Investigation into traffic delays at level crossings

E Delmonte and S Tong
Investigation into traffic delays at level crossings

by E Delmonte and S Tong (TRL)

Prepared for: Project Record: Client's Project Reference No. 4/016/015
Investigation Into Traffic Delays at Level Crossings

Client: Department for Transport, Traffic Management Division
Wayne Duerden

Copyright Transport Research Laboratory December 2008

This final report has been prepared for Department for Transport.
The views expressed are those of the author(s) and not necessarily those of Department for Transport.

<table>
<thead>
<tr>
<th>Name</th>
<th>Date Approved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Su Buttress</td>
<td>17/11/08</td>
</tr>
<tr>
<td>Janet Kennedy</td>
<td>13/11/08</td>
</tr>
</tbody>
</table>
When purchased in hard copy, this publication is printed on paper that is FSC (Forest Stewardship Council) registered and TCF (Totally Chlorine Free) registered.
Contents

Executive summary i
Abstract iv

1 Introduction 1
  1.1 Background 1
  1.2 Research objectives 1
  1.3 Structure of the report 2
  1.4 Research approach 2
    1.4.1 Literature review 2
    1.4.2 Stakeholder consultation 3

2 Level crossings in the UK 5
  2.1 Types of level crossings in the UK 5
    2.1.1 Active crossings 6
    2.1.2 Passive crossings 8
    2.1.3 Footpath or bridleway level crossings 8
  2.2 Safety 8

3 Definition and scale of delay 10
  3.1 Defining delay 10
  3.2 ‘Serious’ delay 10
  3.3 Consequences of delay 11
    3.3.1 Blocking back over a crossing 12
    3.3.2 Road user behaviour 12
    3.3.3 Vehicle emissions 13
    3.3.4 Public response 13
    3.3.5 Community severance and disruption 14
    3.3.6 Economic cost 15
  3.4 Scale and quantification of the traffic delay problem 15

4 Physical factors affecting traffic delays at level crossings 17
  4.1 Railway 17
    4.1.1 Diurnal distribution of trains 17
    4.1.2 Train speed 18
    4.1.3 Level crossing closure time 18
  4.2 Highway 19
    4.2.1 Diurnal distribution of road traffic 19
    4.2.2 Road speed limit 20
    4.2.3 Road design and level crossing location 20
    4.2.4 Roadworks 21
  4.3 Urban planning and development 21

5 Human factors affecting traffic delays 23
5.1 Driver perception and experience of delay 23
5.2 Driver perception and understanding of level crossing operation 24

6 Level crossing interventions which may also help reduce road traffic delay 25

6.1 Railway interventions 25
6.1.1 Constant warning time systems (train predictors) 25
6.1.2 Scheduling of trains 27
6.1.3 Obstacle detection 29

6.2 Highway interventions 30
6.2.1 Red light enforcement cameras 30
6.2.2 Vehicle Activated Signs 31
6.2.3 Lane separators 32
6.2.4 Improved road design and traffic management 33
6.2.5 Traffic management options for dealing with problems at level crossings. 34

6.3 Railway and highway interventions 35
6.3.1 Traffic signal pre-emption in the USA 35
6.3.2 'Hurry calls' in the UK 37
6.3.3 Level crossing closure 39
6.3.4 Level crossing upgrade 40
6.3.5 Improved road / rail authority interaction 41

7 Liaison between road and rail authorities 45

7.1 Road-rail partnership groups (RRPGs) 45
7.2 The AXIAT model 46
7.2.1 Background 46
7.2.2 Approach 47

7.3 The Swedish ‘OLA’ model 48
7.3.1 Background 48
7.3.2 Approach 48
7.3.3 Results 48

8 Case studies 51

8.1 Langley Green (site visit) 51
8.2 Tipton (site visit) 53
8.3 West Sussex 54
8.4 North Sheen 55
8.5 Tallington 56
8.6 Alameda Corridor East, California (Armistead and Ogden, 2003) 58

9 Summary and conclusions 59

10 Recommendations 61

Acknowledgements 62

References 62
List of Figures

Figure 1. Level crossing types and prevalence as at 31 December 2007, not including 2483 footpath/bridleway crossings (adapted from RSSB, 2007) .................................................. 5
Figure 2. Half-hourly distribution of trains to and from North Sheen station .................. 19
Figure 3. Traffic flow data at North Sheen (Manor Road) level crossing, Thursday 28th February 2008 .................................................................................................... 20
Figure 4. Plan view of road layout at a level crossing ..................................................... 33
Figure 5. The dynamic envelope .................................................................................. 36
Figure 6. Illustration of West Worthing level crossing ............................................... 38
Figure 7. Views of Langley Green level crossing ....................................................... 52
Figure 8a and 8b. Illustration of Tipton level crossing and surrounding area before and after construction of the relief road ................................................................. 53
Figure 9. Views of Tipton level crossing ..................................................................... 54
Figure 10. Tallington level crossing ........................................................................... 56
Executive summary

There are currently just under 7,000 level crossings on the national rail network in Great Britain, including around 2,500 footpath-only crossings with up to 2,000 additional level crossings on private railways. Traffic delays caused by those level crossings situated on public roads can be problematic, with congestion concerns being exacerbated by vehicle emissions, safety and economic costs. It is therefore important to investigate whether there are opportunities to optimise level crossing operation from both rail and highway perspectives.

This research study was commissioned by the Department for Transport (DfT) to investigate road traffic delays at level crossings, scope potential routes to reduce delays and propose key areas that would benefit from further research. A multi-method approach was used to investigate road traffic delays at level crossings. A literature review summarises key research relating to traffic management at level crossings, existing guidance on the implementation, design and operation of level crossings, and guidance issued to those responsible for level crossings. A consultation was carried out with 40 stakeholders from railway and highway authorities and other key organisations.

The research is likely to form an interim stage designed to provide an initial assessment of the current situation and to inform the debate about developing the future approach to level crossings.

The report considers various approaches to defining traffic delay, and the potential consequences of delay at level crossings from behavioural, environmental, community and road user perspectives. The highway, railway, planning and human factors which may affect traffic delay are described, as are a number of interventions which may mitigate traffic delays. Most interventions primarily aim to reduce the level of risk at level crossings, with reductions in delay being a potential subsidiary benefit.

The current situation regarding interaction between road and rail authorities is described, including an account of the AXIAT (Assessment of Level Crossing Investment Alternatives) model for evaluating level crossing alternatives, Road-Rail Partnership Groups between Network Rail and local authorities, and a Swedish model which encourages stakeholders to work together to solve problems at level crossings.

Finally, a number of case studies are presented, including accounts of two level crossings visited by TRL researchers. The case studies illustrate the extent of the traffic delay problem, and what can be done on a practical level to tackle it.

The report focuses on active level crossings (those which have a system to warn users of an approaching train, such as a physical barrier or visual/audible warning devices) because delays are expected to be greater at active crossings than at passive crossings, the majority of which are user-worked and located on private land. Particular attention was paid to manually controlled barrier (MCB) and automatic half barrier (AHB) crossing types (constituting 41% and 30% of active crossings respectively).

The principal findings from the literature review and consultation were:

- Manually controlled barrier crossings (with or without CCTV) appear to produce most traffic delays, mainly due to the fact that they require the barrier to be closed for some time before the arrival of the train, and they tend to be located where there is a higher level of road traffic.
- Various factors are used by stakeholders in the rail and road authorities to define serious traffic delay. These often relate to features of the traffic queue, but also include risky road user behaviour and public complaints.
- While various highway and railway interventions at or around level crossings may have a small effect on traffic delays, none have been designed with the primary aim of reducing delay.
The most effective means of reducing delay (and lowering risk) is to close the level crossing. However this has many attendant obstacles to implementation, not least of which is the financial aspect, and bridging/underpass is almost impossible at level crossings with dense housing in close proximity.

There is a desire for more frequent and improved interaction between road and rail authorities, and also for further inclusion of town planners.

Most of the measures described in this report mitigate delay to a small extent whilst giving a safety benefit, generally by reducing the prevalence of drivers violating AHB crossings. In order to substantially reduce the amount of delay at level crossings, it will be necessary to do one or more of the following:

1. Reduce the number of trains on lines with crossings
2. Reduce the time for which the barriers are down
3. Close the crossing
4. Reduce the amount of traffic using roads with crossings

Of these, the first is unrealistic. For the second, the use of obstacle detection in conjunction with Automatic Full Barriers might achieve a small improvement whilst not compromising safety.

The third option, closing a crossing, gives the optimum outcome in both safety and delay terms and therefore the recommendation is to develop a means of prioritising crossing closure which takes into account safety, delay and the feasibility of the closure.

The fourth option, reducing the amount of traffic using a crossing (or increasing traffic throughput) may involve upgrading and signing alternative routes and/or minor local improvements such as prohibiting parking on the approach to the crossing and banning right turns at minor junctions close to the crossing. Where there is a signal-controlled junction close to the crossing, it should be linked into the crossing control in order to minimise disruption. The potential for management of delay at a roundabout or mini-roundabout close to a level crossing is fairly low, but a consideration of how to manage queues should be undertaken on a site-specific basis.

It is worth pointing out that under some circumstances, there is little point in taking action; reducing delay at a level crossing where there is already serious congestion in the surrounding network may be a fruitless exercise.

All local highway authorities and their rail equivalents should be included in a Road Rail Partnership Group (RRPG) so that stakeholders can agree on the best means of handling level crossings on a local level. This will ensure that resolution of the balance of issues for each site location is enabled by the positive engagement of the local Road-Rail Partnership Groups supported by the AXIAT model once the latter can be rolled out to all authorities. Consultation should also include other relevant authorities including the County Surveyors’ Society (CSS) and the Local Government Association (LGA), for both highway and planning authorities as well as the rail organisations.

Currently there is no national funding for level crossing closure. Local highway authorities have difficulty funding level crossing closure as Local Transport Plans typically cover schemes up to about £0.5million. Level crossings account for less than 1% of road fatalities on average.

Further work is therefore recommended under the auspices of a joint road/rail group at national level, possibly the Road/Rail Interface Group led by Network Rail/RSSB with support from CSS and others so that all parties can contribute proactively to the development direction as follows:

- Development of a definition of “serious traffic delay” that takes into account impacts on the community
• Investigating the factors that affect level crossing closure and replacement in order to supplement the AXIAT model and demonstrate how a business case for closure might be made and the means by which closure might be funded on a national basis

• Investigating alternatives to upgrading protection at AHB crossings affected by blocking back
Abstract

This report presents the findings of a literature review and stakeholder consultation investigating traffic delays at level crossings in the UK. The research aimed to investigate road traffic delays at level crossings, scope potential routes to reduce delays and propose key areas that would benefit from further research. The report provides findings on the different types of level crossings in the UK and how their operation may be related to traffic delays (manually controlled barrier crossings are most prone to delay); how traffic delay is defined (many factors are used to define a serious delay); consequences of delay; and factors which may affect traffic delay and interventions which may help to mitigate traffic delays from the perspective of the railway and the highway, and how the two may combine to tackle the problem (no interventions were found which principally aimed to reduce delay, but some might mitigate traffic delay as a subsidiary effect). A number of case studies are also included. The principal findings were that there is a strong need for improved interaction between the road and rail authorities, and that while the most effective means of reducing traffic delay is to eliminate the level crossing, there is no clear funding mechanism to do this.
1 Introduction

1.1 Background

Systems of protection installed at public road level crossings in Great Britain are governed mainly by the Railway Clauses Consolidation Act of 1845, when railway safety was something of an unknown quantity. In order to ensure the safety of the public on the highways, Parliament imposed rigorous regulations on level crossing construction and operation. Such standards of level crossing protection would have caused little delay to road users in the mid-19th century since train and road traffic frequency was low, but even in 1957 it was acknowledged that the great increase in the number and speed of road vehicles had brought about a change in traffic conditions, resulting in delays to road users at level crossings (McMullen et al., 1957).

More than 50 years ago, it was reported that it was not unusual for a crossing to be closed for five minutes or more for a single train, or double if two trains passed a crossing with only a short interval between (McMullen et al., 1957). Although level crossing technology has advanced progressively over the years, level crossings may still be closed for a substantial period of time.

There are currently almost 7,000 level crossings on the national rail network in Great Britain (RSSB, 2006) with up to 2,000 additional level crossings on private railways. Traffic delays caused by those level crossings situated on public roads can be problematic, with congestion being exacerbated by concerns about vehicle emissions, safety and economic costs. It is therefore important to investigate whether there are opportunities to optimise level crossing operation from both rail and highway perspectives.

1.2 Research objectives

The research described in this report was commissioned by the Department for Transport (DfT) to investigate road traffic delays at level crossings, scope potential routes to reduce delays and propose key areas that would benefit from further research. The specific objectives of the project were to:

- Review current practice in the UK and relevant experience overseas including driver behaviour at road traffic signals brought into use only occasionally, the wider issue of peoples’ understanding and perceptions of level crossing operation and the fundamental operating procedures, including safety audits, and the interface with the railway system.
- Consider materials suitable for publication as guidance to road and rail authorities.
- Consult with relevant local highway and railway authorities to understand the issues at level crossings from different perspectives.
- In close working with the Rail Safety and Standards Board (RSSB) and the National Level Crossing Safety Group (which has now been replaced by the Road Rail Interface Safety Group), develop recommendations that address the objectives and concerns of the consulted local highway and railway authorities.
- Confirm, through discussions with relevant specialists and authorities, the feasibility of the recommendations.
- Disseminate and publicise the results of the project to relevant authorities.
1.3  Structure of the report

The remaining sections of the report are arranged as follows:

- Section 2 provides a description of the different types of level crossings currently in use in the UK, in addition to information on issues of safety and risk posed by level crossings.
- Section 3 considers how ‘delay’ may be defined and the potential consequences of traffic delay at level crossings.
- Section 4 outlines the various factors which affect traffic delay at level crossings, from the perspectives of the road, rail, and urban planning.
- Section 5 describes how human factors such as driver perception and experience of delays may affect traffic delay at level crossings.
- Section 6 suggests a number of level crossing interventions which may also help reduce traffic delay.
- Section 7 describes how road and rail authorities interact in the UK and also provides information on a Swedish model of interaction.
- Section 8 consists of six level crossing case studies which illustrate how traffic delays are (or are not) currently managed in the UK and USA.
- Sections 9 and 10 contain the summary, conclusions and recommendations.

1.4  Research approach

The approach used to investigate road traffic delays at level crossings included undertaking a literature review and a stakeholder consultation. The following subsections describe the research methods used for each activity.

1.4.1  Literature review

The literature review summarises key research relating to traffic management at level crossings, existing guidance on the implementation, design and operation of level crossings, and guidance issued to those responsible for level crossings.

In addition, current practice in the UK and relevant experience overseas was considered, including driver behaviour at signals brought into use only occasionally, the wider issue of peoples’ understanding and perception of level crossing operation and the fundamental operating procedures—including safety audits—and the interface with the railway system.

The literature review involved searches of the TRL knowledge base, ‘Google Scholar’ and relevant journals. Search terms included:

- Delay at level crossings
- Delay and level crossing type
- Congestion at level crossings
- Traffic at level crossings
- Vehicle demand at level crossings
- Driver behaviour at level crossings
- Motorist behaviour at level crossings
- Traffic management and level crossings
- Delay management and level crossings
• Blocking back at level crossings
• Guidance on level crossings
• Waiting time at level crossings
• Crossing behaviour at level crossings
• Design of level crossings
• Operation of level crossings
• Choice of level crossing type

For all search terms, ‘level crossings’ was also replaced with the American term for a level crossing, ‘highway-railroad grade crossing’.

The literature tended to be safety-oriented; very little was found relating directly to road traffic delays at level crossings. However, these factors are not necessarily independent of traffic delays (for example, crossing violations can be triggered when drivers are frustrated by delays). Therefore information from safety-oriented literature has been included in the present review where there is a possible direct association with road traffic delays.

1.4.2  Stakeholder consultation

A consultation was carried out with stakeholders from both railway and highway authorities and other key organisations. The objectives of the consultation were to establish the criteria that determine:

• Which type of crossing is installed on a particular road and why.
• The recommended and regulated operating procedures for different crossing types and how they may vary with vehicular demand.
• Which crossings have serious road traffic delays and what the contributory factors are (with specific examples).
• The operational circumstances that may contribute to traffic delay at level crossings.
• To what extent road and rail authorities interact regarding level crossings.
• If and how delays are managed or resolved.

Appropriate organisations from the railway and highway sectors were initially contacted via email with information about the research. A small number of stakeholders provided a sufficiently detailed response by email and no further contact was made. For all other stakeholders, telephone interviews were arranged. The telephone interviews typically lasted for between 30 and 60 minutes, and were digitally recorded with the permission of the respondent. A topic guide was used to structure the interviews (Appendix A).

Overall, 57 stakeholders were contacted and 40 provided a response, representing 22 different organisations. A total of 30 telephone interviews were conducted with the remaining 10 responses provided by email. Of the 40 respondents, 24 represented the rail authorities, 11 represented road authorities (principally county or borough councils), and five were other stakeholders. All recordings from the telephone interviews were transcribed. Two researchers coded the transcripts using an open coding approach (Strauss & Corbin, 1990) to generate descriptive categories, themes and sub-themes. The researchers compared and discussed the themes to ensure consistency of approach. This content analysis continued until no new categories, themes or sub-themes were found. Content analysis was assisted by using the XSight\(^1\) qualitative research program.

\(^{1}\) XSight is a computer software program to facilitate qualitative research methods. It was used to collate the interview data and identify emerging themes.
Throughout the report, quotes in italics are taken from the consultation, whereas all other quotes are from the literature.
2  Level crossings in the UK

2.1 Types of level crossings in the UK

Network Rail currently operates just under 7,000 level crossings on the mainline UK rail network, the majority of which (over 60%) allow both road vehicles and pedestrians to cross the railway; the remainder are for pedestrian use only (RSSB, 2004). In addition there are around 2,000 level crossings located on heritage railways, metro systems and industrial railways (Office of Rail Regulation, 2008). See Figure 1 for a diagrammatic representation of the types of level crossings operated by Network Rail on the UK mainline network, and their prevalence (excluding bridleways and footpaths). Railway safety principles and guidance stipulates that in all cases, “the choice of level crossings should avoid causing unnecessary delay to road users” (ORR, 2005).

![Figure 1. Level crossing types and prevalence as at 31 December 2007, not including 2483 footpath/bridleway crossings (adapted from RSSB, 2007)]
2.1.1 **Active crossings**

‘Active’ level crossings are those with a system to warn road users of an approaching train and are protected by a physical barrier or visual or audible warning devices. Just over one third of the UK’s road vehicle level crossings are classed as active, and they may be automatically or manually operated (ORR, 2005). Automatically operated crossings may be protected by half barriers (which block traffic in the direction of travel only and allow traffic already on the crossing to exit freely), or may be open and protected by audible and visual warnings only. For manually operated crossings, the crossing closure is initiated manually when the person responsible for operating the crossing detects an approaching train.

2.1.1.1 **Automatic half barrier (AHB) crossings**

Automatic half barrier (AHB) crossings have the shortest barrier closure time since they are not “interlocked” with the signalling and are entirely automatic. AHB crossings are closed for a minimum of 27 seconds before the train arrives but the train should pass as soon after this as possible, thus minimising the delay to road traffic. The average closure time of AHB crossings is 35 seconds (Heavisides, Barker and Woods, 2006). As shown in Figure 1, approximately one third of all active level crossings in the UK are AHB crossings. A small proportion are monitored locally by the train driver, where the railway line has a low train speed such that the train driver can stop the train if required (Woods, 2007).

The ORR’s guidance on level crossings (2005) stipulates that there is no particular limit to the amount of road traffic on the road intersecting an AHB crossing, but the road layout and traffic conditions should be such that vehicles are not likely to become grounded or block back, obstructing the railway. AHB crossings may only be situated on crossings with no more than two running lines, and with a maximum line speed of 160km/h.

The fact that AHBs are protected by barriers on the approaching carriageways leaves them open to the risk of road users choosing to drive around the barriers. “Zigzagging around the half barriers at AHB level crossings is a particularly dangerous but common occurrence” (RSSB, 2005c) and one which results in AHBs being perceived as:

“essentially a compromise between safety and road congestion. They have a shorter closure time (because they’re not “interlocked” with rail signals) so traffic flow is much smoother, but they don’t provide the absolute protection provided by a manned gate, manned barrier or CCTV crossing.” (Rail)

In recognition of the positive relationship between the length of delay and the occurrence of crossing violations (see section 5), UK rail authorities have historically taken measures to reduce the propensity for road users to violate at AHB crossings by reducing the strike-in time². AHBs in the UK originally used a minimum 24 seconds strike-in time but this was extended to 37 seconds following the Hixon accident in 1968. The Townsend-Rose report stated that 37 seconds was a longer period than that used in most other countries and recommended a reduction to 27 seconds. The 1981 HMRI requirements then reduced the minimum warning time to 27 seconds. However, this was generally only implemented for existing crossings when it was necessary to carry out significant work.

---

² The strike-in time is the length of time between a train activating a ‘treadle’ on the approach to a level crossing and the train arriving at the level crossing. The treadle starts the crossing closure (either automatically for an automatic crossing, or via a signaller for a manual crossing). The time is usually calculated using the maximum permitted rail speed for the location.
2.1.1.2 **Manned gates (MG) and manually controlled barriers (MCB)**

Manned gates and manually controlled barrier crossings have railway signals that are “interlocked” with the barriers so that it is not possible to clear the signals unless the road is fully closed by the barriers, nor is it possible to open the road unless the signals are red. This system makes them safer than automatic barriers but they usually have a much longer closure time because a longer approach time is allowed in case the train is required to stop.

Manned gated (MG) crossings are protected by a gate which is operated physically by a controller or crossing keeper. Since closure time can be lengthy, MG crossings are not suitable for busy roads (Woods, 2007) and do not therefore delay many vehicles.

Manually controlled barriers (MCB) are protected by a full width, powered lifting barrier, and are operated by a member of the railway staff at the crossing (usually a signaller, but also crossing keepers or train crew). Such crossings are typically operated in combination with visual and audible warning devices. Closed-circuit television (CCTV) is used to assist in the monitoring and operation of around 40% of manually operated crossings (Office of Rail Regulation (ORR), 2005). MCB CCTV crossings are controlled remotely from a signal box or signal centre, where the signalman activates the warning devices when a train is approaching, and uses CCTV to monitor the traffic situation at the level crossing, lowering the barriers when it is safe to do so. The train is given a clear signal once all barriers are down. The barriers can either rise automatically once the train has passed (Woods, 2007) or in some cases they are operated manually—the operator can then choose to leave the barriers down if another train is approaching.

MCBs are seen as a safer option than AHBs since the manually controlled full barrier system offers greater protection to the railway and greatly reduces the risk of a road vehicle being struck by a train on the crossing. The ORR deems them “generally suitable for any situation” (ORR, 2005). The level of protection offered by MCB crossings makes them most suitable for roads with a high traffic volume and for railways with more than two operating lines or fast line speeds (160–200km/h). However, stakeholders commented that, "the manually controlled barriers are the worst for causing delays (rail)." This was "purely because of the time that's required to...check it [the crossing] is clear, and be able to close the crossing if necessary (rail)."

Unlike AHB crossings, there is no standard barrier down time for MCB crossings since several variables may influence the train’s arrival time. The average crossing closure time for an MCB CCTV crossing is 227 seconds (Arthur D. Little, 2003, as cited in RSSB, 2006b).

It should be recognised that in some situations the closure time may be substantially longer or shorter. For example, the length of time between amber light first showing and the train arriving at the crossing may depend on factors such as:

- speed of the train
- type of train (passenger or freight, the latter being slower)
- signal spacing
- distance from signals to level crossing
- signaller’s experience

On busy roads (especially where vehicles blocking back over the railway line is an issue; see section 3.3.1), it may be necessary for barriers to be down for a longer period of time to ensure that the crossing is clear of traffic before the train arrives:

“If traffic delays at level crossings cause blocking back or it is difficult to close barriers on time due to traffic at the crossing, manually operated barriers may be closed earlier than need be to ensure smooth operation of trains. This can typically add 30 seconds to any delays at such crossings” (Rail)
The sequence to open the crossing once the train has passed is either automatic, or initiated manually by the signaller. As suggested above, if the crossing is on a busy road, the signaller may choose to keep the crossing closed even if the next train has not passed the strike-in point in order to avoid problems with road users queuing over the barriers and creating a delay or safety hazard (RSSB, 2006b).

### 2.1.1.3 Automatic open crossings

Automatic open crossings can be monitored locally (AOCL) or remotely (AOCR) and have no physical protection; road users are warned of a train’s presence by traffic light signals and an audible alarm, which are initiated automatically by the train’s approach. The majority of automatic open crossings are AOCL, and are monitored by the train driver. The maximum permitted crossing speed at each AOCL is determined by two factors—the distance at which an approaching train would have a clear view of the crossing and the traffic moment\(^3\) at the crossing (ORR, 2005). Since most are located on quiet roads, automatic open crossings should not delay many vehicles.

### 2.1.2 Passive crossings

Almost two thirds of all level crossings are “passive” in that they do not have a system to warn users of an approaching train (these are mainly on privately-owned land). There are two types of passive crossings: open and user-worked (with or without a telephone). Open level crossings are protected only by signs, but there is a requirement for trains to travel at 16km/h or to stop before proceeding across the crossing (ORR, 2005). User-worked level crossings are generally located on private roads, and require the crossing user to operate them by opening and closing gates manually.

Total delay is expected to be greater at active crossings than at passive crossings since the majority of passive crossings are user-worked and located on private land where low traffic flows are the norm. This review therefore concentrated solely on active level crossings, particularly AHB and MCB crossings.

### 2.1.3 Footpath or bridleway level crossings

There are almost 2,500 footpath or bridleway level crossings. There is a requirement for a minimum “sighting time”\(^4\) for the user or a whistle board for the train driver to warn the user of the presence of a train (ORR, 2005).

### 2.2 Safety

There are an estimated 680 million vehicle traverses, 66 million pedestrian traverses and 109 million train traverses at level crossings annually (RSSB, 2005). Between 2003 and 2007 and excluding suicides, an average of 12 people were killed on UK level crossings each year (RSSB, 2007). From 2001–2005 there were 89 collisions between road vehicles and trains, resulting in ten derailments (RSSB, 2006). The risk of a fatality on a level crossing is far greater to members of the public than to rail passengers or rail workers: excluding trespass and suicide, 72% of public fatalities on the railway occur on a level crossing, compared to 4% of passenger and 2% of workforce fatalities (RSSB, 2007c). Some 70% of the fatal or serious injuries arise from pedestrians traversing the crossing when it is not safe to do so (RSSB, 2007c).

---

\(^3\) “Traffic moment” is the number of road vehicles using the crossing multiplied by the number of trains passing in a given time period. A high traffic moment at an AOCL may require a lower rail speed at the crossing.

\(^4\) “Sighting time” is the time taken to travel the distance measured along the railway from a decision point to the point at which an approaching train becomes visible.
In 2005, 3,201 fatalities occurred on Britain’s roads (DfT, 2005), compared to 33 fatalities in railway incidents, excluding trespassers and suicides (ORR, 2005b). Of these, four fatalities to road vehicle drivers occurred at level crossings, as well as nine pedestrian fatalities (ORR, 2005b). The number of road deaths is approximately one hundred times greater than the number of railway fatalities.

Train collisions with road vehicles and pedestrians remain the largest source of risk at level crossings, and represent 6% of the total railway risk (RSSB, 2006). Collisions between trains and vehicles are principally caused by violations of road traffic controls or signs, misunderstanding of controls or signs, complacency, and underestimation of risk (NLCSG, 2006). The expected frequency of a train colliding with a road vehicle is higher for AHB crossings than for manual gate or barrier crossings (expected frequency per year of 1.00 and 0.29 respectively) (RSSB, 2005). Although automatic open crossings, locally monitored (AOCLs) account for only 2% of all level crossings in the UK, they pose the highest risk to road users since there is no physical barrier between the road and the railway. In addition these crossings tend to be on lines that are less frequently used by trains, potentially encouraging complacency among road users who know the crossing well.

Of the two most prevalent crossing types (AHB and MCB), AHB crossings generate the greater risk and, as described in section 2.1.1, are generally associated with the least delay:

“The safety record of them [AHB and MCB crossings] is different because people take risks more, if they know they’re going to be stuck there for ten minutes they’re more inclined to run the lights [at MCB crossings] and sometimes zigzag at AHBs.” (Rail)

“If we modernised a gated crossing and made it into an AHB level crossing, our risk score for that crossing would significantly worsen because you can’t zigzag round [manual] gates…a staffed level crossing is bound to be ‘safer’ than an automatic level crossing.” (Rail)

Risk at level crossings has, for the past decade, been assessed using the ‘Level Crossing Risk Model’ (the ‘Automatic Level Crossing Risk Model’ – ALCRM - was developed first, followed by the ‘All Level Crossing Risk Model’ in 2005). The ALCRM involves a database of level crossing information and analysis of incident data at various types of level crossing. In 2005, the data was used to create a software model which is now used by Network Rail as an important decision-making tool. It allows full comparison of risk at the various types of level crossing and predicts greatest risk at crossings with busy traffic flows (RSSB, 2007c). The risk models enable a focus on level crossings which have a disproportionate share of the overall risk, and thus allow optimised targeting of expenditure, leading to a reduction in risk at level crossings (RSSB, 2007c).

Current actions to reduce risk at level crossings include a media campaign to highlight the consequences of misusing level crossings, research projects to improve user behaviour and crossing design, upgrading and replacing crossings, and improving train driver competence (RSSB, 2007d).
3 Definition and scale of delay

3.1 Defining delay

Delay may be defined in different ways, depending on the circumstances being considered (e.g. signal controlled junction, roundabout) and there are at least two types of delay (queuing and geometric). However, for the purposes of this research, a definition given by Webster and Cobbe (1966) is appropriate: “the average delay per vehicle on an approach to an intersection is the difference between the average journey time through the level crossing and the time it would take for a vehicle which is not stopped or slowed down by the signals and closure”. Using this definition, total delay is the average delay per vehicle, multiplied by the total traffic flow.

Various simple models of vehicle delay at level crossings have been developed based on the level crossing blockage time and the vehicle arrival rate and departure rates (Ogden, 2003 and Ryan, 1990).

There may be compounding issues to consider, especially when the crossing is heavily used and near to other road junctions. For example, if traffic regularly queues beyond a level crossing, vehicles may take more time to negotiate the crossing if they need to avoid blocking the railway line. This geometric delay may have an impact on any measured delay at the crossing itself, but may have little impact on overall delay in the network since drivers would be queuing anyway, even in the absence of the crossing.

The circumstances associated with traffic delay at level crossings are summarised effectively in a UN report (2000, p.109):

“If barriers remain closed for excessive periods on crossings carrying a high volume of road and rail traffic, the build-up of road traffic will exceed the capacity of the crossing to safely discharge this build-up before the next train arrival at the crossing. Road traffic build-up in this situation obeys the rules of queuing theory: the longer the barrier closure, the greater the build-up and the slower the passage of motor vehicles over the crossing once the barriers have been raised”

3.2 ‘Serious’ delay

Since level crossing closure almost always delays road traffic, it is important to consider what constitutes ‘serious’ delay. From an individual perspective, it is likely to be anything perceived as being “out of the ordinary”, for example a longer than normal barrier closure, such as a second train arriving before the barrier has been raised after the first, or the queue failing to clear before the next train arrives, or regular waits of longer than 2 or 3 minutes. However, if only a few drivers are delayed, the total delay will still be low.

From the point of view of the local highway authority, ‘serious’ delay occurs when queues do not clear before the next train arrives and/or they start to affect nearby junctions. Responses from the consultation included:

- Receiving complaints from members of the public or local councils.
- Queue distance or time, including the existence of uncleared queues between crossing operations or the creation of queues that exceed the storage capacity of the approach road. Some subjective examples were provided by stakeholders for total delay:

  “The length of time waiting at the crossing and the number of vehicles waiting are used to define ‘serious’ delay.” (Road)

  “Queues that go back for quarter of a mile or cause delays of 10-15 minutes.” (Road)
“Could say that a queue that doesn’t clear by the time the barrier comes down again is a serious delay...could also define it in terms of queue length or time. It’s hard to say” (Road)

and for individual delay:

"From a road user perspective, serious delay is when you are stuck for more than five minutes or that you know that when it next opens you won’t clear the crossing before it closes again.” (Rail)

"It’s a personal thing I guess...if I was sat at a level crossing for more than three minutes without a train coming I would think that would be unreasonable.” (Rail)

- Road user behaviour (e.g. red-light running, zigzagging at half barriers, rat-running to avoid a crossing).

  "Any delay which could cause a reasonable person to consider violating that level crossing is serious” (Rail)

- Level crossing closure time, in terms of average duration, maximum duration and, perhaps most crucially, elapsed closure duration (e.g. the cumulative time that a crossing remains closed in an hour of operation).

- Level crossing closure frequency.

- Blocking back (see section 3.3.1), defined as:

  "when congestion builds up across the track and does not clear when the crossing next opens, and prevents the crossing from being closed again.” (Rail)

- Traffic queues that block the flow of vehicles across other road junctions on the approach to the level crossing.

- Traffic delays that are out of context with delays experienced at other traffic signals in the immediate vicinity (in recognition of the fact that a level crossing in a particularly busy urban area may not present an extraordinary level of delay when compared with other signalised junctions in that area). It may be the case that a level crossing is simply redistributing existing congestion in a town.

- Interruption of rail operation:

  "From a railway perspective, delays are only serious when they affect the operation of the railway.” (Rail)

Therefore various factors can be used to determine whether a delay is perceived as ‘serious’, but "it’s not something that we have a formal way of assessing.” Generally, serious delays occur where busy roads meet busy railway lines (i.e. high traffic moment), and queues have difficulty clearing between barrier closures. One highway authority summarised the emergence of delay:

"Where we have major delays, they’re heavily used rail links with heavily trafficked roads meeting them. Where we have the same heavily trafficked rail links crossing minor roads you don’t have much of a problem. In a similar way where you have lightly trafficked rail links on major roads, you don’t get quite the same issues. It tends to be where the two come together.” (Road)

### 3.3 Consequences of delay

Aside from the obvious consequence of increased journey times for road users, traffic delays at level crossings can have other ramifications. For example blocking back over a level crossing is a consequence of delay elsewhere in the network, but also acts to exacerbate the situation (by increasing barrier down time at MCB crossings or prompting
the upgrade of AHB crossings to MCBs—with a corresponding increase in the closure duration). Below are some consequences identified during the stakeholder consultation.

### 3.3.1 Blocking back over a crossing

Blocking back at level crossings is “the formation of a stationary or slow-moving queue of road traffic over a level crossing, due to road traffic conditions, causing obstruction to the railway line” (RSSB, 2004b). This is a significant safety risk at automatic half barrier and automatic open crossings, since there is no monitoring of traffic. For this reason it is stipulated in the ORR’s Railway Safety Principles and Guidance (2005) that at these crossing types, “the road layout, profile and traffic conditions should be such that road vehicles are not likely to ground or regularly to block back obstructing the railway”. At full barrier crossings, blocking back is an inconvenience to the railway but is not safety critical, as the crossings are monitored.

Blocking back at level crossings can be both a product of traffic delays and a contributory factor. If long traffic queues are held behind the barriers before they are opened, there is a greater risk that when the crossing closes again the queues will be uncleared and there may be vehicles still on the crossing. Drivers may be more willing to violate the crossing under such circumstances because the length of the queue will mean that their waiting time has been substantially longer than the actual crossing closure time. Long queues—particularly each side of a crossing—can also increase the risk of blocking back if vehicles leaving the crossing need to turn right across the opposing path of traffic that has just been released over the crossing. Such circumstances can slow the traffic flow over the crossing when it is open and create gridlock situations that can be difficult to clear when the crossing is next closed.

From a rail perspective, blocking back is a safety hazard of sufficient severity to prompt action. If it occurs with any measure of regularity, the rail authorities swiftly act to increase the level of protection at the crossing. In the case of an AHB crossing, that almost inevitably means upgrading the crossing to a full barrier MCB or MCB CCTV crossing. Within the All Level Crossings Risk Model (section 2.2) that is used to guide such decisions, blocking back was described as a ‘switch’ that, once activated, prompts an immediate response:

> “Blocking back is recognised in the risk model as being a key, problem area...if the traffic delay gets to a certain point that blocking back becomes a problem, it can then have a knock on effect on delay because you would perhaps switch [the crossing type] to a full barrier.” (Rail)

In the transition from an AHB to MCB (CCTV) crossing, the crossing closure time increases immediately and substantially (typically by a factor of four) and road traffic is presented with longer delays as a consequence. Furthermore, if blocking back continues to be a concern at a manually operated full barrier crossing, one railway stakeholder explained that:

> “Manually operated barriers may be closed earlier...to ensure smooth operation of trains. This can typically add 30 seconds to any delays at such crossings.” (Rail)

Blocking back can also occur at road junctions. Traffic queuing from a level crossing may block a junction in the vicinity of the crossing. This in turn can result in risky driver behaviour (see section 3.3.2) and, as described above, can further restrict the flow of traffic through a level crossing as drivers find that the routes they need to take are blocked by queuing traffic.

### 3.3.2 Road user behaviour

Traffic delays at level crossings can result in risky road user behaviours such as red-light running, yellow box violations, driving on the footway or on the wrong side of the road,
and zigzagging round the barriers at AHB crossings. Both road and rail authorities offered a number of observations of unsafe road user behaviour that appeared to be related to traffic delay:

"People get so frustrated at the waiting time that they try to beat the barriers or lights...creating abuse." (Rail)

"You get scenarios where people are weaving in and out...vehicles mounting footpaths to get past those that are queuing." (Road)

"There are one or two side road junctions next to some of the level crossings, so you do get vehicles coming up on the other side of the road to overtake the queue to turn into a side road." (Road)

"CCTV has shown how some drivers will arrive at a closed AHB and immediately zigzag through the barriers whilst others will perhaps wait for 20s before deciding to jump the barrier." (Other)

In certain cases it has been reported that traffic delays have resulted in aggression towards railway staff:

"There's a cost to our staff...when they're actually located at the crossing...people just get angry about it and in some cases certain members of society will actually use violence to make themselves feel better or vent their anger." (Rail)

If a solution to traffic delays can be found at certain crossings then the avoidance of antisocial and unsafe road user behaviour can provide yet further justification for action, even if this is rewarding the aggressive behaviour.

### 3.3.3 Vehicle emissions

The congestion created at some level crossings is expected to increase emissions from road vehicles. Traffic flow levels are closely correlated with emission volumes, with over-saturation at critical junctions increasing pollution levels by up to 40% (Bell and Lear, 1989). None of the stakeholders that were consulted had been able to quantify the reduction in air quality or the increase in emissions that might result from traffic queues at level crossings. However, it was clearly a factor that some local highway authorities were keen to address:

"We have issues with drivers just sitting there with their engines on not moving for five minutes. It’s just pumping the CO2 out. We have put ‘switch off your engines’ signs at all of the level crossings in the borough, but those are not really adhered to.” (Road)

"Cars sitting there lead to pollution” (Road)

Given the current climate of environmental awareness, it is possible that the volume of vehicle emissions created by traffic delays at certain level crossings may become a further factor in defining both the severity of delay and the quantifiable economic cost. If emissions become a recognised cost of traffic delays at level crossings, their costs could be offset against the cost of any potential solutions to the problem as a further route to justifying action.

### 3.3.4 Public response

The public may respond to severe delays at level crossings by complaining to relevant authorities or forming action groups of their own to advocate crossing closure (or other outcomes).

"Most of the complaints are from drivers who have had to wait. Most of the letters blame the railway, even though it’s a road rail problem” (Rail)
The formation of action groups may be a good indicator of a particularly bad traffic situation—for example, a level crossing in Tallington, Lincolnshire was reported to be the focus of two action groups, such was the level of public frustration. Action groups can help to place the issue of traffic delays at level crossings “high on the public agenda” which may encourage road and rail authorities to seek solutions. What is clear from these lobby groups is the strength of feeling within a community about how disruptive traffic delays at level crossings are perceived to be.

3.3.5 Community severance and disruption

The divisive effect of a level crossing that is markedly affected by traffic delays was described by some stakeholders as a source of community severance. Community severance occurs when transport schemes have detrimental social impacts on communities that may manifest through physical, social or psychological barriers (James, Millington and Tomlinson, 2005). There are various definitions of community severance, but perhaps the most relevant in the context of traffic delay at level crossings is that the effects on the community range from “small increases in journey lengths or times through to the situation where journeys are no longer made” (Chinn and Davies, 1995). A further effect of community severance may be that “alternative facilities are visited because of the additional inconvenience, delay or danger caused by the barrier or because the barrier is perceived to be impassable” (Chinn and Davies, 1995). Serious delays at level crossings can clearly raise their status as a source of severance in a community.

Community severance has been deemed more likely where there are manually controlled barrier crossings:

“If you had to convert an automatic half barrier to CCTV with full barrier you suddenly take the closure time from 30 seconds to over two minutes. Soon after you do that, that’s when you tend to get complaints from villagers saying it’s cutting our village in half.” (Rail)

Stakeholders were aware of the economic and social costs to a community and summarised several instances where traffic delays at level crossings had affected nearby residents and businesses:

“Once you get so much queuing, it can lead to community severance and can lead to certain parts of the town perhaps not being patronised as much.” (Rail)

“I have seen some evidence at one [level crossing] where houses that are the ‘wrong side’ of the crossing (i.e. residents have to cross the railway to gain access) are several thousand pounds cheaper than equivalent houses on the ‘right’ side of the crossing.” (Rail)

“There are businesses that would say their trade is affected by the adverse traffic conditions around level crossings.” (Rail)

“Delays have caused the closure of many shops and businesses in [one location] as passing trade is completely eliminated and even specific visits need careful planning.” (Road)

“A major issue is severance, particularly as Network Rail took down half the footbridge to relocate their signal box [and have not reinstated it for several years].” (Road)

In addition, delays at level crossings in urban areas may disrupt the reliability of other transport modes within a community, particularly bus services. If public transport is not able to offer a reliable service it may become unpopular. In turn, this may pose problems for local transport plans which often include targets such as to “increase use of buses and community transport” (West Sussex Local Transport Plan, 2007)
3.3.6 Economic cost

The precise economic cost of traffic delay at level crossings is not known. However:

“if these delays could be kept to a minimum...it is likely that significant economic benefits in the form of travel time-savings would accrue to road users” (UN, 2000).

The UN report (2000) proposed that the economic cost of delay to road users at level crossings could be calculated in terms of the time per year spent waiting for the passage of trains. The formula to measure time lost (in person-hours) would require the number of barrier closures, the average duration of each barrier closure, and the average number of persons waiting at a level crossing during each barrier closure. The Gross Domestic Product per capita could then be used to estimate the cost of the delay to the economy.

3.4 Scale and quantification of the traffic delay problem

To the best of the authors’ knowledge, there is no objective data regarding the scale of the problem of traffic delays at level crossings in the UK. Estimates by interviewees from the rail industry varied, with some stakeholders being of the opinion that the traffic delay problem was not particularly serious. Overall, rail stakeholders suggested that some 3–10% of the 1600 public road level crossings had particular problems with traffic delays.

However other stakeholders differed, believing traffic delays to be a more severe problem.

“In the South East, probably about fifty percent of full barrier crossings are a cause of delay and annoyance to road users.” (Rail) [As an indication, there are around 200 full barrier crossings in Anglia, Kent, Sussex, Wessex and the Thames Valley (RSSB, 2008, personal communication)].

“I have 55 CCTV (full barrier) crossings and would say that approx 75–80% of them would have traffic delays, with about 10–20% of those being significant.” (Road)

“I would estimate that about ten of our 32 manually controlled barrier/CCTV crossings have a traffic congestion issue” [West Country]. (Rail)

“It’s fair to say all of the CCTV crossings on the Sussex Route are a problem.” (Rail)

A common theme emerging from the consultation was that the problem of traffic delay is very site-specific.

“It really depends on where you are. Crossings vary from West London crossings where any delay is a disaster [5 on a scale of 1-5, where ‘1’ indicates delays are not a problem at all and ‘5’ indicates that they are a serious problem] and then right down to near Exeter where some CCTV crossings never have queues.” (Rail)

“There are certain parts of the country that suffer more than others just through the lay of the land.” (Rail)

“Locally, you can’t put a number on how many crossings have serious delays, as the seriousness is on a graduated scale.” (Road)

Another common observation was that road traffic delay is primarily a highway problem; as long as trains are running smoothly (i.e. there is no blocking back over crossings) traffic delay does not directly affect the railway.

“From the railway’s point of view it isn’t actually a problem and the problem that exists for motorists does differ from site to site.” (Rail)
“Rating the problem depends on your perspective. A railway operator might say it’s no problem at all. Road users may say it’s an issue, for example if they live near lots of CCTV crossings on a busy line.” (Rail)

“As far as we are concerned, if there are traffic flow issues at level crossings, then we don’t necessarily see it as a railway problem, we see it more as a highway problem.” (Rail)

Nevertheless, rail authorities were neither ignorant of the problems created by traffic delays at level crossings nor insensitive to the call for solutions. In fact, several railway stakeholders were quick to point out how railway funding for projects that may have reduced traffic delay was disproportionately high when compared with the contribution made by highway authorities.

The scale of traffic delay was, according to the consensus view, very site-specific, with some level crossings suffering severe delays while the majority experienced no marked traffic flow problems. However, at those crossings where delay is perceived to be ‘serious’, the situation can cost the economy, communities, businesses and individuals a substantial amount. To understand how delays may be tackled, it is first necessary to understand the factors that affect them.
4  Physical factors affecting traffic delays at level crossings

As discussed in section 3, traffic delay at level crossings can be a substantial problem in the UK, particularly in urban areas with the barriers closed for long periods. Ryan (1990) described the following as the principal parameters affecting delays at level crossings:

- Train length: A longer train will lead to a longer delay, all other factors being equal.
- Diurnal distribution of trains: Trains are more frequent at certain times of the day, leading to longer and/or more frequent closures, in turn leading to longer traffic delays.
- Diurnal distribution of road traffic: Traffic flow is heavier at certain times of the day, leading to longer queues for a given closure time, in turn increasing delays.
- Train speed: A slower train will lead to a longer delay, all other factors being equal.
- Level crossing blockage time: This is the length of time that the crossing is closed for a train. A longer blockage time will lead to a longer delay, all other factors being equal.
- Road speed limit: Assuming that traffic will travel at the speed limit unless forced to slow down or stop by a queue caused by a train, a higher speed limit will lead to a longer delay, all other factors being equal.
- Directional split of road traffic: Volume of traffic in one direction is often heavier than in the other direction, and this needs to be taken into consideration when discussing traffic flow at a particular level crossing. Tidality may also be a factor.

These are physical factors which influence traffic delays. Some are discussed in further detail below, along with other contributory factors. Human factors and traffic delay are discussed in section 5.

4.1  Railway

4.1.1  Diurnal distribution of trains

Trains are more frequent at certain times of day, with very few running during the night. See Figure 2 for a diagrammatic representation of train distribution at North Sheen station (Richmond, London) between 6:15 and 19:45. Traffic queues at level crossings will be longer on occasions when two or more trains arrive at a crossing in close temporal proximity and the barrier is not raised between the two (ORR, 2005) although overall delay may be reduced. These occasions are most likely to occur during peak times for trains and traffic, which is when the consequences to road traffic in terms of both safety and delay will be greatest.

"The frequency of train service means that they can sometimes be closed for several trains at once. Two trains are common and three to four trains are not uncommon." (Rail)

"The issue really comes when there’s more than one train. There are some sections of the network where the timetabling of the trains means the crossing will be shut for 45 minutes in the hour, and obviously if there’s no traffic you’re probably going to get through alright fairly quickly, but if there’s a lot of traffic you might see several cycles [of the level crossing] before you get through." (Rail)
In addition, "the train flow has grown, particularly in peak hours" since many level crossings were established. The feasibility of reducing delay by rescheduling of trains is discussed in section 5.

### 4.1.2 Train speed

The maximum speed at which trains may travel over a level crossing depends on the type of crossing; the speed of trains should not exceed 200km/h over manually controlled barrier crossings (monitored locally or by CCTV), 160km/h over automatic half barrier crossings, 90km/h over automatic open crossings, and 16km/h over passive open crossings (RSSB, 2004; ORR, 2005).

> "If a train goes significantly slower than the line speed, then it’s possible that there could be an excessive delay between the crossing activating and the actual train arriving at the level crossing" (Rail)

Not surprisingly, it has been shown that average vehicle delays are lower when train speeds are higher (Tydlacka, 2004). However, Tsai (1998) showed that changing the line speed has only a minor effect on delay to road users.

### 4.1.3 Level crossing closure time

At wig wag lights (identified by the single amber and two flashing red lights) at level crossings in the UK, it is specified that the amber light should show for approximately three seconds before the red lights show. Four to six seconds later the barriers should start to descend, taking six to ten seconds to reach their lowered position, and once the train has cleared the crossing, barriers should take a further four to ten seconds to reach the raised position (ORR, 2005).

At automatic half barrier crossings and automatic open crossings, trains should not arrive at the crossing earlier than 27 seconds after activation of the amber warning lights (ORR, 2005) as described in section 2.1.1.

Findings from the consultation confirmed that automatic half barrier crossings have the shortest closure time, while manually controlled barrier crossings have the longest closure time (see section 2).

Tsai (1998) developed analytical models for estimating risk and delay at automatic crossings and used cost-benefit analysis to determine optimal “warning times” between the start of amber and the arrival of the train. He found that the optimal time was between 27.9 and 61.2 seconds for automatic half barriers, and from 31.1 to 85.6 seconds for automatic open crossings and concluded that the current recommendations of a warning time between 27 and 75 seconds are reasonable. He pointed out that the optimal warning time varied according to traffic flow, with a higher traffic flow leading to a shorter optimal warning time. This is because a higher traffic flow leads to an increased probability of ‘natural level crossing protection’—there are fewer vehicles traversing the level crossing in any given time period and their reduced approach speed helps reduce the risk. However, a system of variable warning times would be difficult to implement in practice.

> "We’re already doing the optimum in keeping road closure time to a minimum—although I’m sure there are people who don’t think we are—given the constraints of the number of trains we’ve got to run and where the signals are." (Rail)
4.2 Highway

4.2.1 Diurnal distribution of road traffic

Road traffic flow at most level crossings varies throughout the day leading to varying queue lengths. Figure 3 illustrates the variation in road traffic flow over a day at North Sheen level crossing (also see section 3.4). As previously mentioned, delay will be greatest when high traffic flows coincide with a high frequency of trains. The amount of delay can also increase on certain days (for example if a special event is being held at a location accessed by a level crossing) and at certain times of the year (for example "a route into a holiday resort would be a worse problem in summer").

![Figure 2. Half-hourly distribution of trains to and from North Sheen station](image-url)
4.2.2 Road speed limit

The majority of level crossings which experience problems with traffic delays are in urban areas, where the speed limit is likely to be 30mph. Guidance from the ORR (1995) states that the 85th percentile road speed at open level crossings should be less than 35mph, and the RSSB has recommended reducing the approach speed at high-risk crossings (RSSB, 2004). This would need to be done through liaison with local highway authorities. However, such recommendations are almost certainly for safety-related reasons rather than to mitigate traffic delays. A lower speed limit may make drivers more aware that there is a potential hazard ahead.

“If you’ve got a hidden road approach, try and slow the traffic down, not too much but just to make them be aware.” (Rail)

A reduction in road speed limit on the approach to a level crossing may also help to manage drivers’ perceptions of any traffic delays. It is possible that any delay experienced on a road with a higher speed limit will frustrate more than on a road with a lower speed limit because drivers may perceive less of a difference between expected and realised progress. Reducing any cues that may give rise to frustration are critical for avoiding dangerous road user behaviour at level crossings.

4.2.3 Road design and level crossing location

As previously discussed, traffic delay will be worse in areas with a higher traffic density, such as urban areas or popular commuter roads. Traffic delay may increase at level crossings situated on, or close to major roads. The possibility of blocking back may also increase at such crossings, particularly when situated on a road that provides access to major routes, due to the high density of traffic travelling onto and off the major road and forming queues (RSSB, 2008c). Additionally, the width of the road at the level crossing may affect the likelihood of traffic delays, since drivers may need to slow down on or before the crossing to allow oncoming vehicles to pass safely (RSSB, 2008c). It is
unlikely that narrow roads will be found at busy level crossings, so the risk of delay caused by this is minimal; however, a similar effect can be created by parked vehicles adjacent to a level crossing (although this could be managed by prohibiting parking on the approaches to and exits from level crossings).

Level crossings located close to a roundabout or other road junction may also increase traffic delay. (See sections 3.3.1 and 6 for more on this).

"You only need somebody to put [in] a traffic junction, a roundabout or anything that disrupts the working environment...roadworks is another one." (Rail)

"West Barnes crossing [London] suffers from delays because it is close to a road junction and the traffic can easily block back across the railway. The crossing is so close to the junction that a long vehicle delayed at the junction would be sufficient to prevent the level crossing from closing." (Rail)

The second of the above comments emphasises the importance of ensuring that the road provision around a level crossing is sufficient and appropriate for the type and volume of traffic. In essence, this means that the approach and exit roads for level crossings should have sufficient storage capacity for regular vehicular traffic. If it is insufficient, then mitigating measures should be considered—so if there is insufficient space for a heavy goods vehicle to wait at a junction after passing over the level crossing without blocking back then it may be necessary to restrict HGV traffic on that route.

Road users estimate their waiting time to be much longer at level crossings located adjacent to rail stations than at crossings not in the vicinity of a station (RSSB, 2008c).

"Level crossings near railway stations with busy traffic and near platforms for commuter trains are always a problem." (Rail)

Road users may have experience of longer waiting times due to trains slowly pulling into and out of the station, with not enough time to allow the signals to be deactivated to allow cars through the crossing between train departures and arrivals and may therefore be more inclined to take risks (RSSB, 2008c).

4.2.4 Roadworks

Roadworks in the vicinity of level crossings can cause blocking back over the level crossing. The Traffic Signals Manual (Chapter 8, 2006) stipulates that “under no circumstances should portable traffic light signals be used at works within 50m of the level crossing stop line” and that roadwork designers should “avoid blocking back at all times—where works are near to, but not on the crossing, designers should ensure that traffic cannot block back and stop on the crossing”. Anecdotal evidence from the consultation suggests that roadworks can indeed create blocking back, with one county council reporting that they had been prosecuted as a result of roadworks which caused blocking back.

"We have evidence of road authorities putting in...roadworks or drainage works without considering the impact on level crossings." (Rail)

4.3 Urban planning and development

In addition to the factors mentioned by Ryan (1990), delay may be caused by poorly designed roads at and around the level crossing, or by development of areas to include more homes and therefore increased levels of traffic (ORR, 2005). The National Level Crossing Safety Group (2006) recommended that proposed developments which may affect level crossings have conditions imposed on them, for example road layouts, traffic lights, and the size of the development. The effects of town planning were discussed in the consultation:
“Planning authorities do things like putting a housing estate on one side of the railway and a school on the other... New developments might not be near the railway but can have an effect on traffic flow... it’s so important when you’re planning areas that you need to consider the railway as well, I don’t think it’s always considered.” (Rail)

“Should establish a national planning guideline about who is to be consulted when developments are proposed that could impact on level crossings. For example, new housing developments should never be permitted if access is via a level crossing—the developer should be forced to erect a bridge.” (Other)

“The planning legislation is very weak at the moment... what they see as significant [changes in traffic levels] and what I see as significant from a safety point of view are often miles apart.” (Rail)

It is also important to consider that level crossings were often built before towns became built-up, so it is important for the crossing to be considered in the town’s planning and development. There is a need for planning authorities to understand the consequences of their decisions.

“The area around the level crossing has changed significantly and has actually created more traffic. Thirty years ago, there was just a level crossing and a small road with a small amount of traffic. Now, a couple of schools have been built around there and the level crossing is on the school-run now, there’s also been a 24-hour supermarket built there and an industrial estate, which has just increased the traffic” (Rail)

“When planning towns, the railway gets forgotten.” (Other)
5 Human factors affecting traffic delays

5.1 Driver perception and experience of delay

A driver’s perception of delay may be affected by a number of factors. Richards and Heathington (1990) conducted a laboratory study in America in which 60 drivers were shown videos of active level crossings and asked to indicate when the elapsed time without a train arriving had become too long. Half of the participants were shown an activation sequence at a crossing with barriers, and half at a crossing without barriers. For the former group, the mean ‘excessive’ elapsed time for train arrival was 66.2 seconds (or 48.8 seconds once the barrier had descended), and for the latter group the mean ‘excessive’ elapsed time was 39.7 seconds. This suggests that drivers (in America at least) tolerate longer warning times at barrier crossings than open crossings before losing patience.

Road users may have different means of appraising delay, and balancing the costs and benefits to determine whether it is acceptable to wait.

“It’s this idea that if you think you might get held up for 50 seconds then you’re not bothered but if you think you might get held up for ten minutes your ‘risk rating’ changes.” (Road)

“People respond very differently at crossings indicating that perceived delay varies considerably across different road users...It is difficult to work out a model cut-off point for delay...if people can see the danger then they tend to violate more freely—for example, a crossing next to a station where the train is visible in the station encourages people to cross when the crossing is closed because they think they can make it in time.” (Other)

“If people are aware that they are going to be waiting for significant proportions of time, it might tempt them to take risks, zigzag around the crossing, or try to beat the barrier because they’re frightened of being held up.” (Rail)

Pickett and Grayson (1996) propose that drivers who decide not to observe warning signals at level crossings may do so because they perceive the costs of waiting (delay) to outweigh the benefits (avoiding possible sanctions). In an analysis of 419 witness statements given by drivers who had been observed violating warning signals, ten percent stated that they did not want to stop, largely because they viewed the delay as unacceptable.

At some level crossings, drivers may have frequently experienced a time gap between the warning lights being illuminated and the barriers descending, and therefore may base their decision to stop on whether the barriers are descending, rather than on whether the warning lights are flashing. These violators are likely to have had prior experience of the level crossing, and therefore choose to believe that it is not dangerous to ignore the warning systems.

Drivers may use their previous experience of waiting at level crossings to decide whether to cross against an amber or red light, since the length of time a road user expects to wait at a level crossing can influence their risk taking behaviour (HSE, 2005). As one stakeholder suggested, “local users of crossings will often know when a level crossing is usually closed and how much it might affect their journey. Where possible, people will migrate to alternative routes if they have sufficient knowledge of the delay and the area.” When drivers are repeatedly exposed to a phenomenon, they come to expect it (Pickett and Grayson, 1996). Therefore, they may become predisposed not to look for a train on the crossing, if they are familiar with that crossing. Alternatively, drivers may transfer their experience of one crossing to a new crossing, reducing their vigilance (Pickett and Grayson, 1996).
Whilst violating drivers are not likely to affect delay (unless they become stuck on the railway line), expected delay may influence whether drivers decide to violate or obey the crossing signals. Sanders (1976) found that drivers who experience long delays at level crossings tend to behave less safely.

Experience with different types of level crossing may also influence a driver’s perception of when a delay becomes unacceptable. For example a driver who frequently uses an AHB crossing which is down for less than 30 seconds may quickly become impatient when using an MCB crossing:

“If someone is used to that type of crossing [AHB] and they go to a manned gate crossing, they may think a delay beyond the 31st second is unreasonable.”

(Other)

In addition, frequent users of a particular crossing may come to memorise the timetable, and use that to decide whether it is safe to violate the warning lights:

“Local users can come to rely—wrongly—on the timetable. They’ll memorise it and think that as long as they don’t cross when the timetable says there’s going to be a train, that they’ll be safe, and they won’t. Trains are early, trains are late and there are freight trains” (Rail)

5.2 Driver perception and understanding of level crossing operation

In order for level crossings to be effective at controlling road traffic, it is essential that drivers understand and interpret the signs and signals correctly. Pickett and Grayson (1996) presented one hundred drivers (who had been observed crossing against a red signal) with pictorial diagrams of signs and light signals, and asked what the sign or signal meant. A correct answer was defined as one which matched the Highway Code definition. Three level crossing signs were shown: with barrier, without barrier/gate, and without barrier. On average, 41% gave an incorrect response (ranging from 37% to 49%) and 17% claimed that they did not know what the sign meant (ranging from 8% to 32%).

Participants were also asked to interpret two light signals found at level crossings: steady amber (meaning ‘stop at the stop line, you may continue only if you are too close to the crossing to stop safely’), and flashing red (meaning ‘stop at the stop line’). Seventy percent gave an incorrect interpretation of the amber light, and 7% said they did not know what it meant. Thirty six percent interpreted the red light incorrectly, and 10% did not know what it meant.

Whilst only 13% understood the meaning of a steady amber light, closer inspection of the responses shows that the majority were aware that it preceded the red light and lowering of the barriers as a train approached. However, eight percent were not even aware of this; four percent thought it meant continue, and four percent thought it meant proceed with caution. However it is important to bear in mind that the signs and signals were viewed out of context and so the drivers’ responses are not necessarily a true reflection of their behaviour.

Overall, Pickett and Grayson (1996) demonstrated that driver understanding of signs and signals at level crossings could be greatly improved. It also showed that many drivers would prefer to traverse the level crossing rather than wait (if they perceive there to be enough time to do so safely), perhaps because they anticipate a long delay if they choose to stop when the lights are amber. A reduction in traffic delays would possibly lead to a reduction in the risk of road users disregarding the level crossing warning systems.
6 Level crossing interventions which may also help reduce road traffic delay

While level crossing safety is the responsibility of both rail and highway authorities, local highway authorities have the additional concern of reducing road congestion and traffic delay. In congested areas, queues that form when level crossings close may extend to nearby junctions and further disrupt the traffic flow around the crossing. Another problem is blocking back over the crossing (see section 3.3.1).

There is a paucity of comprehensive literature directly related to managing and reducing delays at level crossings. However, there has been some research into various methods of managing delays, as described below.

6.1 Railway interventions

6.1.1 Constant warning time systems (train predictors)

Warning systems must be seen, understood and believed by the general public in order to be fully effective; a warning system that is not believed will be ignored, and loss of credibility is more likely when the warning system causes unnecessary or prolonged delay at the barrier (Monroe, Munsell and Rudd, 1981). For example Hopkins (1981, as cited in Richards, Heathington and Fambro, 1990) reported that drivers who frequently use a level crossing are more likely to proceed through the crossing against the warning system if they believe that the signals have been operational for longer than they may be used to prior to the train’s arrival. In addition, a long warning time was reported to be the predominant contributory factor in accidents at level crossings in the USA (Berg, Knoblauch and Hucke, 1982), perhaps because drivers perceived the warning to be excessive or the signal faulty and therefore chose not to wait.

The strike-in point for activating level crossing protection is calculated to ensure that a train travelling at the maximum permitted speed at that location cannot arrive at the level crossing in less than the minimum prescribed warning time. Therefore, if a train is travelling below the maximum line speed, it will take longer than the minimum prescribed time to reach the crossing, resulting in increased closure times. This could be a critical factor for traffic delay at crossings where train passing speeds may vary widely from the permitted maximum (for example freight trains are often slower).

Constant warning time (CWT) systems, also known as ‘train predictors’ or ‘level crossing predictors’, are based on train detectors (Monroe et al., 1981) and enable road users to have a constant warning time before the train’s arrival, irrespective of train speed (RSSB, 2005b). CWT systems “can ensure that automatic crossings are activated based on the speed of the approaching train”. According to the manufacturer of a train predictor system in the UK, “by accurately predicting when the train will arrive at the crossing, the Level Crossing Predictor ensures optimum deployment of barriers and warning signals, minimising disruption to road traffic and enhancing safety, by eliminating the delays which tempt motorists to ‘race’ or drive round the barriers” (Westinghouse Rail Systems).

Richards and Heathington (1990) conducted a before and after study to evaluate the impact of CWT systems on driver behaviour and safety at active level crossings in Tennessee. It was found that after installation of the CWT system, average warning time (the duration between activation of the flashing light signals and the arrival of a train at the crossing) reduced from 75.2 seconds to 41.7 seconds. In addition, three months after the CWT system had been installed, the average number of vehicles crossing the track against the warning signals decreased from 10.86 to 3.35 vehicles per train arrival. The number of vehicles crossing the tracks within 20 seconds of the train’s

TRL 25 PPR377
arrival decreased by more than half, and crossings within 10 seconds of the train’s arrival decreased by two thirds.

Although there are some 30,000 installations in use in North America and Australia, predictor technology has not yet been widely adopted in Europe. According to RSSB’s Safety Performance Report (RSSB, 2005b), “a relatively low cost ‘predictor’ is being tested that gives a constant warning time to road users, taking account of the train’s speed. This is expected to reduce the tendency of users to ignore the warning, in the expectation that in reality they have plenty of time to cross safely, especially when a slow train is approaching the crossing”. In 2005, a trial site for the WESTeX GCP3000 system was established in the UK to test the expectation that it would reduce road users’ tendency to ignore the warning and try to cross the tracks, especially when a slow moving train is approaching (RSSB, 2005b). Additionally, two sites in Northern Ireland have been installed with the system, which came into operation in August 2007.

At Menarys level crossing in Northern Ireland, the installation of the predictor system proved particularly successful:

"By using a level crossing predictor, we were able to use certain features of the predictor to provide effective controls which have delighted Northern Ireland Railways. The warning time for this type of crossing should be 40 seconds and post-commissioning we have had an average warning time of 41 seconds in the approach without the station, 42 seconds for non-stopping trains, and 53 seconds for stopping trains on the approach with the station—all without any additional controls. This would have been totally impossible without a level crossing predictor. “ (Other)

There is clearly potential for train predictors to be installed in the rest of the UK. The GCP3000 predictor is approved for use on all non-electrified lines, and would primarily be used at automatic crossings. The GCP4000 is suitable for all types of level crossings and is currently undergoing product acceptance with Network Rail (Robertshaw, 2008, personal communication). This predictor would also provide the necessary controls to operate level crossing barriers and warning lights. Currently there are eight AHBs in the UK fitted with level crossing predictors (GETS HXP-3 predictors), and by November 2008 a further eight crossings will be fitted with WESTeX GCP3000 predictors.

One benefit of installing predictors may be reduced misuse of the level crossing since road users will know that when the warning system is activated, a train will arrive imminently:

"An occasional short warning is much, much better than frequent long warnings because the latter encourages misuse. We have done a lot of work with HMRI and Network Rail to demonstrate that an occasional short warning can be tolerated if this is mitigated by a removal of long warning times.” (Other)

However, it may be the case that drivers feel more confident in crossing the railway against an amber light or zigzagging round the barriers if they know exactly how many seconds there are until the train’s arrival. This would require further investigation.

Predictors can reduce the length of time for which the barriers are down but if the delay is caused by a busy junction or roundabout just downstream of the crossing, installing a predictor will not eliminate the delays. Therefore, a level crossing predictor “will generally make the situation much better, but it very much depends on the reason for the traffic delay.” Level crossing predictors provide the minimum warning time in nearly every case, and thus “significantly reduce the length of time that the crossing is closed for.” This has the subsidiary effect of reducing the likelihood of the crossing remaining closed for a second train on another line, thus further reducing the risk of traffic delay.
Constant Warning Time (CWT) systems

Benefits

- Highly likely to reduce delay marginally at level crossings with traffic problems.
- Offer a reduction in cost compared to conventional systems, allowing enhanced protection at more crossings for the same level of investment.
- Should improve road users’ confidence in the level crossing warning systems.
- Allow barriers to lift between trains more frequently.

Barriers to implementation

- The reduction in delay at AHB crossings is likely to be marginal and CWT systems are unlikely to be used where road traffic volumes are high for safety reasons.
- Each location must be examined on a site-specific basis—they cannot be successfully implemented if they need to be located prior to a railway junction or station situated on the approach to the crossing.
- Currently approved for use on non-electrified lines only (but it is possible the next generation predictor may be used on all line types).
- Currently not approved for MCB or MCB CCTV crossings. Moreover, application at full barrier crossings may have little impact on crossing closure times unless implemented alongside obstacle detection devices at the level crossing to ensure that the CWT system does not activate the crossing unless it is clear of vehicles (the same is not true of AHB crossings as there is an ‘escape route’ for vehicles still on the crossing). Furthermore, the greater line speeds at MCB crossings mean that CWT systems must place treadles even further away from the level crossing, increasing the chance of the train encountering unpredictable situations that may divert or impede its continued progress (e.g. junctions, stations) on the line leading to the crossing.
- A constant warning time may not discourage road users from violating the crossing; they may feel more confident in crossing the railway against an amber light or zigzagging if they have a better estimation of the length of time before the train’s arrival.
- Potential higher track maintenance costs, as CWT systems tend to be less tolerant of reduced electrical isolation properties along the track.

6.1.2 Scheduling of trains

Train scheduling may be seen as a contributory factor to road delays since it can result in two or more trains passing a level crossing in close temporal proximity, causing the crossing to remain closed to road users for a considerable length of time. This is particularly likely at crossings with more than two running lines. Whilst the rescheduling of trains could be perceived as a straightforward means of reducing road user delay, further exploration of the proposal reveals some shortcomings.

Train planning is a complex discipline and requires considerable precision in optimising journey times, capacity and train performance. Particularly pertinent is the fact that while crossing users may see a handful of trains at crossings, those trains fit into a wider system. In this system there are often locations more critical to service provision, performance and safety than individual crossings. To examine the effects of optimising train patterns around one or more given crossings would require extensive and costly simulation of a large part of the wider network.

Findings from the consultation confirmed that stakeholders regard rescheduling of trains to reduce barrier downtimes as untenable on a national scale:
“It is quite ludicrous to suggest that train timetables can be adjusted to reduce delays to road users at level crossings.” (Other)

“It is difficult to impossible to manage delay using timetables” (Rail)

“On a congested railway which costs society an awful lot of money to pay for, even to consider re-timing trains so in theory they always cross a level crossing so you reduce the number of times the crossing is closed, or anything that clever, is complete and utter fantasy. Railway timetabling is one of the most complicated things in the world.” (Rail)

“Any attempts to ensure trains cross [a level crossing] at the same time as each other are blown out of the water if one of them is even one minute late.” (Rail)

In addition, optimising the arrival of trains at one level crossing would mean that they are not likely to be optimised at another crossing on the same line.

It is important to note that the rail industry robustly rebutted any suggestion to reschedule trains not because of an unwillingness to explore the opportunity but because they strongly believed that it would be wholly ineffective. Anecdotally, it appears that local highway authorities often make this suggestion based on their understanding of the micro train timetable—the railway authorities, with their understanding of the macro train timetable assert that changes would have negligible and piecemeal benefits and could be completely negated or worsened by the slightest disruption to the expected running times.

To support this point, there are anecdotal reports of rescheduling occurring on a small scale where only local trains are involved. For example, one rail stakeholder claimed that,

“I was involved in a local case where they tweaked the timetable of trains from Harrogate and Knaresborough so that they pass Starbeck level crossing at the same time, but this was a one-off situation.” (Rail)

In addition, one local authority also reported some success in negotiating timetable changes to assist level crossing operation:

“I had some communication with Network Rail in the past, and timetables were amended slightly so trains arrive at the same time, reducing slightly barrier downtime. I don’t know if that was as a result of the discussions.” (Road)

<table>
<thead>
<tr>
<th>Train rescheduling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benefits</strong></td>
</tr>
<tr>
<td>• Theoretically, trains could be scheduled to minimise the incidence of two or more trains passing a level crossing in close temporal proximity.</td>
</tr>
<tr>
<td>• The need for barriers to stay down while two or more trains pass the crossing would be reduced.</td>
</tr>
<tr>
<td>• Potentially achievable with local services that are not directly linked to the running of the wider network.</td>
</tr>
<tr>
<td><strong>Barriers to implementation</strong></td>
</tr>
<tr>
<td>• Not viable to timetable the wider network so that crossing closure is reliably optimised at all level crossings.</td>
</tr>
<tr>
<td>• Most trains run a few minutes late at some point during their journey thus throwing any potential solution into disarray.</td>
</tr>
<tr>
<td>• Does not take into account freight trains, which cannot be integrated into a regular train timetable.</td>
</tr>
</tbody>
</table>
6.1.3 Obstacle detection

The formal inquiry into the accident at Ufton Nervet AHB crossing in 2004 called for more research into a practical system to detect obstacles at AHBs; this resulted in RSSB commissioning a research study (T522) into obstacle detection at AHB and MCB CCTV crossings (Heavisides et al., 2006). Obstacle detection is “a means of identifying the presence of an object on a level crossing as the train approaches, providing information to guide a suitable response so that collision with the object can be avoided or the consequences minimised” (Heavisides et al., 2006).

Obstacle detection systems are currently in use in a number of countries including Germany, Sweden, the Netherlands and Italy, but not the UK. They require a means of detecting objects on the line (e.g. radar, induction loops) and a means of communicating the presence of an object on the line (e.g. existing railway signalling or an in-cab alarm). They are used at full barrier crossings, in order to avoid disruption to the rail service caused by drivers violating the crossing. Most AHBs have a fairly short warning time of around 30 seconds, which would need to be increased if an obstacle detection system was installed, in order to give the train driver time to respond if an obstacle is detected on the line (RSSB, 2006).

In terms of reducing traffic delay at level crossings, “ideally, an obstacle detection system would...cause no or minimal delays for both train and road users” (Heavisides et al., 2006). The obstacle detection system would almost certainly be used in conjunction with an automatic full barrier and this should reduce the length of time the level crossing is closed for each train compared to an MCB crossing:

"We are looking at whether you can put in automatic full barriers at the moment...it’s in its early stages. It should make the crossings more efficient."
(Rail)

"It would take out the human involvement in demonstrating that the crossing’s clear, and...that would reduce the down time of the full barrier crossing by about a minute or a minute and a half.” (Rail)

"Closure times would still be longer than AHBs but would be faster than a manually lowered full barrier.” (Rail)

An obstacle detection system would introduce the risk of detecting objects that a human operator would classify as safe and for this reason might have to be set to detect large (car-sized) objects only. A false detection would result in delays (to both rail and road users) which could be substantial since in many cases there would be no CCTV to allow operators to ascertain the cause of the problem (RSSB, 2006). Automatic full barrier crossings with obstacle detection could not be installed at all level crossing sites, particularly where there is an issue with blocking back or level crossing abuse:

"Manual crossings where the operator tends to lower the barriers earlier because it is difficult to clear traffic in time would probably not change to automatic operation due to the safety implications of the existing traffic problems.” (Rail)

"It’s not perfect for every location...you need to do it somewhere where you can rely on people not to rush the red light.” (Rail)
Obstacle detection

Benefits
- Reduction in crossing closure time by converting an MCB (CCTV) crossing to automatic full barrier with obstacle detection.
- Reduction in risk of trains striking vehicles or pedestrians.
- Upgrading MCB crossings would remove the need for signallers, resulting in a financial saving in the long term.

Barriers to implementation
- May detect and alert train drivers to objects that do not pose a real safety risk.
- 'False alarms' would result in further delay to rail and road users and may pose a safety risk to rail users due to sudden braking by the train driver.
- Obstacle detection would be considered inappropriate at crossings currently subject to blocking back (usually MCB crossings), users may also learn that during heavy traffic the exit barriers will not lower if they are already at least partially on the crossing and may therefore block the crossing intentionally in order to get across without having to wait.

6.2 Highway interventions

6.2.1 Red light enforcement cameras

The legal requirements placed on level crossing users can be enforced by red light cameras to record misuse and support driver prosecution (RSSB, 2007e). This has been trialled both in the UK and internationally; studies of red light enforcement equipment in the USA have shown a modest cost benefit of such systems at road junctions. Red light cameras are primarily installed with the intention of improving safety and will not affect overall delay. They should deter vehicles from entering the crossing once the level crossing warning system has been activated, and thus may help avoid delay caused by vehicles becoming trapped on the tracks due to running a red light and finding themselves in a queue of traffic.

RSSB (2007e) investigated the use of red light cameras at 15 level crossings in north east England and Scotland. It was found that only one of the 15 sites saw a significant reduction in red-light running after installation of the equipment. There was considerable difficulty in assessing the effectiveness of camera use since the ‘before’ data was not systematically collected for research purposes. Overall, an assessment of accident and near miss data led the authors to conclude that there was insufficient evidence of an economic benefit from the widespread implementation of red light cameras in the light of the low collision rates observed (RSSB, 2007e), although the importance of considering each crossing separately is emphasised.

Whilst there was little evidence that red light enforcement cameras reduce violations at crossings, it is important to consider the motivation for these violations; if delay (or expected delay) causes drivers to violate a red light in order to avoid the delay, this itself would be an important issue worthy of further investigation.
**Red light enforcement cameras**

**Benefits**

- Possible reduction in red light violations.
- Equipment can also be used to monitor zigzagging behaviour.

**Barriers to implementation**

- Limited value in reducing road traffic delays.
- Unproven effectiveness at reducing level crossing abuse

### 6.2.2 Vehicle Activated Signs

Vehicle Activated Signs (VASs) are frequently used on the UK’s roads to warn drivers who are exceeding the speed limit of an impending hazard or to remind them of the speed limit and hence improve road safety (Webster, 1995), and research has shown them to be effective at achieving this objective. Winnett and Wheeler (2002) found that VASs are very effective at reducing the number of drivers who exceed the speed limit. They found no evidence that drivers become less responsive to the signs over time (although recent anecdotal evidence suggests that they might). It has also been found that VASs are effective in improving road driver behaviour at crossings over a period of time (HSE, 2005). VASs can also be used to advise road users of level crossing hazards (e.g. serious queues) and discourage blocking back of vehicles onto level crossings (HSE, 2005).

The RSSB is currently investigating this potential and has installed VASs at two automatic half barrier crossings in the UK, at Boldon and Tileshed. Both of these crossings are due to be closed, but this could take up to ten years. The VAS, unveiled in March 2008, reads ‘! Keep crossing clear’ and is only presented to the traffic stream susceptible to blocking back. The VAS is activated for 60 seconds if a car stops on the loop for 25 seconds or more (RSSB, 2008).

Driver behaviour and blocking back were filmed at the two crossings for several months before the VASs were installed and the crossings will continue to be filmed for some months after installation. Initial analysis of 8 weeks of ‘before’ footage identified 32 separate cases of blocking back onto the level crossing (RSSB, 2008). RSSB will compare blocking back before and after VAS installation to analyse the efficacy of the VASs (RSSB, 2008b). It is important to consider not just the potential for reducing blocking back but why that reduction has occurred, particularly regarding drivers’ perceptions and beliefs relating to the VASs. The duration of any effect must also be considered.

Van der Horst and Bakker (2002) found that conspicuous marking of cross section areas (similar to the UK’s yellow boxes) on level crossings in the Netherlands reduced the occurrence of queues over the level crossing, but that active queue-warning systems were much more effective. The implementation of VASs in the way suggested by RSSB (to prevent queuing traffic from obstructing the railway line) would not necessarily prevent delay to road users, but it may help to prevent delay to trains by discouraging drivers from blocking the crossing, and may also help tackle violations.

During the consultation, some alternative uses of VASs (and variable message signs) were suggested:

- "Variable message signs can be used to direct traffic to alternative routes and to warn of expected delay." (Other)
- "To highlight speed, to tell drivers to keep the crossing clear...to highlight to people that there’s a railway here." (Rail)
If used to warn traffic of delay and aid diversion (if a diversionary route is available), the VASs would need to be positioned on the road network some distance from the level crossing so as to offer road users an opportunity to respond to the signs. The technology to implement various VASs does exist and may be a worthwhile area for further research. However, it should be noted that any input to VASs would be simplest if it were to come from systems installed in the road network rather than the rail network.

### Vehicle activated signs (VASs)

#### Benefits
- Successfully convey warnings to drivers travelling too fast; effectiveness does not appear to diminish over time.
- Applicable to traffic situations at level crossings—such as blocking back—and has the potential to warn drivers of serious queues and/or encourage drivers to take an alternative route.

#### Barriers to implementation
- Drivers may choose to ignore the message(s).
- Unlikely to have a substantial effect on reducing traffic delay, unless VASs can give drivers sufficient warning of delays to enable them to take an alternative route or avoid the area.
- Expensive to install, particularly if the message was to be continually updated to reflect the current traffic situation (thus requiring input from linked traffic sensors).

### 6.2.3 Lane separators

Another potential approach to managing delays at level crossings is to install lane separators. These are flexible physical barriers which would stop vehicles crossing into the opposite lane. As well as preventing ‘zig-zagging’ at half barrier crossings, lane separators would prevent vehicles from queue-jumping to reach a junction, and so reduce further delays. For example the situation depicted in Figure 4 shows how two vehicles (A and B) may decide not to wait in the queue until the barriers ascend, instead choosing to drive on the wrong side of the road to reach the junction, causing them to meet in the same lane and finding themselves in a situation where one of them must reverse. The situation may be exacerbated if the crossing barriers ascend and a vehicle wishes to turn left into the side road while vehicles A and B are still manoeuvring.
The installation of lane separators on either or both of the roads in Figure 4 would prevent such situations from occurring and encourage lane discipline, as well as preventing zig-zagging at the level crossing. The prevalence of poor lane discipline exacerbating traffic delays is not known, with the exception of anecdotal accounts, but lane separators would undoubtedly have a role to play in confronting this problem.

The RSSB (2007d) selected three sites at which to trial lane separators, and monitored these sites by CCTV for over two years. This monitoring confirmed that a significant number of drivers violate the red lights or road markings. Lane separators are to be installed at two (possibly three) level crossings by Network Rail (RSSB, 2008d).

### Lane separators

**Benefits**
- Effectively prevent zig-zagging at AHBs.
- Could help prevent delays resulting from vehicles overtaking queuing traffic to reach a blocked junction.

**Barriers to implementation**
- Unlikely to have a substantial effect on reducing overall traffic delay.
- Installation would cause disruption to the road network.
- Only suitable on roads where carriageway width permits a separator.
- Cannot be used across a side road
- If a vehicle parks or breaks down, there may be insufficient space for other vehicles to pass.

### 6.2.4 Improved road design and traffic management

Various aspects of road design and traffic management at and around level crossings will influence the degree of traffic delay that occurs; but "where delays are particularly long,
the type of crossing and the road conditions are probably working against any solutions.” Ensuring optimum traffic flow over the level crossing can be an effective means of reducing traffic delay.

A commonly cited cause of delay is close proximity to roundabouts or other junctions. Their effect on level crossings can sometimes be improved by banning particular turns or changing timings at a signal-controlled junction. Another simple way of improving flow can be to prohibit parking close to crossings:

“there is a junction further upstream of the crossing where vehicles are turning right off of the main road - queues form behind vehicles wanting to turn right, the queue extends back to, and across the level crossing. The approach we want to take is to eliminate the right turn all together” (Road)

“keeping either side of the crossing free of obstructions, e.g. banning right turns which hold up traffic from crossing the tracks and banning parking near to crossings, which can hold up traffic and large vehicles.” (Rail)

Ideally, alternative routes should be available to drivers, allowing them to avoid the level crossing should they choose to do so. Changing fundamental road layouts would be extremely costly but when planning new roads—for example from a new housing development—that may impact traffic flow at a level crossing, the design of the road and its effect on the level crossing should be evaluated.

### Improved road design/traffic flow

**Benefits**

- Improved road design at and around level crossings would reduce delay by increasing traffic flow over the crossing, and possibly providing alternative routes, avoiding the crossing.
- Small changes can be implemented at low cost, for example prohibiting parking on the approach to a crossing.
- In a situation in which new roads are being built, determining the effect on the level crossing at the design stage can help minimise further delays at the level crossing.

**Barriers to implementation**

- New road layouts may be costly and problematic to construct.
- Modelling the magnitude of the effect of any alteration to road design may not accurately establish the true result of the change.

### 6.2.5 Traffic management options for dealing with problems at level crossings.

Whenever a level crossing exists in an urban area, there are likely to be signal controlled junctions nearby, possibly operating from an urban traffic control (UTC) Centre. In these cases there is the potential to control traffic by changing the signal timings such that the impact of the level crossing is modified or even reduced.

As often seems to be the case, the problems caused by the presence of a level crossing are very site specific. Therefore any involvement of UTC operation to change traffic signal operation around a level crossing would also be site specific.

The likelihood of being able to deal with problems by altering signal timings on nearby junctions seems limited. There may be situations where a traffic stream passes close enough to a level crossing to be affected by it without actually crossing it, but is blocked by other traffic streams that do cross. Holding traffic back away from the level crossing
may improve the operation for some traffic streams. However, the number of situations that could benefit from such an approach is probably very small.

Another situation that could potentially be affected by traffic signals is blocking back over a level crossing. An obvious answer would be to improve the operation of downstream junctions so that the traffic never queues back far enough to affect the level crossing. An alternative could be to reduce throughput at upstream junctions thus reducing the amount of traffic being fed to the source of the problem (i.e. a downstream junction not having enough capacity).

Such measures are likely to move the problems elsewhere rather than solve them. This might be acceptable if there is somewhere to store the resulting queues, and/or if the perception of network operation is improved (even if in reality there is no change). However, if the resulting re-distribution of traffic starts to affect major arterial routes then the acceptability will rapidly diminish.

6.3 Railway and highway interventions

6.3.1 Traffic signal pre-emption in the USA

Level crossings are sometimes located near road junctions, potentially causing confusion to road users as well as increased delay. In the USA, guidelines state that if the clear storage distance, i.e. the distance between the railway and the intersection, is less than 60 metres, the intersection should be designed for interconnection, whereby the level crossing warning system is connected to the highway traffic control (e.g. traffic signals). This will allow the level crossing warning system to clear traffic off the tracks before the train’s arrival, and avoid queues from the intersection blocking back over the level crossing (Wooldridge et al., 2000). See section 3.3.1 for more on blocking back.

In addition to possible blocking back over the level crossing, road junctions located close to level crossings may result in increased decision-making by road users and increased errors. The primary focus of vehicle drivers is likely to be on the actions of other road users in and around the junction, with their secondary focus being the level crossing (HSE, 2005).

Highway traffic signals (not level crossing traffic signals) are sometimes interconnected to the railway track circuits, allowing “pre-emption” of train arrival, by transferring normal traffic signal operation to a special mode designed to clear any vehicles within the ‘dynamic envelope’ (Kenon, 1996). According to the Manual on Uniform Traffic Control Devices (MUTCD) (Federal Highway Administration, 2000), the dynamic envelope (in the USA) is an area which typically consists of six feet of track plus six feet of clearance on either side, as illustrated in Figure 5.
6.3.1.1 Pre-emption time

In the USA, pre-emption of traffic signals as a supplement to active warning systems at level crossings is designed to prohibit any signal phases that would allow more road vehicles into the dynamic envelope and thus ensure there are no collisions between road vehicles and trains. The MUTCD (Federal Highway Administration, 2000) states that "when a highway-rail grade\(^5\) is equipped with a flashing-light signal system and is located within 200 feet of an intersection or mid-block location controlled by a traffic control signal, the traffic control signal should be provided with pre-emption". In some cases, pre-emption may be appropriate if the signal is more than 200 feet from the railway (Kenon, 1996).

Once it is established that pre-emption is required (approximately 1.5% of level crossings in the USA are interconnected to traffic signals), analysis must take place to determine exactly how long the pre-emption time must be, including the time required for a vehicle that has stopped within the dynamic envelope to move out of the dynamic envelope (the ‘clear track green interval’) (Kenon, 1996). If this time is over-estimated, the intersection may experience longer traffic queues and lower efficiency; if it is under-estimated, this may result in a vehicle being in the dynamic envelope when a train approaches (Kenon, 1996).

There are currently several methods available to estimate pre-emption time, but no official recommendations. Kenon (1996) compared two existing calculation methods with field observations for 24 intersections and found that the field observation method yielded lower results in 71% of the cases. The author concluded that the observation method gives a better approximation of the clear track green interval and recommended that every interconnected level crossing should be investigated by field observation.

In some cases, for example if the volume of vehicles at the level crossing is very large or the duration/frequency of passing trains is high, the pre-emption control scheme may not be able to clear all the vehicles, creating congestion and operational issues. It may take a number of cycles, particularly if another train passes before the congestion caused by the previous train has cleared (Roberts and Brown-Esplain, 2005).

\(^5\) The term for a level crossing in the USA.
6.3.1.2  Optimisation of traffic signals

Pre-emption could interrupt normal highway traffic operations and frustrate drivers, therefore research has sought to optimise traffic network signals at level crossings in the USA (Zhang, 2000). Zhang proposed SOURCAO (Signal Optimisation Under Rail Crossing sAfety cQnstraints)—an approach to improve safety and reduce traffic delay around level crossings. The first step in SOURCAO was to choose a proper pre-emption phase sequence and the second step was to find the optimum signal phase length to reduce traffic delay (Zhang, Hobeika and Ghama, 2002). SOURCAO integrated artificial intelligence (intelligent agents that perceive their environment through sensors, and neural networks that mimic the human brain and can store experimental knowledge acquired through learning) and optimisation technologies (Zhang et al., 2002). A simulation demonstrated that both objectives were reached, with the average network delay reduced by eight percent. It also demonstrated that safety was improved and that SOURCAO worked well under both heavy and light traffic volumes, and under a wide range of level crossing closure times.

Due to the fact that the SOURCAO system was tested in a simulated environment and using one case study, its effectiveness requires further testing. Zhang (2000) also suggested faster and more efficient neural training algorithms. The SOURCAO system and others like it offer a possible method of delay management at level crossings that are located near to traffic signals.

6.3.2  ‘Hurry calls’ in the UK

Where a signal controlled junction is situated close to a level crossing, it may be that some traffic can continue to manoeuvre around the junction when the crossing is closed. In some situations, the benefit afforded by this is sufficient to warrant some form of coordination between the level crossing closure and the traffic signal operation. In other situations, it may even be necessary for a particular stage to be running before the barriers can safely close.

In the UK, signal controllers are configured for each junction, and one of the available features is known as a ‘hurry call’, whereby:

"Before the crossing is closed, the traffic lights adopt a particular sequence that will tend to clear traffic off the crossing and then while the barriers are closed, it will avoid giving a signal phase that will send traffic towards the crossing, which will perhaps then queue and block back towards the road junction. It might perhaps adopt a phase that allows other flows of traffic that are not affected by the crossing to continue.” (Rail)

A ‘hurry call’ is an input to a signal controller that results in a particular signal stage or stage sequence being run either as soon as possible, or at least sooner than would otherwise be the case. It is normally used for bus priority, where the hurry call is made by a bus passing a detector, whereupon the stage that caters for that bus is run. For level crossings the principle is exactly the same, except that the hurry call will be made either manually by the level crossing operator, or automatically at a pre-defined point in the process of level crossing operation. A stage or stage sequence that is different from normal can be run, possibly to allow traffic not wanting to cross the railway to continue to move. In practice it is possible to configure a signal controller to do virtually anything with the traffic signals in response to a hurry call. However, it will be impossible to override stage minima (the minimum time that a green signal must appear for) or intergreen periods with a hurry call.

Hurry calls are normally initiated by the signalman. They tend to be “less to do with road congestion and more to do with reducing blocking back.” However, they should reduce traffic delay by “getting other traffic flows to move when there are queues at the level crossing” and “feeding them [road vehicles] back into the system the way we want
them fed back into the system rather than the normal sequence” (see below for examples).

6.3.2.1 Examples of level crossings with ‘hurry calls’

West Worthing level crossing is operated from Lancing signal box, from where the signalman sends a hurry call to the signals when a train is approaching. This calls a special signal stage that gives a green light to vehicles not crossing the railway, as shown in Figure 6.

![Figure 6. Illustration of West Worthing level crossing](image)

Depending on exactly which stage the signals are running at the time of the hurry call, they can respond within 5 seconds but can take as long as 30 seconds. As described in Peirce (2002), at this particular location, it is necessary for the signals to be running the special stage by the time the barriers are closed. Therefore, the signalman must always assume that the lights will take the full 30 seconds to respond to the hurry call. This means that up to 25 seconds of normal traffic signal operation can be lost each time the level crossing closes. When the barriers are fully ascended, the traffic signals return to normal operation within 15 seconds. Peirce (2002) suggest that the signal’s response could be tailored such that it is always timed with five seconds to spare, and estimated that this would save an average of 15 seconds for each crossing closure. It was also suggested that the traffic signals return to normal operation when the barriers begin to open, rather than when they are fully opened. Implementation of these two measures would increase the time the traffic lights are in normal operation from 55% to an estimated 63%.
6.3.2.2 Automated ‘hurry calls’

Examples where traffic lights are integrated into the level crossing signalling system are Victoria Terrace in Hartlepool, and Kendray Street in Barnsley (Boulton, 2008, personal communication). These automated hurry calls do not require a signalman to initiate them.

There is very little queuing space between the level crossing and traffic signals at the Victoria Terrace level crossing. The crossing is MCB CCTV and controlled from Clarence House signal box. When a train approaches, a hurry call is automatically issued so that traffic that has just traversed the level crossing is given a green signal allowing it to disperse. At the same time, traffic turning right onto the crossing is given a red signal to prevent further vehicles from entering the crossing. When the barriers are confirmed closed and the signalman is satisfied that the crossing is clear, he will press the ‘crossing clear’ button to remove the hurry call after which the traffic signals show green for traffic not using the level crossing (Madgwick, 2008, personal communication). The crossing is typically closed for around three minutes per train, and 42 trains pass the crossing each day, resulting in closure of the crossing for around two hours in every 24.

**Traffic signal interconnection**

**Benefits**
- Gives priority to vehicles that are not traversing the level crossing, thus improving traffic flow.
- Can result in reduced barrier downtime, as demonstrated at West Worthing level crossing.

**Barriers to implementation**
- Can be costly to implement at an existing crossing; cheaper to link the crossing with the traffic signals when it is being renewed or replaced.
- Only viable at level crossings that are located near signalised road junctions.

6.3.3 Level crossing closure

The most commonly suggested solution to the problem of traffic delay during the consultation was level crossing closure:

"I feel quite strongly that the best way to get rid of delay is to get rid of the level crossings." (Rail)

"I think that on the mainline, the only way you can really do it [reduce delay] would be to grade separate." (Road)

"It’s all about closure and installation of an alternative route, i.e. bridge or underpass." (Rail)

Level crossing closure is high on the rail industry’s agenda and the industry is currently undertaking an initiative to implement a programme of level crossing closures, particularly at crossings that are currently disused or at those awaiting an upgrade that could allow an alternative means of access such as a bridge (RSSB, 2007d). Network Rail policy states that “where reasonably practicable we will seek to close and/or divert crossings” (in other words, where the economic benefits exceed the cost). It is important to note that strategy to close level crossings where possible is principally driven by safety and risk reduction rather than traffic delay:

"Bridges are rarely—if ever—implemented to clear up traffic delays.” (Rail)

"Crossing closures are not due to delay.” (Other)
However, reducing traffic delay would be an important consequence of building a bridge, underpass or diversionary road. In theory, eliminating level crossings is the safest and most effective solution to traffic delay but there are numerous obstacles that can hinder progress, not least of which is the financial implications. As a guide, the current work to close the level crossing at Tipton station and replace it with an underpass (see section 8.2) is estimated to cost £22 million; the closure of Beddingham level crossing and replacement with a bridge cost around £19 million.

“Traffic delays at crossings tend to occur in busy town centres where building bridges would be prohibitively expensive and would require demolishing a lot of property.” (Rail)

“Closing them and putting something else in its place, e.g. a bridge, is an expensive option.” (Road)

Another obstacle is potential political opposition, for example:

“It would be expensive and I don’t think that politically that would be an acceptable solution—you’d probably need to take away some housing for either an underpass or a bridge.” (Road)

“There were objections on environmental grounds because of increased traffic. Making the route more desirable [by eliminating the level crossing] would increase the amount of traffic going through” (Road)

See section 7.2 for a discussion of funding of level crossing closure.

Replacing a level crossing may not always result in a beneficial outcome in terms of risk reduction. Construction of a bridge may not be possible at the site of the level crossing and, especially in urban areas where the topography does not allow for a bridge. In some cases there is a public right of way making it necessary to:

“leave a footpath in place even if the traffic goes over a bridge, so in terms of risk, a closure to traffic doesn’t really decrease the risk of an incident taking place.” (Rail)

<table>
<thead>
<tr>
<th>Level crossing closure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Benefits</strong></td>
</tr>
<tr>
<td>• Building a bridge, underpass or road diversion to replace a level crossing eliminates traffic delay at that crossing.</td>
</tr>
<tr>
<td>• The risk associated with the level crossing will also be removed (or substantially reduced when a footpath or bridleway remains).</td>
</tr>
<tr>
<td>• May improve air quality.</td>
</tr>
<tr>
<td><strong>Barriers to implementation</strong></td>
</tr>
<tr>
<td>• Very costly, with no clear funding structure.</td>
</tr>
<tr>
<td>• Can have social, political and environmental ramifications.</td>
</tr>
<tr>
<td>• Dependent on the topography of the area surrounding the level crossing.</td>
</tr>
</tbody>
</table>

6.3.4 Level crossing upgrade

Since some types of level crossing have shorter closure times than others, ostensibly, changing the crossing type could improve traffic delays. Level crossings are "due for renewal around every 30 years" but Network Rail begin investigating the level crossing ten years before the renewal is due and spend the "first five years looking at solutions other than renewing the level crossing, for example an upgrade or a diversionary road or
a new bridge.” The extent to which local highway authorities are consulted at this early stage varies and certainly offers scope for improvement.

The 2003 Railway Group Safety Plan had a scheme to reduce risk at level crossings by upgrading automatic open crossings (locally monitored) to automatic barrier crossings (locally monitored), and automatic half barrier crossings to manually controlled barrier crossings (with CCTV) (Network Rail, 2003). Upgrades generally lead to an increase in delay since the crossings with the lowest risk are MCB:

“Several planned upgrades to crossings will replace AHBs with MCBs (to combat blocking back) and thus increase delays.” (Rail)

“Upgrade would normally be from automatic to full barrier, resulting in longer closure times but a safer crossing.” (Rail)

But on lightly trafficked roads, upgrading a crossing may reduce closure time:

“Delays are a consequence of the type of crossing put in. A shift from manned gate to full barrier may deliver a slight reduction in delays because operation will be slightly faster. Upgrading a gated crossing to automatic will deliver much faster operations and should reduce delays.” (Rail)

### Level crossing upgrade

**Benefits**

- Generally increases safety and reduces risk at the level crossing.

**Barriers to implementation**

- Often results in longer delays to road users, since upgrades usually take place to improve safety, which typically increases delay by extending the time for which the barrier is down.

- Can be costly.

### 6.3.5 Improved road / rail authority interaction

In general, a prevailing conclusion from the consultation was that traffic delay is seen as a bigger problem for local highway authorities than for rail authorities, whose primary concern has to be to “look after the safe passage of trains and protect the trains.” Therefore, from the perspectives of many rail authority stakeholders, delay only becomes a ‘serious’ problem when it interferes with the safe and smooth running of trains. From the perspective of local highway authorities and road users, delay generally becomes serious when it interferes with the normal or expected journey time.

This difference in concerns—and the fact that the highway and railway only physically interact at a very small point—has resulted in a generally poor standard of interaction between the highway and railway authorities, as reflected in the consultation.

A recent RSSB report (2006c) investigated the attitudes to, and funding for, crossing closures in the UK and other countries. It found that “no single body in Britain has final and overarching responsibility for level crossings in respect of their instigation or closure”, and that “there is a strong commonality in tendencies to have positive relationships between railway, highway and political authorities...some countries formalise these relationships to a greater extent than is the case in Britain”.

A common opinion among stakeholders from the railway authorities was that there is a need for more local highway authority involvement and responsibility when seeking solutions to level crossing issues:
“We feel highway authorities should take more involvement in level crossings.” (Rail)

“If there are serious problems at a particular site, Network Rail would try and speak with the local highway authorities, but often they’re not terribly interested.” (Rail)

“We could solve the [traffic delay] problem by actually dealing with the level crossing in the context of the wider road network instead of having two separate organisations doing their different assessments...the road and rail people need to work together.” (Rail)

“In a lot of cases there isn’t a problem and we live with one another quite happily, we’ll come together usually at their [the local highway authority’s] instigation because we don’t see the problem until we’re told about it...I think we need to work together more.” (Rail)

Equally, representatives of local highway authorities commonly held the view that there needs to be improved interaction with the rail authorities:

“Generally if you spoke to most highway authorities, they would say their relationship with Network Rail was abysmal...we feel that it is such a huge organisation, you could never find out who you needed to talk to.” (Road)

“At the moment we’re almost two separate entities, and we go away and do our own thing...the communication doesn’t seem to be there...we’re stuck with how they choose to operate.” (Road)

“There is a need for improved interaction, the arrangements for meetings and exchange of information is very ad hoc at the moment.” (Road)

According to Woods (2006), the lack of shared ownership or joined-up thinking regarding the problems at level crossings may be due to the fact that—as a proportion of all road deaths—so few road deaths occur at level crossings. The basis for decision-making on safety or other investment grounds is rather different between the rail and road infrastructure providers. See section 2.2 for more discussion of the risk posed by level crossings to road and rail users.

The fact that the railway industry’s main principle is reducing the level of risk to “as low as reasonably practicable” (HSE, 2001) and that traffic delay does not affect trains means that risk mitigation is far higher on their agenda than traffic delay, whereas the highway authorities may focus more on traffic delay.

“The UK starts from a very high level of risk control and that is part of the dilemma between road and rail authorities—it drives down the risk of level crossings to the road to 1% or less whereas for rail they remain a substantial risk factor. Managing the priorities that go with these differing assessments of risk is very challenging.” (Other)

The importance of liaison between road and rail authorities was stressed by ORR in their 2007 policy on level crossings: “rail companies, highway authorities and others need to co-operate to manage safety at crossings...Decisions about level crossings must involve rail companies, highway authorities and other relevant organisations as early on as possible“.

Encouraging the two entities to understand each others’ priorities and concerns is an important step in ensuring that the authorities work together to improve both safety and traffic delay (which are essentially inter-related):

“If you say the objective of the exercise [improving interaction e.g. through road-rail partnership groups] is solely to reduce delay to road users, you won’t turn the railway people on at all because you’re improving the efficiency of a competing mode.” (Other)
The Road Safety Act 2006 added a clause to the Level Crossings Act 1983, substituting:

“An order under this section may make such provision as the Secretary of State considers necessary or expedient for the safety or convenience of those using the crossing; and, in particular—(a) may require any such barriers or other protective equipment as may be specified in the order to be provided at or near the crossing, and to be maintained and operated, in accordance with the order”

For:

“(a) may require the operator of the crossing or the local traffic authority (or both) to provide at or near the crossing any protective equipment specified in the order and to maintain and operate that equipment in accordance with the order”

In essence, this means that local traffic authorities are jointly responsible with the crossing operator for providing and maintaining equipment at level crossings. This change to the law should be effective in bringing the two sides together:

“The road safety bill had a clause inserted which makes the highway authorities jointly responsible with Network Rail for the safety of level crossings...so nationally we’re trying to develop some sort of protocols for dealing with that change in responsibility.” (Road)

“The level crossing legislation changed in 2007 as a result of the last Road Safety Act...since then there are more explicit duties on traffic authorities...it promotes the debate.” (Rail)

As well as working more closely together regarding level crossing maintenance, upgrades and closure, road and rail authorities could also generate joint technical solutions to the traffic delay problem, for example it was suggested that:

“In some situations it would be better to have some sort of direct link between the road and rail systems [possibly hurry calls]. We’re developing our intelligent transport systems strategy...to provide links between different systems” (Road)

Additionally, steps have recently been taken to build a better relationship between rail and road authorities, including the establishment of road-rail partnership groups (RRPGs), and this was acknowledged amongst some of the consultation participants.

“They are beginning to talk to each other...they are beginning to understand each other’s problems, which is probably the first step.” (Road)

“Interaction is getting better.” (Rail)

“Up to a number of years ago I’d probably say not much [interaction], not on a regular basis...but a number of years ago we created road-rail partnership groups.” (Rail)

See section 7.1 for more on RRPGs.
7 Liaison between road and rail authorities

7.1 Road-rail partnership groups (RRPGs)

As mentioned in section 6.3.5, Road-Rail Partnership Groups (RRPGs) have been formed between Network Rail and some local councils. They are a Network Rail initiative to discuss, “on an ad hoc basis, what Network Rail can actually do to help or make the situation better. We do work through our RRPG meetings with local authorities to see what can be done at each individual crossing.” Representatives from other appropriate groups are involved in the RRPGs (such as planning authorities, road safety partnership representatives, etc), and various issues related to crossing operations are discussed, including traffic delay.

"Last year we joined with Network Rail to form a road-rail partnership. There was concern about interaction between road and rail at areas where they intersect and the purpose of the partnership was to manage that interaction at locations which caused concern to Network Rail and the local authority. It’s proving quite productive insofar as Network Rail highlight concerns or objectives, e.g. closing level crossings, making the road network generally more efficient, or providing an improved pedestrian network.” (Road)

"We just talk to each other, see what’s going on and discuss whether it’s going to impact on safety—that seems to be the purpose of the meeting. It was very much Network Rail that approached us to get it set up.” (Road)

Currently, councils involved in RRPGs include Lincolnshire, West Sussex, Sandwell, Bedfordshire, North Yorkshire, Carmarthenshire and Dorset. The first RRPGs were established around 2006, and are currently voluntary. Network Rail has so far approached those councils where a partnership may yield an improved interaction:

"Our liaison with the rail sector has been very poor over the last few years. We did have a meeting earlier this year that was requested by Network Rail who suggested that we ought to sign up to a formal partnership which we’re happy to do...they want to work in partnership with us.” (Road)

It has been suggested that RRPGs should become compulsory:

"These road-rail partnerships are a voluntary way of tackling the problem but they don’t have statutory backing and I think that’s what needs to come in—when you get a collective will to do something, it can happen quicker than a single voice campaigning for something.” (Rail)

However, there is "a huge resource implication” for Network Rail in terms of staff time and costs. The consultation revealed that there are local authorities who feel they have significant issues with level crossings but who are not aware of road-rail partnership groups. Some felt that “an improved dialogue on issues would be something that we would welcome” and current RRPG members felt that “they’re giving benefits” and “they spearhead much better relations with local highway authorities”, indicating that the establishment of more RRPGs in appropriate areas would be beneficial.

An important potential role for the RRPGs is to form a joint approach to funding issues. As previously mentioned (see section 6.3.5), there are difficulties in encouraging road and rail authorities to accept ownership of the problems at level crossings.

"We receive no funding whatsoever to reduce road delays at level crossings, the benefit is on the highway authority side of things, so that’s why we’ve introduced road-rail partnership groups, so we can try and get that joint approach where they contribute to schemes on the basis of benefits to them in terms of congestion, etc.” (Rail)
“How effective they [RRPGs] are I don’t know…it’s the old thing about money, the highway authorities say they haven’t got any money…they’ll be looking for us to fund, and we’re the same.” (Rail)

Despite the perceived lack of benefits to rail authorities in funding crossing closures to reduce road delays, closure would also result in a reduction in risk to rail users.

7.2 The AXIAT model

7.2.1 Background

The AXIAT model (‘Assessment of Level Crossing Investment Alternatives’) is a cost-benefit model bringing together significant road and rail costs and benefits associated with continued level crossing use versus implementing an alternative to the level crossing (such as a bridge, underpass, or closure of the road either side of the crossing). An RSSB project aimed to identify the costs associated with level crossing alternatives to both the road and rail industries. An equal proportion of road and rail personnel were involved in the project. Costs were assembled from a range of sources including reports, reference books, expert opinion and previous construction projects. The model was trialled at seven level crossings and successfully predicted that there was an economic case for closing the two crossings that were closed or about to close (RSSB, 2007f).

Further trials are being conducted with road-rail partnerships in West Sussex, Lincolnshire, Dorset and North Yorkshire, with the aim of establishing which level crossings have a strong business case for closure, and arranging these into a ‘priority table’. Whilst AXIAT has been shown to be effective at establishing which crossings would lead to greatest financial benefit from closure, there is currently no funding mechanism:

“It can present a convincing case for doing something but there doesn’t seem to be a mechanism yet to determine who will spend the initial costs to achieve the long-term benefit” (Rail)

“AXIAT aims to produce a cost-benefit model, which is great, but it still brings up the question of who would fund work to reduce those delays, which might typically be by bridging the location or an underpass…it doesn’t actually work unless we get funding” (Rail)

Currently there is no guidance concerning who should pay for crossing closures, with both rail and road authorities potentially benefiting. Road authorities may be particularly likely to benefit from closure of crossings suffering from serious traffic delays. Townsend-Rose (1978) recommended that:

“Consideration be given to capitalising the savings in road delays at very busy crossings (and)...the attention of highway authorities be drawn to the potential savings in road delays so that the full benefits of these may be considered in bridging schemes”

The economic benefit to railway authorities of crossing closure was estimated by Woods (2006) who calculated that level crossings cost the railway industry £219 million per annum. In addition, it is estimated that two percent of delay costs to the railway industry (with a value of £6.7 million) are attributable to level crossing issues. Any funding policy for level crossing closures needs to take into account the benefit to various parties:

“There are benefits to railway authorities to closing a level crossing so they should rightfully pay something. If it were defined in legislation what each party should contribute, it would be easier to implement solutions. However, the
railway will not be the prime beneficiary and this must be represented as a function of national policy when it comes to funding railway solutions". (Other)

Currently there is no national funding for level crossing closure. Local highway authorities have difficulty funding level crossing closure as Local Transport Plans typically cover schemes up to about £0.5 million. Level crossings typically account for less than 2% of road casualties. Until the recent development of the AXIAT model, rail authorities have only been able to justify closure on safety grounds. Further work is required in order to demonstrate how a business case for closure might be made and the means by which closure might be funded on a national basis.

It was suggested that a funding structure similar to that of Sweden may be the best way forward, whereby the level of funding is negotiated between the highway, railway and planning authorities based on the proportion of benefit to each (RSSB, 2006c). It is hoped that (if and) when the AXIAT model is implemented, it will “improve road-rail dialogue and interaction”.

7.2.2 Approach

The AXIAT model compares the costs of allowing a level crossing to remain open with the cost of upgrading it or replacing with a bridge, tunnel or diversion. The economic case is based on user-associated costs, operating and maintenance costs, construction costs and other exceptional costs. It provides the total cost of each option, which is further broken down into rail cost savings, road cost savings, and a ratio of savings to construction costs. The output also provides a ranking of total cost savings, and savings to construction costs. An example of a data input screen can be found in Appendix B.

The model takes into account road user delay costs, which are estimated at £9.30 per vehicle per hour (2002 prices). Delay is measured using the following algorithm:

\[ D = T \times N \times (M + C + A) \]

Where
\[ D \] = Delay for the number of road users travelling over the crossing in a standard hour
\[ T \] = probability of train passing in a standard hour
\[ N \] = number of road users in a standard hour
\[ M \] = barrier movement time
\[ C \] = time taken for train to clear the crossing once the barriers are down (distance of rail signal trip point from crossing/train speed in mph) x 60 mins
\[ A \] = additional delay time

However, many indirect costs associated with traffic delay at level crossings are not taken into account by AXIAT. These may include further economic costs (for example the value of houses adversely affected by the presence of a crossing, costs to local businesses) as well as environmental costs (such as reduced air quality, noise pollution) and social costs (community severance, anti-social driving behaviour). The AXIAT model does not claim to provide a comprehensive cost-benefit assessment, but it is important to bear in mind that many other factors are involved in building a case for level crossing replacement and such factors may need to be considered alongside an AXIAT assessment.
7.3 The Swedish ‘OLA’ model

7.3.1 Background

The Swedish Road Administration developed the OLA working approach in 2002. OLA is an acronym for Objective data, List of solutions and Addressed action plans. According to Hook et al. (2008), the working approach involves system designers working together to provide solutions to a common road safety problem. With this approach, all key stakeholders are offered an opportunity to present the measures that they are able to implement and as a result to contribute to improved traffic safety. The purpose of OLA is to prevent serious accidents from occurring in the future while also allowing collaboration with relevant system designers and developing solutions and addressed action plans.

The principal aim of OLA is that Swedish stakeholders (listed below) contribute to the development of specified action plans leading to better traffic safety:

- Swedish National Rail Administration (Banverket)
- Swedish Road Administration (Vagverket)
- Association of Swedish Train Operators
- Bombardier Transportation
- The National Federation of Private Road Associations
- Stockholm Transport
- The Swedish Association of Local Authorities and Regions
- Swedish Association of Road Haulage Companies

The dangers of level crossings were brought into focus after two serious incidents in 2004 and 2005. The Swedish National Rail Administration took the first steps towards cooperation among the main stakeholders. The Swedish Road Administration proposed the OLA working approach. The decision that the two organisations should pursue Level Crossing OLA together was made in the spring of 2005.

In terms of level crossings, the ‘Objective data’ consisted of information about level crossings in Sweden and level crossing accident statistics from the road and rail administrations. There are approximately 10,000 level crossings in Sweden. About 3,000 of them have some kind of signalling equipment. Banverket is responsible for 8,000 level crossings. Of these, 2,200 have barriers and 700 have some kind of visual and/or audible signal. All installations are automatically operated by the movements of trains. The number of grade separated road/rail intersections is nearly 3,000.

7.3.2 Approach

The first step is collection of objective data by means of analysis of in-depth studies, literature reviews, official statistics and other data. Next, a ‘List of solutions’ is drawn up by asking key stakeholders to identify effective solutions (short and long term) based on the following questions: What can my organisation do? Is cooperation between organisations needed? What is needed from other organisations?

7.3.3 Results

For level crossings, OLA resulted in ‘Addressed action plans’ from all participating key stakeholders. Without OLA these stakeholders would not have assembled and collaborated during these systematic circumstances. Action plans included:

- Improved design of level crossings
- Increased information and facts
- Exchange of accident investigation experience
- Abolishment of 400 level crossings between 2006–2008 (the proportion that would be public road crossings is not known)
- Prevention of driving through the barrier by installation of object detection devices
- Improved road profiles—approximately 10% of level crossings do not have a good road profile (i.e. they are on humps, inclines, or angles)

According to a review of international crossing closure procedures, the recent closure rate of level crossings in Sweden has been around 80 per year, but it peaked at 300 per year in 2000. Costs are normally shared between the highway authority, the local authority and the infrastructure operator, with the exact proportions being negotiated based on the proportion by which each party will benefit. Proposals for crossing closures may be submitted by either the railway or local or highway authority, and “once one body flags up a crossing for closure then they will tend to work with the other interested parties to reach a solution. There is a quasi-legal requirement for road and rail administrations to work together” (RSSB, 2006c).
8  Case studies

In this section a number of existing level crossings with traffic delays are described, as well as examples of how the problem can be tackled. It is by no means a comprehensive list, but aims to be illustrative of the present situation regarding traffic delays at level crossings.

8.1  Langley Green (site visit)

Langley Green level crossing is situated in Oldbury, on the Birmingham to Worcester (via Kidderminster) line. It is an MCB CCTV crossing operated from Stourbridge and is located 300 metres from Langley Green Rail station. The crossing is under the authority of Network Rail and Sandwell Metropolitan Borough Council, both of which are involved in a Road-Rail Partnership Group (RRPG). According to RSSB (2006) figures, Langley Green level crossing was the sixth worst crossing in the country from 1998-2005 in terms of level crossing misuse, with 10 recorded near misses.

A visit to Langley Green level crossing was conducted in August 2008 with a representative from Network Rail. The crossing was chosen because Network Rail believes it to have severe problems with traffic delays at peak times. The majority of the following information was provided by the representative and photographs of the crossing (see Figure 7) were taken during the visit.

With around ten trains an hour, the crossing is closed for approximately 45 minutes in every peak hour. It was reported that the crossing closes for approximately two to three minutes per train, or longer if a second train is also passing. When visited, the crossing was observed to be shut for three minutes before a train passed, and remained down for another minute until a second train passed. If an approaching train stops at the nearby station (visible from the crossing) the barriers will remain down until the train has passed over the highway. This occurs around four times per hour. At peak times, the traffic queue is reported to extend for up to 150 metres (around 20 cars) on the west side of the crossing and, if drivers see the amber light, they often use an alternative route. The T-junctions on either side of the level crossing can be difficult to negotiate when the crossing is closed.
Delays (which mainly occur at peak times) may result in the following road user behaviours:

- **Drivers taking diversionary routes**
  
  There is an alternative route that bypasses the level crossing which drivers may decide to take if the crossing is closed.

- **Driving on the wrong side of the road**
  
  Queuing drivers may decide to skip the queue in order to turn into a junction prior to the crossing, if the crossing is shut.

- **Yellow box violations**
  
  Traffic has been reported to ignore the yellow box on the east side of the level crossing.

Pedestrians also abuse the crossing. There is evidence of their jumping the barrier or prising apart the barriers in the middle to gain access to the crossing. Buses now avoid the level crossing because of the potential for delay and local residents often complain about the length and frequency of delay.

South-west and adjacent to the level crossing there is a large area of derelict land. A development of approximately 250 homes has been proposed for this area of land—Network Rail is opposed to another heavily used junction being introduced within the vicinity of the crossing and has raised such objections with the local planning authority. Any development of the land would ideally have an access point located as far from the

---

**Figure 7. Views of Langley Green level crossing**
level crossing as possible to reduce the impact on traffic demand for, and flow over the level crossing.

8.2 Tipton (site visit)

Tipton MCB-CCTV level crossing is located adjacent to Tipton railway station and is also under the authority of Network Rail and Sandwell Metropolitan Borough Council. It is situated on the Birmingham to Wolverhampton line and suffers severe traffic delays in both directions, with 15 to 20 trains per hour traversing the crossing. There are plans for at least one more train per hour to use the line from December 2008. Of the passing trains, only four stop at Tipton station every hour. According to a representative of Sandwell MBC, “the crossing is closed up to 45 minutes in any hour and often closed in a single closure for eight minutes...such unreasonably long delays lead to greater risk taking by drivers when the barriers are about to close.”

Figure 8a and 8b. Illustration of Tipton level crossing and surrounding area before and after construction of the relief road

The site was also visited in August 2008 and was chosen because work is currently underway to close the level crossing. Figure 8a illustrates the present layout around Tipton level crossing. The relief road will link Owen Street at Alexandra Road via a new bridge under the railway line, as shown in Figure 8b. Photographs taken during the visit are presented in Figure 9.
The level crossing is due to close in 2010. Unlike Langley Green, the level crossing on Owen Street is the only through-road for the town; there are no diversionary routes for road traffic (there is a subway for pedestrians that will remain open). The following excerpt from the ‘Owen Street Relief Road’ newsletter (November 2007) explains the reasons for the scheme:

“No doubt that everyone knows local, cross-country and inter-city trains use the railway line with the majority of local trains stopping at Tipton Station. Rail safety considerations dictate that the level crossing is closed to road traffic when trains approach within a certain distance of the level crossing; this includes trains that are stopped at Tipton Station. The frequency of trains and proximity of the station means the level crossing can be closed to road traffic for approximately 45 minutes in each hour.”

According to Sandwell Metropolitan Borough Council, the scheme will cost £22.5 million, and includes the construction of a new car park for the railway station, the reconstruction of approach ramps to the pedestrian subway and reconstruction of an existing canal bridge. The work is funded by Sandwell MBC, Department for Transport, Network Rail and Centro.

8.3 West Sussex

West Sussex is a good example of an area which is proactively tackling the problem of traffic delay at level crossings. West Sussex County Council has identified congestion at all four level crossings in the Downland area as “a long standing problem, which also affects emergency services, buses, pedestrians and cyclists. Road traffic has steadily increased on these routes over the years, increasing the scale of the problem and
spreading it over more hours of the day” (West Sussex County Council’s Area Transport Plan, 2006). West Sussex Council has outlined their concerns relating to level crossings and traffic delays. These are:

- Network Rail has increased the distance ahead of an approaching train for level crossing barriers to descend in recent years. This has increased delays and resulting congestion.6
- The barrier closure time varies for each crossing, with some of the longer closures being at the Ford crossing and the shorter closures at the B2132 Yapton crossing encouraging traffic to pass through Yapton.
- The delays to journeys across the area waste time and fuel and can have a negative effect on the local economy and quality of life.
- If barrier closure is for excessive periods it can cause or increase community severance.
- There can also be safety problems, notably if emergency service vehicles are delayed or if traffic queues block back across nearby road junctions.

The Council accepts that there is limited scope for bridging these routes in the near future (“due to cost, environmental impact and effects on property”) so the Area Transport Plan has proposed to reduce congestion at these level crossings by:

- Encouraging routing of traffic, especially HGVs, away from congested level crossings. A route map avoiding level crossings has been produced for HGV drivers and is distributed locally and nationally.
- Promoting journeys at alternative times and using alternative methods of transport, for example through green travel plans at schools and workplaces.
- Urging Network Rail to balance the need to preserve safety at level crossings with reducing severe road delays at peak times for road and rail traffic. This is done through continuing correspondence with Network Rail and the formation of the Arun Valley Rail Partnership.
- Reviewing the effects of congestion on and around the A259.
- Considering carefully any proposals for infrastructure to support strategic developments that may require a new bridge over the coastal railway line in the Downland area.

8.4 North Sheen

North Sheen is an example of an urban level crossing with traffic delay issues. Traffic flow data from North Sheen level crossing in Richmond-Upon-Thames (see Figure 3) clearly shows that traffic delay is far more likely to occur at certain times of the day. Traffic levels peak between 8am and 9am, and again between 3pm and 4pm. This is likely to coincide with the school run; note that the majority of traffic travels south in the morning and north in the afternoon. There are two secondary and four primary schools less than a mile south of the level crossing. During the peak hours there were 222 and 288 vehicles travelling across the level crossing in the morning and afternoon, respectively.

The crossing is located in an urban, built-up area. Parked cars, particularly on the southern approach to the crossing, exacerbate the traffic situation. Consultation with a representative of Richmond Borough Council revealed that, “a major issue is severance, particularly as Network Rail took down half the footbridge to relocate their signal box.”.

---

6 This information was stated in West Sussex Council’s area transport plan http://www.westsussex.gov.uk/CS/committee/dac/Downland%20ATP.pdf. At the time of reporting it was not possible to clarify precisely what action Network Rail had taken to increase the closure time.
A survey in 2008 revealed that the level crossing was closed for 32 minutes per hour in the morning peak, and that, "generally, throughout the day, it's around the half hour mark and we've got something like 50 plus vehicles in the queue [northbound]." The respondent reported that the queues can be problematic both for local residents and for users of other roads:

"It causes problems for local residents because it [the delay] can be anything up to five minutes if there are two or three trains going through, so it's quite a significant delay. Plus Manor Road can queue back onto the A316 so it does occasionally cause problems on the trunk road, too."

The location of side roads near the crossing means that:

"You do get vehicles coming up on the other side of the road to overtake the queue to turn into a side road which has caused some issues."

Overall, the location of North Sheen level crossing makes it susceptible to delay but also means it would be difficult to tackle the problem through grade separation which "would be expensive, and I don't think that politically it would be an acceptable solution."

8.5 Tallington

Tallington level crossing in Lincolnshire (see Figure 10) was commonly mentioned during the consultation as being an example of a level crossing with some of the most severe traffic delays. Tallington level crossing is an MCB CCTV crossing between Grantham and Peterborough and is located on the East Coast Main Line. The level crossing is in a rural area, located just north of Tallington village. The level crossing traverses four railway lines. Although there are less than 200 houses in the village, the crossing is situated on the A16, which is a busy road and long tailbacks can occur when the crossing is closed.

![Figure 10. Tallington level crossing](image)

(© Copyright Rodney Burton and licensed for reuse under the Creative Commons Licence)

A closure analysis of the level crossing at Tallington showed that during the working day (7am to 7pm), the crossing was closed on average 40% of the time in 2000, rising to 57% in 2006 (with an average closure time of 5.14 minutes), while the forecast closure time for 2010 is 86% of the working day. It is expected that by 2010, there will be periods in the day when more cars join the queue at the level crossing than are able to
move over the level crossing when it is open, resulting in gridlock (Allen, 2007). According to a representative from Lincolnshire County Council, “you get traffic queuing for two to three miles...we’re worried that there are plans for more trains down the East Coast Main Line so the barriers would be shut even longer.” The fact that there are four running lines at the crossing makes it likely that more than one train will pass for each crossing closure. The increase in crossing closures and traffic levels will result in high economic costs as well as damaging the quality of the local environment and community.

Lincolnshire County Council is part of a RRPG. The rail authorities realise that there is a severe traffic problem caused by the level crossing but state that “from our point of view, it’s a compliant level crossing, fully protected; mitigation-wise, it’s top of the range, you can’t get a more protected level crossing...it’s really a highways issue.” The parish council at Tallington has formed a working party for the level crossing, stating on their website that:

“For many years there has been anxiety about the effect on the village of the level crossing, and the increasing length of time that it is shut to road traffic. The Highway Authority is however not able to fund a by-pass to alleviate the problem, and Network Rail cannot justify bypassing the crossing.

Efforts are being made to bring together all the interested bodies to make a joint effort to solve the problem, but this is slow going.

In Autumn 2006, the Parish Council established a working party with the following terms of reference:

• Establish current position.
• Determine the main players and their stated position.
• Establish factors affecting route/bridge position; (i.e. is the old route out of date because of subsequent building, what are the rules governing the location of a bypass etc.).
• Consider all available options and associated time scales.
• Determine the relationship, if any, between a Tallington bypass and other potential local bypasses (e.g. for Stamford).
• Make recommendations to the Parish Council for subsequent action."

Pressure groups have been formed to assemble proposals for a bridge and/or underpass and the issue is high on the agenda of local forums. The following excerpt from the minutes of Deepings’ local forum in early 2008 explain the current situation regarding a potential solution to the crossing and the viewpoints of the relevant rail and road authorities:

“There were a number of possible solutions including the building of a bypass or a bridge over the East Coast Main Line. A bridge could be funded by Network Rail. However, Network Rail had stated that the crossing was safe and from their point of view worked well, if there was a road traffic issue this was not Network Rail’s problem but the County Council as Highway Authority. There were other congested rail crossings in the county such as Lincoln High Street.

Lincolnshire County Council stated that the highest priority scheme in the County was for a Lincoln Eastern bypass, but this had not attracted any Government funding. Then there were a further 7 schemes including Boston, Skegness and Sleaford, then a further 18 schemes of which Tallington was one. It was therefore unlikely that a Tallington bypass would be constructed in the foreseeable future. No other development work would take place unless there was a major change in funding arrangements”
It seems that although Tallington level crossing is recognised as having severe problems with traffic delays, there are no plans to tackle the issue and, indeed, “there are plans for more passenger trains” on that line.

8.6 Alameda Corridor East, California (Armistead and Ogden, 2003)

The safety and traffic concerns at 39 level crossings in the San Gabriel Valley near Los Angeles are being addressed through the Alameda Corridor East (ACE) grade crossing programme. The programme will eliminate and improve grade crossings in the area. The total budget is estimated at almost $500million and specific improvements included:

- New traffic and train signs
- Striping (line painting) or re-striping of streets
- Updated signal pre-emption
- Measures to eliminate gate drive-arounds (zig-zagging)
- Minor roadway widening
- Installation of active warning devices
- New pedestrian sidewalks and safety protection
- Re-grading and repair of vehicle crossings

The ACE project involved up to 20 grade crossing separations and four grade crossing closures. It aimed to “increase safety, improve mobility, improve air quality and foster economic vitality” and involved new and traditional improvements, including an Intelligent Transport Systems (ITS) element known as the Intelligent Roadway/Rail Interface System (IR/RIS) traffic management system in the city of Pomona. This used advanced software to coordinate and control traffic, and was developed as an independent system to act as an addition to existing railroad communications. As part of the IR/RIS implementation, the feasibility of various traffic management techniques was tested, as described below.

- Display of advisory notices to motorists (with relation to predicted or existing level crossing blockages)
  
  The IR/RIS project included Dynamic Message Signs (DMS) to advise road users of conditions at downstream level crossings and suggest an alternative route if feasible. Messages displayed on the DMS include ‘train ahead’, ‘stopped train ahead’, ‘tracks clear in X minutes’, ‘possible delay’ and ‘use [alternative route]’.

- Adjustment of traffic signal timing in response to detected train movements
  
  Traffic signal timing plans were modified in conjunction with the DMS advisory messages. Where DMS messages were used to encourage road traffic to divert, the traffic signals increased green time for vehicles not travelling towards the level crossing.

- Modification of intersection timing plans to minimise disruption from traffic signal pre-emption.
  
  The primary objective of the IR/RIS project was to reduce motorist delay and the secondary objective was to achieve safety benefits through less risky behaviour due to reduced queuing and subsequent driver frustration.

Overall, the ACE project demonstrates improvements to level crossings on a grand scale in order to improve safety and decrease traffic delay.
9 Summary and conclusions

This investigation has indicated that there is no single solution to traffic delays at level crossings; instead there are a number of interventions that may manage delay if the crossing is to remain open, whilst the most effective solution appears to be crossing closure. The following points draw conclusions from the main research findings:

- Of the numerous level crossing types, manually controlled barriers (with or without CCTV) are most affected by traffic delays, since they require the barrier to be closed for some time before the arrival of the train. There are over 800 such level crossings in the UK, and they tend to be located where there is a higher level of road traffic.

- Various factors are used by stakeholders in the rail and road authorities to define ‘serious’ traffic delay: the number of complaints from members of the public; the distance or time spent queuing; uncleared queues exceeding the approach road’s storage capacity; risky road user behaviour; duration and frequency of level crossing closure; occurrence of blocking back; delays at the level crossing that are out of line with delays experienced at signal-controlled junctions in the vicinity; and interruption of railway operation. The consequences of ‘serious’ delay include increased emissions, possible community severance, in addition to the economic cost.

- There are currently no highway or railway interventions with the primary aim of reducing road traffic delay at level crossings; most aim to reduce risk. The most effective means of reducing delay (and lowering risk) is level crossing closure. However this has many attendant obstacles to implementation, including finance, environment and politics, and the difficulty of building bridges or underpasses where there is dense housing in close proximity. There are several technological interventions that may reduce delay marginally (e.g. constant warning time systems) although their implementation at the types of crossings most affected by traffic delays may be unlikely for safety reasons.

- Level crossings are sometimes made into a scapegoat for general traffic problems in a town, and features of roads in the vicinity of level crossings (particularly roundabouts and other junctions) may affect traffic delays at the level crossing.

- Currently there is no national funding for level crossing closure. Local highway authorities have difficulty funding level crossing closure as Local Transport Plans typically cover schemes up to about £0.5million. Level crossings account for less than 1% of road fatalities on average.

- There is a desire for more frequent and improved interaction between road and rail authorities, and also for further inclusion of town planners. International level crossing models for interaction can be used as a guide. Government intervention may be necessary to structure funding of interventions. It is important not to lose sight of the need for improved road-rail interaction, for it is this process that will challenge highway authorities to seek solutions to traffic delays at level crossings and to avoid allowing poor urban planning to exacerbate the delays. It is also likely to be the best route to empower railways authorities to enforce guidance with regard to level crossing operations.
10 Recommendations

Most of the measures described in this report mitigate delay to a small extent whilst giving a safety benefit, generally by reducing the prevalence of drivers violating AHB crossings. In order to reduce substantially the amount of delay at level crossings, it will be necessary to do one of the following:

1. Reduce the number of trains on lines with crossings
2. Reduce the time for which the barriers are down
3. Close the crossing
4. Reduce the amount of traffic using roads with crossings

Of these, the first is unrealistic. For the second, the use of obstacle detection in conjunction with Automatic Full Barriers might achieve a small improvement without compromising safety, whilst highway and railway authorities should work together to determine whether AHB crossings are upgraded to full barriers—this is perhaps the single greatest increase in the time for which the barriers remain down.

The third option, closing a crossing, gives the optimum outcome in both safety and delay terms and therefore the recommendation is to develop a means of prioritising crossing closure which takes into account safety, delay and the feasibility of the closure.

The fourth option, reducing the amount of traffic using a crossing (or increasing traffic throughput) may involve upgrading and signing alternative routes and/or minor local improvements mentioned in Section 6.2.4 such as banning parking on the approach to the crossing and banning right turns at minor junctions close to the crossing. Where there is a signal-controlled junction close to the crossing, it should be linked into the crossing control in order to minimise disruption. The potential for management of delay at a roundabout or mini-roundabout close to a level crossing is fairly low, but a consideration of how to manage queues should be undertaken on a site-specific basis.

It is worth pointing out that under some circumstances, there is little point in taking action; reducing delay at a level crossing where there is already serious congestion in the surrounding network may be a fruitless exercise.

All local highway authorities and their rail equivalents should be included in a Road Rail Partnership Group (RRPG) so that stakeholders can agree on the best means of handling level crossings on a local level. This will ensure that resolution of the balance of issues for each site location is enabled by the positive engagement of the local Road-Rail Partnership Groups supported by the AXIAT process once the latter can be rolled out to all authorities. Consultation should also include other relevant authorities including the County Surveyors’ Society (CSS) and the Local Government Association (LGA), for both highway and planning authorities as well as the rail organisations.

Further work is therefore recommended under the auspices of a joint road/rail group at national level, possibly the Road/Rail Interface Group led by Network Rail/RSSB with support from CSS and others so that all parties can contribute proactively to the development direction as follows:

- Development of a definition of ‘serious traffic delay” that takes into account impacts on the community
- Investigating the factors that affect level crossing closure and replacement in order to supplement the AXIAT model and demonstrate how a business case for closure might be made and the means by which closure might be funded on a national basis
- Investigating alternatives to upgrading protection at AHB crossings affected by blocking back
Acknowledgements

The work described in this report was carried out in the Safety, Security and Investigations Division of the Transport Research Laboratory. The authors are grateful to Janet Kennedy who carried out the technical review and auditing of this report, and to RSSB for granting permission to use an example screenshot from the AXIAT program which is not in the public domain.

References


RSSB (2007c). Design and implementation of the All Level Crossings Risk Model. London: RSSB.


# Glossary of terms and abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACE</td>
<td>Alameda Corridor East</td>
</tr>
<tr>
<td>AHB</td>
<td>Automatic half barrier</td>
</tr>
<tr>
<td>AOCL</td>
<td>Automatic open crossing, locally monitored</td>
</tr>
<tr>
<td>AOCR</td>
<td>Automatic open crossing, remotely monitored</td>
</tr>
<tr>
<td>AXIAT</td>
<td>Assessment of level crossing alternatives</td>
</tr>
<tr>
<td>CCTV</td>
<td>Closed Circuit Television</td>
</tr>
<tr>
<td>CWT</td>
<td>Constant Warning Time</td>
</tr>
<tr>
<td>MCB</td>
<td>Manually controlled barrier</td>
</tr>
<tr>
<td>MG</td>
<td>Manned gate</td>
</tr>
<tr>
<td>OLA</td>
<td>Objective data, List of solutions and Addressed action plans</td>
</tr>
<tr>
<td>ORR</td>
<td>Office of Rail Regulation</td>
</tr>
<tr>
<td>RRPG</td>
<td>Road-rail partnership group</td>
</tr>
<tr>
<td>RSSB</td>
<td>Rail Safety and Standards Board</td>
</tr>
</tbody>
</table>

**Highway-rail grade**
- The term for a level crossing in the USA

**Sighting time**
- The time taken to travel the distance measured along the railway from a decision point to the point at which an approaching train becomes visible.

**Strike-in time**
- The length of time between a train activating a ‘treadle’ on the approach to a level crossings and the train arriving at the level crossing. The treadle starts the crossing closure (either automatically for an automatic crossing, or via a signaller for a manual crossing). The time is usually calculated using the maximum permitted rail speed for the location.

**Traffic moment**
- The number of road vehicles using the crossing multiplied by the number of trains passing in a given time period.

**Treadle**
- A mechanical or electrical device that detects that a train axle has passed a particular location.
Appendix A  Topic guide

Survey introduction

The Department for Transport has asked TRL to investigate traffic delays at level crossings. This interview is one of several with highway and railway stakeholders to try and understand the scope of the problem, how it is currently managed and the range of potential solutions. We are interested to hear your experiences of this issue.

We would like your permission to record this conversation so that your responses can be summarised after this interview. I can assure you that your responses will remain confidential and anonymous and will not be related to you in any published material. The information supplied by stakeholders during this consultation will be presented anonymously in a report at the end of this project.

Do you consent to this conversation being recorded?
Do you agree to your responses being used in the way that has been described?

Experience of serious delays at level crossings

- Are you aware of any level crossings that cause particular concern with regard to traffic delay?

- How widespread are ‘serious’ traffic delays at level crossings?
  - Can you quantify the problem locally (or in the areas that you manage)? e.g. No. of crossings affected, no. of hours lost waiting for crossings to open, specific locations of specified crossings
  - Can you quantify the problem nationally? (e.g. No. of crossings affected, no. of hours lost waiting for crossings to open, etc.)
  - If no formal quantification, ask for an informed but informal rating of how much of a problem such delays are (e.g. on a scale of 1-5, where ‘1’ = not a problem at all, ‘5’ = substantial problem)

- How do you define a ‘serious’ traffic delay at a level crossing?
  - Length of queue?
  - No. of complaints?
  - Frequency of crossing closure/% time closed?
  - Frequency of uncleared queues between closed periods?
  - When the duration of delay exceeds a certain threshold?

- In what ways do crossings with ‘serious’ delays differ from those with only minor delays?
  - Any examples? (Please consider highway and railway features)
• **How do delays vary between different types of crossing?**
  
  o Are some crossing types more prone to delays than others? Consider:
    
    ▪ Manual full barrier (locally [MCB] or CCTV operated [MCB CCTV]);
    ▪ manual gate [MG]
    ▪ Automatic half barrier [AHB];
    ▪ Automatic open crossing locally monitored [AOCL]

• **In what ways do traffic delays generate other problems?**
  
  o Blocking back to junctions
  o Disrupting access to businesses/services,
  o Increasing risky driver behaviour/collisions, etc.
  o Other?

**Managing delays at level crossings**

• **How are delays to road users at level crossings currently managed?**
  
  o Consider varying approaches, e.g.
    
    ▪ technological (e.g. variable message signs)
    ▪ operational (e.g. changing timings, retraining crossing operators)
    ▪ addressing road user behaviour (e.g. encouraging alternative routes,
      advanced warnings, education and/or enforcement).
  o Consider all crossings, not only those you operate or oversee.
  o Other?

• **To what extent are the problems associated with traffic delays being managed?**
  
  o E.g. blocking back to junctions, disrupted access to businesses/services, risky
driver behaviour/collisions
  o Are associated problems (e.g. those above) managed instead of addressing
the primary issue of the delays?

• **How could delays at level crossings be managed better in the future?**
  
  o Are operations already optimised or is there scope for improvement?
  o Are you aware of any planned measures to manage delays at level crossings,
and which particular level crossings will be affected? (e.g. filter lanes or lane
separators for busy junctions on approach to crossings)

• **How much success have you had with methods of reducing delay?**
  
  o How have you measured the success or failure of a system for managing
delays?
  o Do you have any examples of where methods of reducing traffic delays at
level crossings have been formally evaluated?

• **When operating level crossings, are there formal processes or guidance for
related traffic management issues?**
  
  o Consider guidance to/from railway operators and local highway authorities
  o How are crossing operators/signal operators trained to manage traffic delays
(if at all)? What is the decision making process? Do they have authority to
change crossing closures to respond to traffic delays?

• **To what extent do the railway and local highway authorities interact over
the operation of level crossings?**
  
  o How much dialogue is there regarding traffic delays? Who initiates this
dialogue? Is it continuous or only when delays become severe?
  o How much pressure is there from each party to reduce traffic delays at level
crossings? (e.g. by changing the timing of crossing closures)
- Are potential solutions generated in cooperation?
  - Are there barriers on either side to finding a solution? What are they?

- How many level crossings are likely to be decommissioned in the future?
  - Are crossings earmarked for decommissioning those with traffic delays?
  - When are they due to close?

- It is our understanding that no new level crossings are planned. Are you aware of any new level crossings being commissioned?
  - Will such new crossings be likely to generate traffic delays?
  - How have potential traffic delays been considered in the planning?

- How many level crossing upgrades/changes are planned?
  - Please describe the nature of these upgrades/changes.
  - Are the upgrades likely to affect the extent of traffic delays?
  - How have potential traffic delays been considered in the planning?
  - Were the changes/upgrades in response to any particular issue (e.g. traffic delays or the issues associated with such delays OR safety concerns (possibly at the cost of longer road closure times).

- How do local populations respond to traffic delays at level crossings?
  - What is their behaviour at the crossing if delayed?
  - How unhappy are locals with level crossing delays?
  - How does local feeling affect the decisions that are made regarding level crossings?

Questions specifically for local highway authorities

- As a local highway operator, how much control do you have over the design and operation of level crossings?

- What measures are in place to deal with the issue of blocking back either over the level crossing or onto nearby junction(s)?
  - Has traffic light signalling been changed at junctions near to the crossing to help to control traffic delays?

Questions specifically for railway authorities

- How often are there circumstances in which the train timings (timetables) might be adjusted to minimise any negative impacts of crossing closure?

Sharing knowledge

- Do you have any documents (guidance, policy, evaluations) that discuss the operation of level crossings and the matter of traffic delays? Would you be willing to share these with TRL for this project?

- TRL are keen to consult with stakeholders who have direct experience of operating level crossings where traffic delays are a particular problem. Is there anyone else we should be talking to about this issue?
Appendix B  AXIAT overview

Reproduced with permission from RSSB

- **Options to assess**
  - Base option
  - Upgrade crossing
  - Replace with bridge
  - Replace with tunnel
  - Divert traffic
  - Replace with alternative pedestrian, cycle and bridleway access
  - Number of crossings to be replaced (1, 2 or 3)

- **Ground quality at scheme site**
  - Average, no piling required
  - Poor, piling required

- **Project optimism bias values**
  - Road, rail, fixed links (bridge, tunnel)
  - Confidence intervals of 50% to 90%

- **Future growth figures**
  - Assumed inflation
  - Required start year
  - Appraisal periods
Investigation into traffic delays at level crossings

This report presents the findings of a literature review and stakeholder consultation investigating traffic delays at level crossings in the UK. The research aimed to investigate road traffic delays at level crossings, scope potential routes to reduce delays and propose key areas that would benefit from further research. The report provides findings on the different types of level crossings in the UK and how their operation may be related to traffic delays (manually controlled barrier crossings are most prone to delay); how traffic delay is defined (many factors are used to define a serious delay); consequences of delay; and factors which may affect traffic delay and interventions which may help to mitigate traffic delays from the perspective of the railway and the highway, and how the two may combine to tackle the problem (no interventions were found which principally aimed to reduce delay, but some might mitigate traffic delay as a subsidiary effect). A number of case studies are also included. The principal findings were that there is a strong need for improved interaction between the road and rail authorities, and that while the most effective means of reducing traffic delay is to eliminate the level crossing, there is no clear funding mechanism to do this.

Other titles from this subject area

PPR298 The travel of errant vehicles after leaving the carriageway. D A Lynam and J V Kennedy. 2008
PPR292 A review of simplified Streetscape Schemes. A Quimby and J Castle. 2007