail less than 2m below road on slope less than 1:2**

**Score E for rail more than 2m below road or below road on slope steeper than 1:2**

| Scoring matrix for factor 1 | A | B | C | D | E |
|---|---|---|---|---|---|
| Road is downhill steeper than 1:8 | 1 | 5 | 7 | 9 | 10 |
| Road is downhill between 1:20 and 1:8 | 1 | 4 | 6 | 8 | 10 |
| Road is less than 1:20 (uphill or downhill) | 1 | 3 | 5 | 7 | 10 |
| Road is uphill between 1:20 and 1:8 | 1 | 3 | 6 | 7 | 10 |
| Road is uphill steeper than 1:8 | 1 | 3 | 7 | 8 | 10 |

### 3.8.2: Site characteristics

A road and railway may be separated by either a high bund or a deep ditch or watercourse. This means that there is no realistic chance that a road vehicle could reach the railway. Smaller bunds and ditches will reduce the chance but not prevent it. Include other factors that reduce the chance of vehicles reaching railway lines here, such as heavy vegetation or sidings. Where the score is a letter, use the matrix below to convert it into a number.

**Score M for bund over 2m high or a ditch over 1m deep and over 3m wide**

**Score N for bund up to 2m high or ditch up to 1m deep or up to 3m wide or heavy vegetation**

"Heavy vegetation" means trees greater than 500mm in girth growing less than 2m apart along the entire stretch of any road running parallel with a railway.

**Score P for smooth gradient/level: over 15m distance between road and rail**

Assessors should measure this from the edge of the road to the nearest running rail. Include sidings and empty land (for example, where tracks have been removed).

### Score Q for smooth gradient/level: 5 – 15m distance between road and rail

Assessors should measure this from the edge of the road to the nearest running rail. Include sidings and empty land (for example, where tracks have been removed).

### Score R for smooth gradient/level: less than 5m distance between road and rail

Assessors should measure from the edge of the road to the nearest running rail. Include sidings and empty land (for example where tracks have been removed).

| Scoring matrix for factor 2 | M | N | P | Q | R |
|---|---|---|---|---|---|
| Road is downhill steeper than 1:8 | 3 | 6 | 9 | 12 | 14 |
| Road is downhill between 1:20 and 1:8 | 2 | 5 | 8 | 11 | 14 |
| Road is less than 1:20 (uphill or downhill) | 1 | 4 | 8 | 11 | 14 |
| Road is uphill between 1:20 and 1:8 | 1 | 4 | 6 | 9 | 12 |
| Road is uphill steeper than 1:8 | 1 | 3 | 5 | 8 | 10 |

### 3.8.3: Interface arrangements

Assessors should use this factor to consider the possibility of a road traffic accident (RTA) resulting in a vehicle or debris getting onto the track, or gaining access before the start, or after the end, of the parallel stretch.

Where containment varies, assessors should consider the highest scoring portion. They should particularly consider containment immediately adjacent to bends and score the factor accordingly.

Where a section is nearly perpendicular to the railway line, containment is likely to be less effective. For instance, safety barriers are not designed to stop HGVs.

Where the score is a letter, use the matrix below to convert it into a number.

### Score T for buildings between road and railway

Buildings have to cover the complete section being assessed to score T.

This means that there is virtually no chance of a road vehicle penetrating or evading the end of the containment following a RTA. A score of 1 means that there is no realistic incursion risk across the entire site, so the assessment ends there.

### Score V for acceptable containment (for example, a safety barrier or concrete walls 450 mm or thicker)

Assess whether the barrier meets normal design parameters. For example a safety barrier is not designed to resist perpendicular loading at Z bend. Score concrete walls in good condition and at least 450mm thick as V.

### Score W for partially acceptable containment (masonry wall 450mm or thicker)

Score masonry walls in good condition and at least 450mm thick as W.

### Score X for barely adequate containment (concrete wall between 225mm and 450mm thick)

Score concrete walls in good condition and at least 225mm thick as X.

### Score Y for inadequate containment (for example, inadequate safety barrier or masonry walls between 225mm and 450mm thick)

At this score, the safety barrier is being expected to provide containment perpendicular to its face, or it meets a standard now superseded, or it is a non-standard type. Masonry walls are in good condition and a minimum of 225mm thick.

This score also applies to sites where several layers of protection exist, each of which would be inadequate on its own, but which together offer reasonable containment. For example, a site may have a pedestrian safety barrier at the kerb and close-boarded fence on concrete posts at the boundary.

**Score Z for non-existent containment (including post rail/wire fencing and brick walls less than 225mm thick)**

These sites have road approach slopes with no fencing or only post/wire or post/rail fencing. There is a high chance of vehicles that leave the road continuing at the same speed.

| Scoring matrix for factor 3 | T | V | W | X | Y | Z |
|---|---|---|---|---|---|---|
| Road/rail angle 60° – 90° | 1 | 8 | 12 | 12 | 18 | 24 |
| Road/rail angle 30° – 60° | 1 | 4 | 6 | 10 | 15 | 24 |
| Road/rail angle 10° – 30° | 1 | 2 | 3 | 8 | 12 | 24 |
| Road/rail angle less than 10° | 1 | 1 | 1 | 8 | 12 | 24 |

### 3.8.4: Road alignment (horizontal) at ends of parallel section

Road width and horizontal alignment are important. A wide straight road with passing clearance for two oncoming vehicles is an obviously lower risk than a narrow road where one vehicle has to give way. Curved approaches reduce the distance over which drivers can see, so they have less reaction time.

We define road width as the width of road surface, disregarding any footpath or verge.

### 3.8.5: Actual speed of approaching road traffic

Higher traffic speeds increase both the risk of an accident and also contribute to its effect.

Assessors should use actual speeds, taken from site measurements. If these are not available, they should evaluate speeds during the site visit. Assessors can disregard signed and designed speeds, as experience indicates that actual speeds may be much higher.

### 3.8.6: Site specific hazards increasing the likelihood of a RTA

Because it is not practicable to have a simple risk ranking which considers all possible hazards we decided to include a factor so that the assessor can take account of additional hazards that may increase the risk of a RTA. These include, but are not limited to:

- steep descent on the road approach and parallel stretch and adjacent access tracks;
- lay-bys;

- bus stops;
- car parking;
- cafes and shops;
- likely surface conditions (for example, some areas are more prone to ice);
- likely vehicle conditions (for example, vehicles in areas of social deprivation may not be in top condition);
- inadequate or non-existent signage; and
- traffic calming measures that direct vehicles towards the railway boundary.

**Score 1** for no obvious hazard.

**Score 5** for a single minor hazard, such as a field gate, lay-by or bus stop.

**Score 7** for multiple minor hazards or a single major hazard, such as sharp bends, junctions leading to conflicting traffic movements, downhill gradient steeper than 1:10.

**Score 9** for multiple major hazards.

### 3.8.7: Road traffic incidents

This factor relates to specific issues that could affect the likelihood of RTAs – accident history and sleep related accidents.

The second of these mainly applies to trunk roads and motorways but the first can apply anywhere.

### 3.8.7a: Road traffic accident history

Where there is a history of accidents, score this factor as follows:

**0 for no evidence or recorded history**

**1 for evidence of damage but no recorded history**

**2 for one reported incident in the last three years**

**4 for more than one reported incident in the last three years**

### 3.8.7b: Sleep-related vehicle accidents

Recent research has identified a number of RTAs caused by drivers falling asleep. These are known as sleep-related vehicle accidents or SRVAs. The study found that SRVAs are relatively common on high-speed major roads. Proportions ranged from 16 per cent to 30 per cent of all reported fatal, injury and damage only accidents.

In a recent study of SRVAs, the highest proportion was found on a featureless, unlit stretch of the M40 in rural Warwickshire. The research indicated that SRVAs are independent of traffic density, but there are some identifiable characteristics that lead to clusters of these accidents. Availability of service areas did not seem to affect SRVAs. But the study found clusters of SRVAs on slow right hand bends and towards the end of a long route.

For example, run-off accidents were clustered on the eastbound carriageway of the eastern end of the M180 and A180, but there was no such cluster on the westbound carriageway. SRVAs also occur on slow left hand bends. Most major roads have a central reservation safety barrier, which heavy goods vehicles (HGVs) may broach thereby posing a particular risk of incursion on to railway lines.

Note that sites not on long distance routes score 0.

### 3.8.8: Site specific hazards increasing the effects of the event

We have included a factor so that the assessors can take account of various hazards that can worsen the effects of RTAs. These include, but are not limited to, exposed pipelines, water mains and so on that run parallel with the railway tracks. Risk increases where there is more than one pipeline carrying different substances.

Some railway infrastructure is likely to make the results of an accident even worse. Some, such as switch and crossing work or junctions, are a derailment hazard. Others are likely to increase the severity of an accident if hit by a derailed vehicle. These include station platforms, bridge piers and abutments and tunnel portals within 800m (half a mile) of the site. Disregard overhead line masts within this factor.

**Score 1** for no obvious hazard.

**Score 3** for single hazard, such as a gas main or oxygen pipe.

**Score 5** for multiple hazards increasing consequences of an accident and/or railway infrastructure likely to increase the severity of any accident.

### 3.8.9: Length of parallel section

The longer the parallel section is, the more chance of a vehicle ending up on the railway. Score this factor for the full length of the parallel site, even if assessing in sections.

### 3.8.10: Kerbs

Kerbs help to keep vehicles on the road.

**Score 1** for Trief or other safety kerbing.

**Score 2** for physical kerb more than 100mm high.

**Score 4** for carriageway edge marking or physical kerb less than 100mm high.

**Score 5** for no kerb or marking (just grass, gravel, or similar).

### 3.8.11: Volume of road traffic

Road traffic volume increases the probability of a RTA. We developed the model using figures based on the number of HGVs per day, but assessors can apply any measure of recorded traffic flow, subject to similar weighting. HGVs and farm traffic are more likely to be involved in an accident on narrow roads where there is less space for traffic to pass.

Assessors may have to adjust this factor upwards to the next category where local conditions, such as the presence of a quarry, increases traffic.

Assessors may use the following vehicles per day figures where the highway authority cannot provide traffic volumes in HGVs.

Amend traffic volume where a route is a strategic diversion to reflect this.

**Score 1** for 0 to10 HGVs per day (<200 vehicles per day)

**Score 2** for 11 to 100 HGVs per day (<2,000 vehicles per day)

**Score 3** for 101 to 500 HGVs per day (<7,150 vehicles per day)

**Score 4** for 501 to 1,000 HGVs per day (<12,500 vehicles per day)

**Score 5** for 1,001 to 5,000 HGVs per day (<60,000 vehicles per day)

**Score 7** for over 5,000 HGVs per day (>60,000 vehicles per day)

The highway authority will provide traffic figures

### 3.8.12: Permissible line speed and track alignment

This is important because the risk of derailment is greater on high-speed routes. We have included the curve factor because of the increased chance of derailment on curves, where the train driver has less opportunity to brake.

The scoring reflects the greater likelihood of derailment with increased speed or curvature. It also reflects the fact that the consequences of an accident increase with speed.

We have included speed categories higher than present operating speeds so that assessors can use the model on the Channel Tunnel Rail Link and other high speed routes. It also allows ranking where speed enhancement schemes are being considered.

Details of line speeds are available from the railway infrastructure authority. This may be Network Rail, London Underground Ltd, NEXUS (Tyne and Wear PTE), a private railway operator or other infrastructure authority.

The site inspection will establish whether the line curves.

### 3.8.13: Type of rail traffic

The type of rail traffic can affect the severity of an accident following a RTA. The five categories below are a development of work to assess the risk from signals passed at danger (SPADs). This includes the likelihood of derailment and the crash resistance of different rolling stock types.

If a route used primarily by lower risk trains carries more than five higher risk trains per day (or 15 per cent of trains on lower traffic routes are higher risk), then score the route for the higher scoring group.

For example, the East Coast Main Line north of York is principally a loco hauled passenger route for high speed trains and IC225s, but it also carries sliding door Sprinters and some dangerous goods traffic, so it scores 5.

**Score 1** for freight only routes, not carrying dangerous goods such as petrol. These are considered the least risk, as generally there is less chance of derailment. Also fewer casualties are possible.

**Score 3** for loco hauled passenger trains, to include push-pull services such as high speed trains and IC225s and similar. These have a reduced risk of derailment as they are loco hauled and have better crash resistance than lighter rolling stock. The number of possible injuries, however, increases risk.

### Score 5 for sliding door multiple units (max speed 100 mph), and/or dangerous goods freight trains

Modern diesel and electric sliding door multiple units (Sprinters, EMUs) and trains carrying dangerous goods increase risk. This is due to the high number of possible casualties following any explosion or fire.

### Score 7 for slam door and sliding door multiple units (maximum speed greater than 100 mph)

This is because older slam door trains have less structural integrity than modern ones and passengers in the leading vehicles of modern higher speed multiple units are at greater risk of death and injury.

### Score 11 for light rail

Lightweight passenger trains, as operated by NEXUS (Tyne and Wear Metro) are at greatest risk. This is due to the high number of possible casualties and the increased chance of derailment of a light rail vehicle, compared with conventional multiple unit or loco hauled services.

Light rail does not include preserved railways operating under a Light Railway Order. You should assess these against the types of vehicles operated.

The railway infrastructure authority will confirm the types of traffic likely to use a route.

### 3.8.14: Volume of rail traffic

The more trains use a route, then obviously the greater the chance of one being involved in the aftermath of a RTA. The railway infrastructure controller will provide usage figures. Network Rail will provide them from its NETRAFF system.

NETRAFF will give information for each track at a location, split into passenger/freight movements. Assessors should score the total for the location, even at multi-track sites. The information by track, split into passenger/freight movements, may be useful later, when carrying out a more detailed risk assessment.

# Form 2 Neighbouring road vehicle incursion risk ranking scoring spreadsheet

| Factor | Options | Score | Factor | Options | Score |
|---|---|---|---|---|---|
| f1 (See Note 1) | **Relative level of Road and Rail**<br>Score A for rail more than 3m above road with >30 degree slope<br>Score B for rail above road with <30 degree slope or <3m vertical rise<br>Score C for rail level with road<br>Score D for rail less than 2m below road on slope<br>Score E for rail more than 2m below road or vertical drop of any height | | f8 (See Note 4) | **Site Specific Hazards Increasing Consequences of Event**<br>Score 1 for no obvious hazards<br>Score 3 for single site specific hazard<br>Score 5 for multiple site specific hazards and/or railway infrastructure likely to increase severity of an incident. | |
| f2 (See Note 1) | **Site Characteristics**<br>Score M if bund over 2m high or ditch/river over 1m deep and 3m wide between road and rail<br>Score N if bund up to 2m or ditch up to 1m deep or 3m wide between road and rail or heavy vegetation<br>Score P if smooth gradient/level over 15m distance between road and rail or medium vegetation<br>Score Q if smooth gradient/level 5 – 15m distance between road and rail<br>Score R if smooth gradient/level less than 5m distance between road and rail | | f9 | **Length of Parallel Section**<br>Score 1 for less than 100m<br>Score 3 for 101m – 501m<br>Score 5 for 500m – 2km<br>Score 7 for 2.1km – 5km<br>Score 9 for more than 5km | |
| f3 (See Notes 1) and 2 | **Interface Arrangements**<br>Score T for buildings<br>Score V for acceptable (safety barrier or concrete wall thicker than 450mm)<br>Score W for partially acceptable (brick wall thicker than 450mm)<br>Score X for barely acceptable (225mm thick concrete wall)<br>Score Y for inadequate (imperfect fencing or 225mm thick brick wall)<br>Score Z for non-existent (no fencing or only post and rail/wire) | | f10 | **Road Kerbs**<br>Score 1 for Trief or other safety kerbing<br>Score 2 for physical kerb higher than 100mm<br>Score 4 for carriageway edge marking or physical kerb less than 100mm high<br>Score 5 for no kerb or marking (just grass to carriageway) | |
| f4 | **Road Alignment (Horizontal) at Ends of Parallel Section**<br>Score 1 for straight road with at least 7.3m carriageway<br>Score 2 for straight less than 7.3m carriageway or gently curved at least 7.3m carriageway<br>Score 4 for gently curved road less than 7.3m carriageway<br>Score 4 for tightly curved road more than 7.3m carriageway<br>Score 7 for tightly curved less than 7.3m carriageway | | f11 (See Note 5) | **Volume of Road Traffic**<br>Score 1 for 0 to 10 HGVs (<200 vehicles) per day (generally green lane or farm access)<br>Score 2 for 11 to 100 HGVs (<2000 vehicles) per day (generally unclassified)<br>Score 3 for 101 to 500 HGVs (<7,150 vehicles) per day (generally C or B class)<br>Score 4 for 501 to 1,000 HGVs (<12,500 vehicles) per day ("Other Strategic" roads)<br>Score 5 for 1,001 to 5000 HGVs (<60,000 vehicles) per day (generally "Primary Routes")<br>Score 7 for Over 5,000 HGVs (>60,000 vehicles) per day (motorways and major trunk routes) | |
| f5 | **Actual Speed of Road Traffic**<br>Score 1 for <10mph<br>Score 3 for <30mph<br>Score 5 for <50mph<br>Score 7 for <70mph<br>Score 9 for >70mph | | f12 | **Permissable Line Speed and Track Alignment**<br>Score 1 for straight track up to 45mph<br>Score 4 for straight track up to 75mph or curved up to 45mph<br>Score 8 for straight track up to 90mph or curved up to 75mph<br>Score 12 for straight track up to 100mph or curved up to 90mph<br>Score 16 for straight track up to 125 mph or curved up to 100mph<br>Score 20 for straight track up to 140 mph or curved up to 125mph<br>Score 24 for straight track above 140 mph or curved above 125mph | |
| f6 (See Note 3) | **Site Specific Hazards Increasing Likelihood of RTA**<br>Score 1 for no obvious hazards<br>Score 5 for single site specific hazard<br>Score 7 for multiple minor hazards, or single major hazard (e.g. junctions, steep slopes, sharp bends)<br>Score 9 for multiple major hazards | | f13 | **Type of Rail Traffic**<br>Score 1 for Non-Dangerous Goods Freight<br>Score 3 for Loco-Hauled Stock<br>Score 5 for Sliding Door Multiple Units (up to 100mph) or Dangerous Goods Freight<br>Score 7 for Slam Door Multiple Unit or Sliding Door Multiple Units (over 100 mph)<br>Score 11 for Light Rail (see definition in guidance notes) | |
| f7 | **7a: Road Traffic Incident History**<br>Score 0 for no evidence or recorded incident history<br>Score 1 for evidence of damage but no recorded incident in the last 3 years<br>Score 2 for 1 recorded incident in the last 3 years<br>Score 4 for more than 1 recorded incident in the last 3 years | | f8 (See Note 6) | **Volume of Rail Traffic**<br>Score 1 for seldom used route (fewer than 500 trains per year)<br>Score 3 for lightly used route (501 to 3,000 trains per year)<br>Score 5 for medium used route (3,001 to 10,000 trains per year)<br>Score 8 for heavily used route (10,001 to 50,000 trains per year)<br>Score 12 for very heavily used route (more than 50,000 trains per year) | |
| | **7b: Long Distance Route Effects**<br>Score 0 for not a long distance route<br>Score 1 for no obvious risk factor<br>Score 3 for a site on a featureless rural road<br>Score 5 for a long sweeping right hand bend or at the end of a long route<br>Score 9 for a combination of the above two factors | | | | |
| Note 1<br>Note 2<br>Note 3 | For factors f1, f2, and f3 refer to the matrixes in the guidance note to determine the score.<br>Score f3 on the basis of the stretch with the least containment.<br>Site specific hazards increasing the likelihood of a RTA include the following features in the length of the section: farm access, road junction, private driveway, lay-by, bus stop, steep downhill slope, on approach, etc. Lack of adequate signage would also be included here. | | Note 4<br><br><br>Note 5<br><br>Note 6 | Site specific hazards increasing the consequences of the event include the following features in proximity to the site: exposed gas or chemical pipelines, etc.<br>Railway infrastructure likely to increase severity of incident to include pointwork, platforms, bridge piers and abutments and tunnel portals etc within 800m (½ mile) of structure.<br>Equivalent traffic flows for all vehicle types may be substituted, depending upon the units of measurement used by the relevant highway authority.<br>Volume of rail traffic to be provided by railway infrastructure authority, see guidance notes. | **Total** |

# chapter four: Assessing scope for treatment at a site

Chapter 1 sets out the process for considering treatment of sites where there is a probability of vehicles leaving a public road and reaching a railway line. The first stage (Chapter 3 ) is to rank all sites in terms of their relative risk. The second stage is to assess the scope for treatment by investigating in more detail the sites with the highest risk ranking to decide the scope for treatment.

Using the scoring procedure provided (forms 1a, 1b or 2), the highest risk ranking score is likely to be around 130. It is estimated that, nationally, about 95% of the risk will occur at sites that have been scored above 100. It is recommended that sites with scores between 90 and 100 are also investigated further, although only relatively low cost improvements are likely to be justified at these sites. Highway and rail authorities may wish also to review signing or road marking at some sites scoring below 90 to see whether improvements could be made at low cost. As a guide, it has been estimated that an average cost of treatment of about £45,000[1] might be justified at sites scoring above 100, although more might be needed at the worst sites. Sites scoring well above 100 might warrant an expenditure of £200,000. But most sites will warrant much lower expenditure as the appropriate treatment and its cost will be very dependent on individual site conditions and regional location. Therefore, these figures should be taken primarily as a guide to the overall budget to be spent by an authority, based on the number of high scoring sites it identifies. Decisions on individual sites should be based on local assessment.

But the purpose of the risk ranking is to highlight sites in clear need of treatment. Highway and rail authorities may wish to extend treatment to lower ranked sites, particularly as part of broader network management programmes, and where environmental or other local concerns warrant this. Authorities responsible for major, high standard, high speed roads are particularly likely to consider programmes of improvements at sites with lower initial ranking scores. This partly reflects the higher traffic disruption costs that are likely at these sites if incidents were to arise, but also their continuing drive to improve safety standards on such roads in line with best international practice.

Section 4.3 gives further information on the basis for the indicative costs quoted.

## 4.1 Different types of site

If a vehicle leaves the carriageway without hitting another vehicle (e.g. through loss of control or inattentiveness), it is most likely to continue to travel in the same direction as before leaving the carriageway. It is unlikely to leave at an angle of more than 20 degrees to the direction of travel, (although, subsequently, the angle of divergence from the carriageway may be affected by the topography, e.g. a vehicle would tend towards

1 All prices and costs given in this document are for 2002.

the line of steepest gradient when going down an embankment, and this should be taken into consideration in determining the vulnerable area based on the guidelines below). Such vehicles are most likely to leave the road to their nearside. However, there still may be a risk of vehicles leaving to the offside, particularly if the road alignment is curved to the left.

The dimensions of the vulnerable zone should be determined by considering a length equal to the likely vehicle stopping distance based on the appropriate road speed, nature of the terrain and topography in a zone up to 20 degrees from the original direction of travel of the vehicle. Note that stopping distances may vary with the effects of seasonal changes.

Sites may need to be considered as being made up from a number of individual components. The figures below illustrate typical situations where errant vehicles may encroach onto the railway and are drawn to show a vehicle travelling from left to right. Similar consideration must be given to vulnerable areas for vehicles travelling from right to left. All assume the road runs either above or approximately at the same level as the railway track. Vehicles are less likely to reach the railway if it is higher than the adjacent ground.

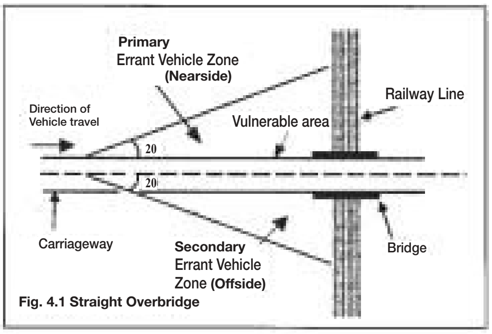


Fig. 4.1 Straight Overbridge

### Fig. 4.1 Road approaching and crossing rail at the same angle

Nearside errant vehicle zone extends for a distance appropriate to ensure the vehicle stops before reaching the tracks. The offside zone may also need to be considered.

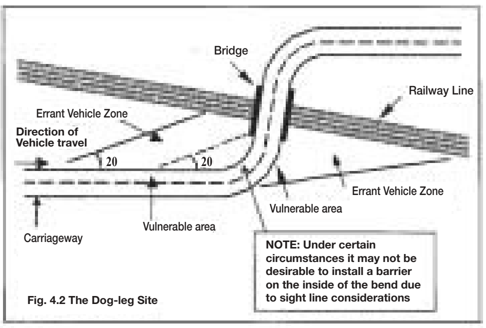


Fig. 4.2 The Dog-leg Site

### Fig. 4.2 Road approaching parallel to rail and crossing rail after sharp bend ("dog leg" site)

The errant vehicle zone shown is for vehicles leaving the carriageway on the nearside on the approach and to the offside if the bend is not safely negotiated. Note that standard safety barriers may not be sufficient to contain vehicles which impinge upon them at angles greater than 20 degrees within normal containment systems (i.e., in this example, on the approach to the bridge, barriers would be less effective at constraining vehicles leaving the bend on the road to the offside than the nearside). A simpler version of this type of site would only have a bend on one approach.

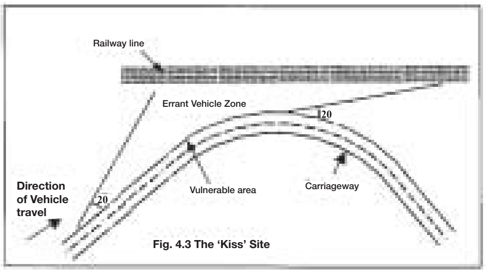



**Fig. 4.3 Road running towards railway and then bending away again ("kiss" site)**

The start of the errant vehicle zone is determined as in Fig. 4.1 and extends round the curve until the stopping distance line at 20° no longer reaches the railway.

The situation where the road runs parallel to rail for some distance is a specific case of this example where the road has zero curvature. In this case, the approach and the parallel section need to be assessed separately since, with the change of orientation of the stopping distance line (Sd) around the bend, protection may be required on the approach but the line may not reach the railway on the parallel section (i.e. road and rail separation Sd > Tan 20)

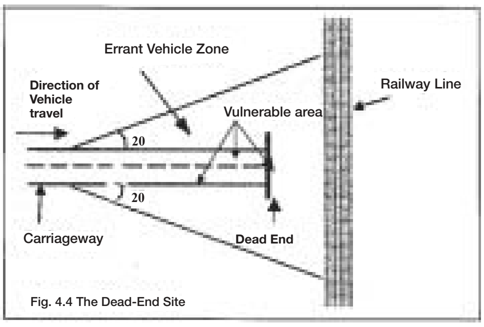



**Fig. 4.4 Road running towards railway and terminating close to a rail line ("dead end" site)**

Similar to the situation in Fig. 4.1 except that protection at the dead end needs to be able to contain a "head-on" impact.

## 4.2 Second stage assessment

Once an overbridge or parallel site has been identified as having a high score, the second stage of the assessment process needs to be undertaken. The aim of this stage is to consider in more detail what the problems are and how best to address them in terms of introducing mitigating measures.

The second stage involves the following steps (1-6 for overbridges, 2-6 for parallel sites) –

1. For overbridge sites with an initial score of more than 90, review the initial risk ranking and undertake separate assessments of each corner in order to determine a realistic score for the bridge (to be taken as the highest scoring corner).
2. For all sites scoring more than 90, distinguish which parts of the site are higher risk.
3. Identify any evidence of accident damage at the site.
4. Identify road gradients and existing street layout and furniture.
5. Complete a mitigation spreadsheet to:
   - recognise which options for treatment are feasible/practical; and
   - prioritise treatment options in terms of cost and expected effectiveness of individual measures.
6. Safety audit of proposed measures.

In the interests of efficiency, it is suggested that the information required to carry out the 6 tasks above will be collected on the same site visit as the initial risk assessment.

The information collected under points 1-3 above should be noted in the assessment report. It should be used to help assess the effectiveness of alternative measures at the site. It is suggested that OS maps (at least as detailed as 1:2500) of a site be used to record locational details of the results of the first three tasks. The mitigation spreadsheet accompanying these notes will assist in the execution of step 4.

The successful completion of the steps will depend heavily upon the judgement of the engineer as every site will be different and inevitably some balancing of conflicting issues will be necessary. The following sections try to provide some basic guidance relating to each task and raise some specific issues that may need consideration.

**Step 1. For overbridge sites with an initial score of more than 90, review the initial risk ranking and undertake separate assessments of each corner in order to determine a realistic[2] score for the bridge (to be taken as the highest scoring corner)**

Some sites may score highly in the initial ranking because of the presence of several high scoring factors found at the site but do not, in practice, apply together over any particular part of the site, and so, artificially increase the ranking score. Rescoring these sites, corner by corner is recommended. If the scores for each corner do not exceed 90, the site should no longer be considered a priority. In these instances, the ranking scores should be recorded for audit purposes. If any corner still scores more than 90, proceed to step 2 below.

**Step 2. For sites with a score of more than 90, distinguish which parts of the site scored are high risk**

The initial risk assessment only considers the worst potential outcome over a whole site for each factor. In practice, some sites may have some sections that are higher risk than the rest of the site, and others that are lower risk. For example, the level of containment may be inadequate on only one approach to a bridge and taking this into account will increase the scope for making other safety improvements at a site. This will be particularly important at sites with bends or junctions in the vicinity as these will substantially increase the likelihood of vehicles leaving the road at specific points, as a consequence of the type of vehicle conflict or driver error most likely to arise. An initial check could be made at the time the risk ranking scoring sheet is completed.

If a bridge site has an overall score of at least 90, then the different characteristics of different parts of the site should be recorded.

**Step 3. Identify any evidence of accident damage at the site**

The frequency of accidents at any site is likely to be low and most accidents will not be reported, especially if they did not involve incursion onto the railway track or result in severe injuries. However, evidence of damage to street furniture (signs, barriers, posts etc) and skidding can be helpful in pinpointing elements of the road layout and design that some road users are failing to negotiate safely.

2 This is to account for sites which score highly in the initial ranking because of the presence of several high scoring factors found at the site but do not, in practice, apply together over any particular part of the site, and so, artificially increase the ranking score.

### Step 4. Identify road gradients and existing street layout and furniture

In order to consider future treatments it is, of course, important to assess the current existence of safety measures at a site. Any specific site hazards (such as bus stops or pedestrian crossings or steep gradients) and the presence of HGVs, motorcycles, pedal cycles and pedestrians may also affect the suitability of certain measures. In addition, certain treatments may be impractical or prohibitively expensive at certain sites – for example the installation of safety barriers at a site may unacceptably block an access or require retaining walls to be built onto a steep embankment. These sorts of issues need to be identified during the site visit.

### Step 5. Complete a mitigation spreadsheet

An example mitigation spreadsheet is reproduced below. A spreadsheet with a blank mitigation spreadsheet (form 3) which includes all the necessary formulae to automatically carry out the calculations described below is on the DfT website www.dft.gov.uk. It is intended for use at both overbridge and parallel road/rail sites. The spreadsheet is protected to minimise the chance of information and formulae being altered or deleted accidentally. Only columns (a), (d), (e), (f) and (h) can be modified. However, this protection can be removed if the user does wish to modify other parts of the spreadsheet.

One sheet should be completed for each site for which the process is being applied. The sheet is provided to help engineers assess the most suitable options for treatment and to prioritise options. It can also be used to compare sites.

The sheet is not intended to be prescriptive and engineers are encouraged to adapt it for each specific site as appropriate – by adding measures, adjusting costs and estimating effectiveness, for example.

The measures in column (a) have been selected as those most likely to reduce the likelihood of vehicles leaving the road and constraining them from reaching the railway if they do leave the carriageway. If the spreadsheet is unprotected (this does not require a password), it is possible to add rows to the spreadsheet table to include other measures for consideration in the same way but it should be noted that the formulae must also be copied to the appropriate new cells. Alternatively, a measure can be replaced by another by over-writing column (a) and entering appropriate values in columns (d), (e) and (f), as described below. The suitability of particular measures at various types of site is discussed, by measure, in section 4.4.

The costs provided in column (b) are given as a rough guide and, in practice, will vary across different parts of the country, manufacturers, materials and specifications etc. The costs do not include any allowances for extras such as road and rail traffic management, electrical supply etc or for scheme design. These additional costs should be included when making an overall judgement as to which measures should be applied at individual sites (as discussed below).

The estimated average effectiveness provided for each measure (column (c) ) have been derived from average injury road accident reduction results achieved after the installation of local authority safety schemes and the following points and assumptions should be kept in mind:

- some estimated average reductions are based on only a few sites;
- some (highlighted yellow) have been based on judgement alone;
- commonly, a wide range of reductions are observed across sites;
- no two schemes are identical;
- many schemes incorporate more than one measure and it is hard to identify contributions from individual elements; and
- most reductions relate to the probability of accidents occurring but the safety barrier figure relates to the probability of reaching the railway.

Therefore, an engineer should replace these estimates if more robust information about a particular measure becomes available.

Column (d) should be used to record whether or not the measure is suitable for use at the site, assuming it is not presently installed. Some guidance on the issues leading to judgements for column (d) for each type of measure is also given in section 4.4.

Using the information gathered in tasks 1-4, the engineer should complete column (e) with the total cost of each suitable measure for the specific site in question. For example, this value will vary depending on the length of barrier required or whether one or two vehicle-activated signs are required. If there is no electricity supply nearby and significant road and rail traffic management will be required, the costs of certain measures will need to be increased accordingly.

Similarly, engineers can adjust the estimated effectiveness values in column (c) and enter more appropriate values for the site in column (f). For example, supposing there was a likelihood of vehicles leaving the carriageway on both sides of the road but that access constraints meant only one side of the road could be protected, the effectiveness of safety barriers might be estimated to be only 45%. On sharp bends on the approach to rail bridges, vehicles that leave the road on the offside, will tend to strike any barrier at a relatively high angle. The effectiveness of the barriers will be less at these high angles, and this too can be shown through this column.

The cost-effectiveness (column (g)) is then calculated by dividing the total site-specific cost (column (e)) by the estimated site-specific effectiveness (column (f)). The engineer can then use the results to prioritise treatments by selecting the most cost-effective ones according to his or her overall budget.

Care should be taken when estimating effectiveness to make sure benefits are not double-counted – i.e. that the effect of other measures are taken into account when several measures are used together. For this reason, the engineer should record the order of selection in column (h). Then, interactively, as measures are selected:

- column (i) gives a revised estimate of the cost effectiveness of a measure, **given those already selected** (based on a revised effectiveness of the measure as a percentage of the possible reduction available). After the first measure has been selected, subsequent selections should be based on the most cost-effective values in column (l);

- column (j) gives the site-specific costs of those selected measures (as given in column (e)); and

- at the bottom of column (j) the cumulative total cost is given.

In this way, the engineer may seek to develop a package of measures, up to the spend level considered appropriate.

But safety barriers will usually be the most effective measure to prevent a vehicle reaching the railway. Therefore, it is generally recommended that if safety fencing is appropriate and the cost is within the guideline budget (according to the risk ranking score for the site), safety fencing should be selected as the first measure and other measures added afterwards according to their cost-effectiveness, if appropriate. It may not be appropriate to install other measures which may be more cost-effective individually but when used in combination with safety fences will not significantly reduce the overall risk. If the cost of safety fencing exceeds the guideline budget, the selection of other cost-effective measures should be considered to improve safety at the site instead. Alternatively, the engineer may be able to find a combination of measures which are more cost-effective than the most obvious choice. For example, faced with high costs for safety barriers because of ground conditions, it may be possible to implement speed reducing measures at the site, which would enable less expensive barriers to be used.

In the full example mitigation spreadsheet shown, a total budget for measures of about £16,000 has been considered appropriate based on the initial ranking score.

As individual measures are selected the estimated overall effectiveness for the combination of measures selected is given at the bottom of form 3. This is shown in the example mitigation spreadsheet.

### Step 6. Safety audit of proposed measures

As with all engineering schemes, the proposed measures should be subject to safety audit. All measures to be introduced on the road need to be assessed carefully to consider whether they introduce any likelihood of additional conflicts or reduced understanding of the likely actions of other road users. It is important not to add to the road vehicle occupant risk while reducing the rail passenger risk. Safety barriers themselves can add to road vehicle occupant and other road users risk if not carefully sited.

# 4.3 Deciding what to spend at each site

The risk at most sites is very small and it is very difficult to assess the cost – effectiveness of treatment at a particular site. The approach that has been taken is to calculate the total cost that might be appropriate to spend to reduce the national risk. This is then distributed, in broad terms, between individual sites on the basis of the proportion of total risk represented by different types of site. Sites are allocated to risk bands on the basis of their score in the risk ranking process. As this score is only a general guide, the banding (and therefore the typical cost that might be justified at a specific site) needs to be treated flexibly, and to reflect any other factors which might influence the case for treatment at the site.

The HSC report *'Obstruction of the railway by road vehicles'* made the following estimates, in round terms:

- on average, there are 0.1 train occupant deaths and 0.4 road vehicle occupant deaths every year as a result of all vehicle incursions onto railway lines; and
- the value of eliminating all casualties from these incidents would be about £1 million per year.

## Estimating total investment at all sites

For injuries to third parties, it is reasonable to assume that highway and rail authorities might consider investing in treatments up to the full cost that might be incurred by these third parties, if this could remove most of the likelihood of such events occuring in future. In practice, given the random nature of events, it is likely that incidents will still occur at sites ranked as very low risk. Nevertheless, it is assumed that a budget covering the full cost of third party injuries should be considered. At a valuation of £1.15 million per death, the 0.1 train occupant deaths represent an annual total cost of £115,000. To cover the cost of non-fatal injuries this should be increased by a factor of 1.5, to £172,500 per year. A further £1.2m should be added to these costs based on average accident investigation costs and additional disruption costs associated with restoring the rail line to full operation if derailment or track damage occurs. Similarly, at a valuation of £1.15 million per death, the 0.4 road deaths represent an annual total cost of £460,000, rising to £690,000 per year when the cost of non-fatal injuries is included.

The most likely treatment to be considered will be an improvement in containment through the provision of safety fencing. This typically has a life of at least 20 years. Although other low cost treatments, with much shorter lives will also be considered, an effective life of the investment of 20 years is assumed.

The current value[3] of future benefits over this twenty year life is therefore £32 million, so this is the maximum total investment that can be justified for the country as a whole.

3 A capital multiplier of 17.5 is used which includes an allowance for the projected increase in GDP per head. However, the figures for disruption and accident investigation costs were simply discounted and so for them the corresponding capital multiplier used was 14.7.

### Estimating numbers of sites

This report was prepared using risk ranking scores collated by Network Rail for a sample of 500 bridge sites. The distribution of scores show about 3% of sites scoring above 105, 5% scoring 100-104, 5% scoring 95-99 and 7% scoring 90-94. The sample includes several sites with high speed railway lines, and therefore the distribution in other areas might show fewer high scoring sites. However, although very few parallel sites were included in the sample used, it is anticipated that these might achieve slightly higher scores than the overbridge sites. For the purposes of estimating indicative budgets, a national distribution of the scores for all types of site has been assumed to be the same as that for the sample used. This suggests 8% of sites (640 sites) might score over 100 in initial ranking, with a further 12% (960 sites) scoring between 90 and 100.

### Average cost per treated site

On the basis of these two estimates, an average budget of £45,000 per site scoring over 100 might be required, with the very worst sites justifying expenditure up to £200,000 whilst those scoring 100 might only warrant £5,000. Road and rail authorities should, jointly, consider the relative risk at individual sites and make judgements about the appropriate amount to spend at them. In practice, regional cost variations and practical engineering options may mean much lower figures are appropriate or other factors, such as local concerns or environmental issues, might warrant higher expenditure and for that expenditure to be extended to lower scoring sites.

## 4.4 Suitability of measures

Aside from the practical considerations of whether a measure can be installed at a site and, if so, over how much of the site or how often, there will be certain types of site at which a particular measure is likely to be more effective than at others. There may also be sites where environmental concerns mean that safety fences are not appropriate and others where excessive signing, traffic calming or road marking is not appropriate due to their visual impact, residents' objections, historic context etc. In these cases, more environmentally sensitive restraint systems may be needed. Site authorisations should be sought where appropriate if any situations or measures are non-standard.

### Advisory/mandatory speed limits

It is now a well-established fact that reducing vehicle speeds results in lower accident frequencies and that the higher a vehicle's speed the higher the energy of a collision and the greater the distance a vehicle will travel before coming to a stop. Therefore, speed reduction may be a desirable aim at high risk sites in order to reduce the likelihood of vehicles being involved in accidents and breaching the railway. However, the introduction of a new speed limit may not be appropriate over very short distances and must be realistic, consistent with respect to the surrounding roads, enforceable (and, preferably, self-enforcing). A speed restriction is unlikely to be appropriate if existing 85th percentile speeds are about 20% or more above the proposed new limit, although the situation may be helped by introducing speed-reducing engineering measures (such as traffic calming – see below) or continual enforcement. Part-time speed limits may be effective but difficult to enforce, for example, during arrival and leaving times at isolated schools.

The use of supplementary plates to encourage speed reduction or with advisory maximum speeds are not generally very effective but may be useful at particularly hazardous locations (for example, at a bend where the visibility or geometry depart from standards). They are most effective if the advised speed is less than the mean vehicle speed. They are unlikely to be very effective alone and should be considered in conjunction with other measures, if possible.

Although there will always be exceptions, it is likely that the following types of sites would be least suitable:

- overbridge sites for new speed limits as it is unlikely that the length of road is long enough to be suitable and self-enforcing (unless a nearby lower speed limit can be reasonably extended); and

- trunk road and motorway sites for lower speed limits as they are unlikely to be reasonable or self-enforcing.

And similarly, although there will always be exceptions, it is likely that the following types of sites would be most suitable:

- sites where there may be a number of drivers who are not familiar with the road (for example, tourist areas) may benefit from advisory speed plates;

- sites with long straight or humped approaches to a bend on a bridge, or kissing a railway;

- sites where, on an approach to a junction, some of the junction arms are not visible;

- sites where there is a lot of pedestrian activity;

- sites where the layout precludes the use of containment and other engineering measures; and

- sites with immovable, high risk hazards.

## Traffic calming

Physical traffic calming measures (including road humps, thumps, speed cushions, one-way and two-way working chicanes, narrowings or throttles, mini-roundabouts, refuges etc) can be very effective at reducing vehicle speeds and (especially pedestrian) accidents. However, they are not generally suitable for use or allowed on high speed roads and have to be designed carefully, taking account of the needs of pedal cyclists, motorcyclists, HGVs, buses and emergency vehicles. Physical measures need to be clearly visible under all conditions and priorities must be clearly defined.

In general, physical measures may not be very suitable at sites on main, high speed roads, and with high levels of HGV traffic. Also the installation of some measures may not be supported by local residents or drivers. They may be most suitable at sites where inappropriate speeds are leading to a high level of risk, for example:

- on local roads;
- at sites with high proportions of vulnerable road users, particularly where pedestrians and equestrians are crossing; and
- to manage traffic flows where there is a visibility problem (over a narrow, humped, bendy or dogleg bridge) leading to a likelihood of head on accidents.

## Perceptual measures

Perceptual measures can be used to encourage (rather than enforce) lower vehicle speeds. “False” speed cushions and road humps can be designed with optical illusions and road markings to make a flat road appear raised. Similarly, dragon’s teeth markings, hard edge strips, channelisation markings etc. can encourage drivers to follow a prescribed path along the carriageway. They also make a road appear narrower to the driver than it actually is, which gives a driver the illusion that they are travelling faster than they actually are, and thus encourages drivers to travel at lower speed. Ghost islands and hatched areas can be used to keep areas free of vehicles to facilitate turning movements, protect pedestrians etc. They will be most suitable at the same kinds of sites that would benefit from, but are unsuitable for, physical traffic calming.

## Warning signs and alerting devices

If not already in place, a wide range of warning signs and alerting devices may be appropriate to reduce the probability of vehicles leaving the road at all types of site. The signs may be at the side of the road (e.g. bend and junction warning signs, chevron signs, slippery road, hump bridge, steep gradient, queuing, pedestrians etc) and/or on the road surface (e.g. speed limit roundels, SLOW markings etc.).

### Vertical measures

At sites where there is a problem not managed with standard signing, vehicle-activated signs which target only specific (e.g. speeding, too heavy for bridge) vehicles or, perhaps, that only operate under certain conditions (e.g. icy) can be suitable. Signs that have yellow backing boards may serve to accentuate the level of risk to a driver, but may be unacceptable on environmental grounds. Information, alerting and warning signs can be of great benefit to drivers but can cause clutter and prove a hazard to road users who leave the carriageway and impact them.

Other measures that may be considered to increase driver alertness include livening up the visual landscape, perhaps through coloured street furniture and architecture, varied planting or roadside sculpture.

At some sites, the installation of traffic lights may have been considered on other grounds and they too alert drivers to a junction or priority control ahead and compliance with them is generally good when the phases are well-designed. Traffic lights may be of most benefit either at junction sites with complex or numerous opportunities for conflict or, at narrow (and especially poor forward visibility) sites where two-way working is either impossible or high risk.

Alerting devices will be highly effective at sites which are visually unstimulating (and perhaps likely to be part of a long route or journey) that may encourage drivers to fall prey to fatigue. They may be highly effective at sites which are overstimulating, leading to distraction or information overload (e.g. with a high density of accesses, junctions and signing). They are also likely to be particularly suitable for sites where there is a problem with loss of control accidents. They will not be cost-effective if they require electricity and there is no supply nearby.

### Horizontal measures

The road surface can be used to reduce the likelihood of vehicles leaving the carriageway by improving tyre grip (with anti-skid surfacing); alerting drivers and encouraging them to slow through the noise and vibration from travelling over raised transverse lines (yellow bar lines, rumble strips, riblines, thumps or rumble areas); alerting drivers who may be more likely to notice changes in the road surface (e.g. coloured areas or SLOW markings) than roadside signs.

Anti-skid surfacing is likely to be highly effective at sites where speeds are too high and where sudden changes in speed and acceleration are commonplace, such as on the approaches to crossings, junctions, bends and at dead end sites. In particular, it can be of benefit at sites where speed-reducing measures are not appropriate. Anti-skid surfacing is also useful for sites with a low skid resistance, particularly at sites most likely to be wet or icy and where vehicles tend to lose control.

Raised transverse markings can be most effective at non-standard sites but are not suitable near areas with housing as such schemes are frequently removed due to the noise generated.

### Delineation and visibility

Delineation of the carriageway using e.g. running lanes, turning lanes and on and off slips, junctions, parking areas, laybys, bus stops etc is very important (particularly at night and on roads with unexpected geometry or poor sight distances) to guide vehicle paths, deter manoeuvres (e.g. overtaking) and improve driver anticipation of hazards. Delineation can be introduced using white centre- and edge-lining (raised or plain), lane markings, channelisation, hatching, and reflectorised road studs or posts. Care should be taken in the designs so that drivers do not become overconfident in their ability to read the road ahead. Lighting columns can also be used to help delineate roads and can be visible for some distance ahead in some instances. Visibility splays can be improved by cutting back vegetation, particularly near junctions.

Delineation markings will be most highly effective at sites where there is no lighting and where there are no verges or kerbing present, particularly if this means roadside hazard warning signing is not possible.

## Containment measures

Once a vehicle leaves the carriageway, the presence of safety barriers, fencing and bridge parapets can be crucial in absorbing the energy of a vehicle upon impact and deflecting vehicles back onto the carriageway and away from railways. The ideal type of containment for the site will depend on the geometry and the types of traffic. Sites need to be protected at their most vulnerable points (e.g. at bends) and from all possible points of approach (nearside, offside, all directions and access points). However, barriers etc are likely to be less effective at points where the risk is of a head on impact (e.g. at dogleg, kiss, dead end or right-angled bend sites).

At sites with very steep embankments down to railway lines, no verges, no kerbing, steep downhill approaches, or very narrow roads, a high standard of containment may be the most effective way of preventing incursions onto tracks.

Standard safety fencing and parapets may not be effective enough on roads with high proportions (>10%) of HGV traffic. In such instances, high level safety barriers and strengthened parapets will be most effective.

On high speed roads, fencing is unlikely to be adequate to contain vehicles and some form of safety barrier will be preferable. Similarly, the higher the vehicle speeds, the greater the zone of influence and the greater the length of barrier required.

## Off-carriageway measures

Once a vehicle has left the carriageway, there are various measures that can slow or stop vehicles to reduce the probability of incursion by vehicles and debris. These include planting and retaining measures, humps and ditches, impact attenuators, crash cushions, arrestor beds, vehicle and debris nets etc.

These types of measures will be most effective at sites where containment measures are not feasible and where vehicles are unlikely to come to a halt on their own, for example if speeds are high, distances between the carriageway and track are small, or the embankment between the road and railway track runs down steeply.

# 4.5 Examples of site assessments

## Example 1: Parallel site – Ashby St Ledgers, Northamptonshire

*Photo 1a: Parallel site – Ashby St Ledgers, Northamptonshire, before treatment*

## Risk Ranking Score

The parallel risk ranking score for this site was very high at 108. The main contributions to this high score were due to the proximity of the road to the rail track, the gradient of the embankment, the lack of containment and the volume and speed of train traffic below.

## Risk Assessment

The A5 to Ashby St Ledgers road, Northamptonshire runs parallel to and above the railway line for about 100m until the railway enters the Kilsby tunnel (southeastern portal – just in front of the photo above) where the road bends very sharply, over the tunnel and around the hill beyond. The road is a narrow, rural, single-carriageway with no kerbs or road markings, carrying less than 7,000 vehicles per day. The slope down to the railway track is 1:2 for less than 15m and there is then a vertical drop, directly onto the line below. The only containment measure between road and track was a low concrete post and wire fence (pictured above) which, despite vehicle speeds of less than 30mph, would be unlikely to contain a vehicle leaving the road. The railway track is straight, used by more than 50,000 trains per year (which can include dangerous goods freight), and trains can travel at speeds of up to 140mph.

The most vulnerable zone is approximately 160m long (on only one side of the road).

## Potential Mitigation

At the time of preparing this example, treatment for this site had already been planned.

The railway authority have installed the fence (shown in the picture below). In the near future, Northamptonshire County Council will install 160m of high containment kerbing at a cost of £11,500. A post-measure example mitigation spreadsheet is shown below.

### Mitigation spreadsheet (form 3)

| (a) | | (e) | (f) | (g) | (h) | (i) |
|---|---|---|---|---|---|---|
| **Measure** | **Approx cost per item (2002) prices** | **Approx cost for this site** | **Estimated effectiveness for this site** | **Cost-effectiveness (b/1000e) measure alone** | **Selection order** | **Cost of selected measures** |
| Rail fence | estimate 10,000 | 10,000 | –60% | –17 | 1 | £10,000 |
| High kerbing | | 11,500 | –60% | –19 | 2 | £11,500 |
| | | | | | Total cost of selected measures | £21,500 |
| Estimated overall effectiveness –84% | | | | | | |

*Photo 1b: Parallel site – Ashby St Ledgers, Northamptonshire, mid-installation*

## Example 2: Bridge site at Browney Lane, County Durham

*Photo 2a: Bridge site at Browney Lane, County Durham – before treatment*

### Risk Ranking Score

The overbridge risk ranking score for this site was very high at 101. The main contributions to this high score were due to the gradient of the embankment leading down to the track, the poor containment on the approach to the bridge, the uncertainty of the reliance of the bridge parapet and the volume and speed of trains travelling on this stretch of the East Coast Main Line.

### Risk Assessment

The bridge (grid reference NZ 258 380) carries the B6300 over the East Coast Main Line railway between Meadowfield to the north and the A167 at Croxdale Bridge to the east, carrying an annual average of about 4,300 vehicles per day. Network Rail is responsible for the bridge.

The carriageway over the bridge is located on a slow bend and has a 1 in 8 gradient at the bridge, however visibility is considered to be satisfactory. The carriageway over has a surface dressed wearing course in an acceptable condition and has a de-restricted national speed limit.

A pre-cast concrete rail and slotted post fence is located at the back of the verge with the original ashlar parapet set at a skew to the rear of the fence. Neither the fence nor the parapet was considered to meet the current criteria for vehicle containment.

A concrete post and rail fence was erected at the rear of the verge on the approach to the bridge. However, there was no vehicular safety fencing provided to the approaches.

There were no injury accidents recorded at the site.

The vulnerable zone was identified as being about 226m long.

## Potential Mitigation

At this site, treatment was installed before the mitigation spreadsheet was developed.

This site was treated with 226 linear metres of single height open box beam (OBB) safety barriers (as shown in photo 2b below) on one verge only and extended across the deck to a field gate on the downhill side of the bridge. Some retaining works were undertaken to raise levels to provide support at the back of the verge. The scheme also involved negotiations with a local landowner to relocate a farm access gate. The cost of the scheme was £55,000. A post-measure example mitigation spreadsheet is shown below.

### Mitigation spreadsheet (form 3)

| (a) | | (e) | (f) | (g) | (h) | (i) |
|---|---|---|---|---|---|---|
| **Measure** | **Approx cost per item (2002) prices** | **Approx cost for this site** | **Estimated effectiveness for this site** | **Cost-effectiveness (b/1000e) measure alone** | **Selection order** | **Cost of selected measures** |
| Low-level safety barrier | £100+/lin m | 55,000 | –95% | –58 | 1 | £55,000 |
| | | | | | Total cost of selected measures | £55,500 |
| Estimated overall effectiveness –95% | | | | | | |

*Photo 2b: Bridge site at Browney Lane, County Durham – after treatment*

# Form 3 Example mitigation spreadsheet

| (a) | | (b) | (c) | (d) | (e) | (f) | (g) | (h) | (i) | (j) |
|---|---|---|---|---|---|---|---|---|---|---|
| Measure | Approx cost per item (2002 prices) | Approx max cost (£ per site) | Estimated average effectiveness | Suitable for site? (Y/N) | Approx. cost of measure for this site | Estimated effectiveness of measure for this site | cost-effectiveness (b/1000e) measure alone | Selection order | cost-effectiveness of measure given others selected | Cost of selected measures |
| Low level safety barrier | £100+/linear m | 40,000 | –95% | Y | 15,000 | –95% | –16 | 1 | | £15,000 |
| High level safety barrier | £500+/linear m | 200,000 | –95% | Y | 15,000 | –50% | –30 | | –1,319 | |
| Advisory speed limits | £100/sign | 400 | –5% | Y | 400 | –5% | –8 | | –352 | |
| Traffic calming – physical | | 7,000 | –62% | N | | | | | | |
| Traffic calming – marking signing only | | 1,000 | –20% | Y | 1,000 | –20% | –5 | | –220 | |
| Marking narrowings | | 500 | –5% | Y | 500 | –5% | –10 | | –440 | |
| Metre strips (marking only) | £0.5p/linear m | 200 | –5% | Y | 200 | –5% | –4 | | –176 | |
| Hazard signing | £100/sign | 400 | –31% | N | | | | | | |
| Accident history signs (yellow backed with legend) | £500/sign | 1,000 | –30% | N | | | | | | |
| Chevrons (excluding lighting costs) | £300/sign | 600 | –70% | N | | | | | | |
| Vehicle-activated signs | £8000/sign | 16,000 | –25% | Y | 8,000 | –25% | –32 | | –1,407 | |
| Traffic signals | | 50,000 | –53% | N | | | | | | |
| Coloured road surfacing | £15/m² | 180 | –5% | N | | | | | | |
| Rumble strips | £5/lin. m or £25/strip | 250 | –35% | Y | 250 | –35% | –1 | 2 | | £250 |
| Anti-skid surfacing | £10/m² | 3,000 | –32% | N | | | | | | |
| Lighting (excl.elec supply) | £200/column | 10,000 | –31% | Y | 5,000 | –31% | –16 | | –709 | |
| Edge-lining (raised/plain) | £0.75/linear m | 300 | –30% | Y | 300 | –30% | –1 | 3 | | £300 |
| Reflectorised posts | £20/post | 600 | –30% | Y | 600 | –30% | –2 | | –88 | |
| Reflectorised studs | £6.50/stud | 390 | –5% | Y | 390 | –5% | –8 | | –343 | |
| Lane markings/hatching | £0.75/linear m | 450 | –10% | N | | | | | | |
| Overrun areas | £100/m² | 5,000 | –20% | Y | 5,000 | –20% | –25 | | –1,099 | |
| Cut back vegetation | £0.5/linear m | 100 | –5% | Y | 100 | –5% | –2 | | –88 | |
| Planting to stabilise slope | | 1,000 | –10% | N | | | | | | |
| Vehicle/debris nets | | 5,000 | –20% | N | | | | | | |
| | | | | | | | | | Total cost of selected measures | £15,550 |

| | |
|---|---|
| Estimated overall effectiveness for the combination of all selected measures | –98% |

# appendix 1: Working group members

**Working Group 1**

**Development of a protocol for apportioning responsibility and costs of improvements made at locations where roads meet, cross or run close to railways**

| | |
|---|---|
| CSS (formerly County Surveyors Society) | – David Lynn<br>Greg Perks |
| Department for Transport (DfT) | – Margaret Clare<br>Marilyn Waldron<br>Kirstin Green<br>Michael Pocock |
| Health and Safety Executive (HSE) | – Shila Patel<br>Dean Munson |
| Highways Agency (HA) | – Brian Barton<br>Victoria Hogg |
| London Technical Advisers Group (LoTAG) | – John Roberts |
| London Underground Limited (LUL) | – Mike Gellatley |
| Network Rail | – Kim Teager<br>Andrew Litherland |
| Office of the Rail Regulator (ORR) | – Jon Clyne |
| Railway Safety | – Bill Robinson |
| Welsh Assembly Government | – Ian Davies |

**Combined Working Groups 2 & 3**

**Development of tools and data for use at the local level to assess the risk of vehicles leaving the road and getting onto the railway**

**and**

**Development of good practice guidance on the available measures suited to different circumstances for the management of risk at specific sites**

| | |
|---|---|
| Association of London Government (ALG) | – Richard McFarlane |
| CSS | – Brian Poole<br>Robin Hodsdon |
| Department for Transport (DfT) | – Margaret Clare<br>Marilyn Waldron<br>Michael Pocock |
| Health and Safety Executive (HSE) | – Jeff Doolan |
| Highways Agency (HA) | – Brian Barton<br>Victoria Hogg |
| London Technical Advisors Group (LoTAG) | – Paul Redman |
| London Underground Limited (LUL) | – Jim Moriarty |
| Network Rail | – Brian Bell<br>Mike Rayner<br>Amar Rehal<br>Peter Stanton |
| Northern Ireland Roads Service | – Bob Cairns |
| Railway Safety | – Colin Dennis<br>Andrew Sharpe |
| Society of Chief Officers for Transportation in Scotland (SCOTS) | – Iain Mackinnon |
| Transport for London (TfL) | – Ken Duguid |
| Transport Research Laboratory (TRL) | – David Lynam |
| Welsh Assembly Government | – Ian Davies |

## Working Group 4

**Identification of the relevant information that it would be practicable and useful to collect about incidents where road vehicles get onto railway property**

| | |
|---|---|
| British Transport Police (BTP) | – Alan Clark |
| CSS | – Jon Shortland |
| Department for Transport (DfT) | – Margaret Clare<br>Marilyn Waldron<br>Jeremy Moore<br>Valerie Davies<br>Emma Snelling<br>Michael Pocock |
| Health and Safety Executive (HSE) | – Paul Wilkinson |
| Highways Agency (HA) | – John Smart |
| London Technical Advisors Group (LoTAG) | – Frank Paine |
| London Underground Limited (LUL) | – Jill Collis |
| Network Rail | – Mike Rayner |
| Railway Safety | – Jeff Brewer |

The following also attended Working Group Meetings on an ad hoc basis:

| | |
|---|---|
| Working Group 1: | Eric Burley, DfT |
| Combined Working Groups 2 & 3: | John Cope, Network Rail<br>Ian Medd, CSS<br>Jamie Stemp, LUL |
| Working Group 4: | Anil Bhagat, DfT<br>Steve Hudson, Railway Safety<br>Ian Sandle, HA |

# appendix 2: Contact points

**Highways Agency**
Victoria Hogg
020 7081 7533
Victoria.hogg@highways.gov.uk

**Local Authorities**
Robin Hodsdon
01604 236286
rhodsdon@northamptonshire.gov.uk

or

Ray Christian
Atkins Northamptonshire
01604 883400
ray.christian@atkinsglobal.com

**CSS Bridges**
Brian Poole
0191 3833427
brian.poole@durham.gov.uk

**Transport for London**
Ken Duguid
020 7654 3275
kenduguid@tfl.gov.uk

**Network Rail**
(Treatment)
Brian Bell
020 7557 8355
brian.bell@networkrail.co.uk

(Assessment/Ranking)
Amar Rehal
020 7557 8991
amarjit.a.rehal@networkrail.co.uk

or

Peter Stanton
020 7557 9534
peter.j.stanton@networkrail.co.uk

**London Underground Limited**
Malcolm Payne
020 7308 3102
malcolm.payne@thetube.com

**Railway Safety**
Colin Dennis
020 7904 7499
dennisc.railwaysafety@ems.rail.co.uk

**Wales**
Ian Davies
02920 826443
ip.davies@wales.gov.uk

**Scotland**
Iain Mackinnon
01738 476570
imackinnon@pkc.gov.uk

**Northern Ireland**
Robert Cairns
028 2566 2501
bob.cairns@drdni.gov.uk