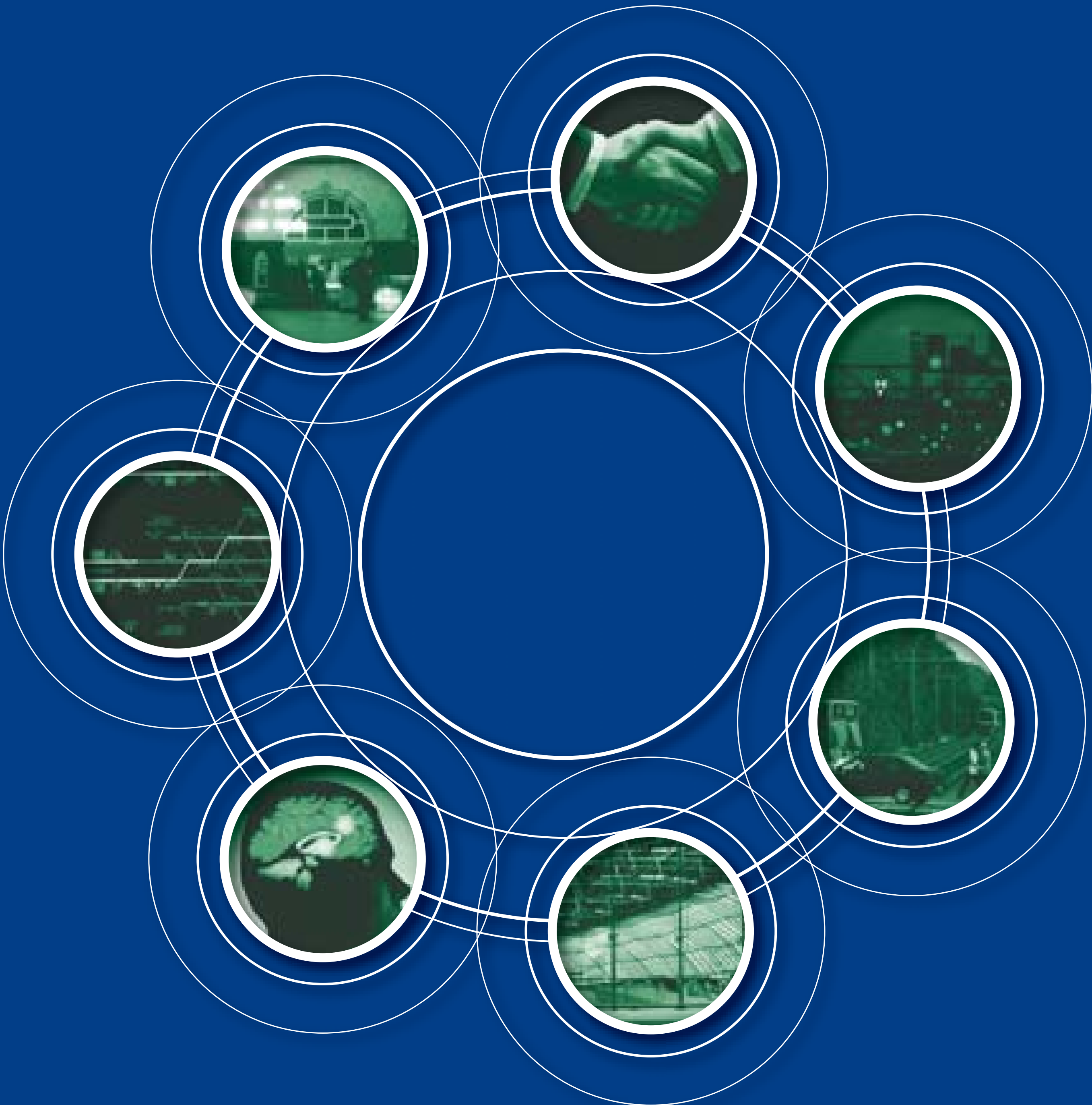
Rail Safety & Standards Board

Research Programme

Operations

T668 Research into the safety benefits provided by train horns at level crossings



Arthur D Little

T668 Train Horns
Risk Review

Report to
Rail Safety and Standards Board

December 2006

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Executive Summary

Introduction

Whistle boards are provided at approximately one fifth of footpath, user worked and open crossings, to provide sufficient warning time for pedestrians to cross safely. The introduction of new types of rolling stock from the year 2000, which have train horns that are louder than those of older trains, has apparently contributed to a significant increase in the number of noise complaints from residents living near crossings with whistle boards.

RSSB has therefore commissioned this project on behalf of the British rail industry to **better understand the risk mitigation associated with the use of whistle boards** at footpath, user worked and open level crossings. It will also support the industry in identifying the level of mitigation that is reasonably practicable to implement. Two specific issues the work had to investigate were the possibility of introducing ‘quiet periods’ in which sounding of the train horn would not be mandatory, and the possibility of reducing the loudness of the newer horns.

The results of this study will be used, together with other research, to inform decisions regarding provision of whistle boards, and identification and assessment of alternatives.

About the research

The work was conducted over a six-month period from May 2006 to October 2006 and comprised review of historic data, site visits to a selection of 51 crossings, a hazard identification workshop, investigation of train horn noise criteria in other countries, development of a tool to be used for assessing the safety risk at individual crossings, and evaluation of the impact of various mitigation measures (to be developed following this report).

The project included regular reporting to industry and circulation of interim reports to the Train Horns Steering Group. Specific meetings were held with parallel workstreams being led by RSSB, which focused on noise contours at specific sites, and opinions on the noise of train horns from residents near to whistle boards, and other members of the public.

Conclusions

The study makes nine key conclusions, and 14 supporting conclusions:

Key conclusions

1. The review shows that there is significant uncertainty over the national level of safety benefit provided by whistle boards
   - The best estimate of the national safety benefit of whistle boards is that it is of the order of 1 to 2 Fatalities and Weighted Injuries (FWI) per year
   - This translates to a 'value' of £1.5m to £3m per year (using the current industry Value to Prevent Fatality)
   - Distributed evenly over the 1,200 (approximate) crossings provided whistle boards, this equates to an average of between £1,250 and £2,500 per year per crossing
   - However, safety risk is not evenly distributed over level crossings, and as such the safety benefits at the highest risk crossings could significantly exceed this (for example £250,000 at a very small number of the very highest risk crossings assuming that they have 100 times the average risk)
2. Whistle boards are an inexpensive (ca £5,000 per whistle board) means of providing sufficient warning at crossings with restricted sight times. Therefore, although safety benefits at most crossings will not be high, whistle boards can be justified on cost-safety benefit grounds
3. We have been informed that other work currently being carried out by RSSB shows that the ill effects to railway neighbours from train horns sounded at whistle boards can be significant. As such, it is likely that at the lower risk footpath and user worked crossings (such as those that have only light use), the cost valuation assigned to a modest impact on the health of railway neighbours would counter, and could potentially outweigh, the safety benefits to crossing users provided by the whistle board
4. There is reportedly a strong association between the increase in number of complaints relating to noise of train horns and the introduction of rolling stock with 'louder horns', and we understand that the industry is considering a return to 'quieter horns' to reduce this impact. This work has found no evidence that, overall, this would lead to a significant change in the risk to crossing users

5. Should the industry decide to reduce the sound level of train horns to reduce the ill effects to railway neighbours, then this will change the balance of the crossing user safety benefit versus noise impact across the population of crossings. Generally, this would increase the number of crossings at which the whistle board could be justified. We would therefore caution against decisions to remove whistle boards based on the current noise levels of train horns
6. Another option being considered by RSSB, is the introduction of 'quiet periods' during defined periods of the night, during which sounding of the train horn would not be mandatory. The work shows that risk to users normalised by exposure (number of trains x number of traverses) is around 15 times higher at night than during the day, although at most crossings low levels of night time use means that the contribution to overall safety loss is small. However, at crossings that are used comparatively heavily at night (we expect that this is true of only a relatively small number of locations) the night time contribution to risk would be significant. A network-wide 'quiet period' implemented at all crossings is likely to have a potentially adverse impact on risk at such locations. Therefore, decisions to implement 'quiet periods' should consider local characteristics, most importantly crossing use at night-time
7. The site visits suggest that there are locations where whistle boards could be considered for removal, since sufficient sight time may be available either because actual train speeds are lower than linespeed, or if vegetation could be further controlled
8. Should the industry decide to remove any whistle boards, it will be very important to consider any possibly adverse impacts on risk during the 'transition' period. Many users will have become accustomed to the sound of the train horn being a prompt to look for an approaching train; this expectation could lead to increased risk for a period after the whistle board is removed
9. Based on the above, the risk to crossing users, and therefore the safety benefits associated with whistle boards, will vary by crossing. Therefore, decisions on whether or not to retain existing whistle boards, provide new whistle boards, and provide alternatives will need to be made on a crossing by crossing basis, and make use of the ongoing work to provide a measure of the ill effects of the train horn on railway neighbours.

Other conclusions - risk at passive crossings, generally

- A review of historic data shows that there are no discernable trends in the number of pedestrians struck by trains at FP and UWC; variations year on year appear to be random
- When normalised by number of crossings, more incidents occur at crossings with miniature warning lights than other types (FP, UWC, and OC). This could be due to the fact that miniature warning lights have been provided at crossings with higher risk and with a higher number of users
- Risk appears to vary by user type. Elderly users are over-represented in incidents compared with other adults. Children and youths are over-represented in near misses, but are relatively rarely involved in actual incidents; in contrast to elderly users they seem adept at getting out the way of the train in the last few seconds

Other conclusions - safety benefit of whistle boards

- Site visits show that train drivers do not always sound the horn at whistle boards. Data collected for this study indicates that the average compliance rate is around 93% in the daytime, is highly variable by location, and is also lower at night (data suggests between 18% and 33%). This suggests that drivers are using judgement in the sounding of the horn. Therefore, the level and consistency of compliance of sounding the horn at whistle boards is an issue for the industry to address
- Although the safety benefit of whistle boards averaged over all 1,200 crossings is not high, (very broadly £1,250 to £2,500 per crossing per year) at some relatively high-risk locations (such as those with very high levels of use or where sight times are particularly short), the safety benefits of whistle boards will be comparatively higher. As such, it is likely to only be possible to justify reduction in the use of the whistle board at these locations where ill effects to railway neighbours are very significant
- The broad estimate of the safety benefit associated with whistle boards (1 to 2 FWI per year – see key conclusion 1) can be compared to some other railway risks as follows (all from the Risk Profile Bulletin Issue 5):
  - Current pedestrian risk at FP, UWC and OC is 4.7 FWI per year
  - Risk to pedestrians struck by trains at all level crossings is 7.3 FWI per year
  - Risk associated with passenger train collision with road vehicles on level crossings is 2.6 FWI per year
- User observations and a structured industry workshop suggest that as well as giving advanced warning of train approach where sight times are

limited, whistle boards also provide a more general warning of a train approaching for users who may not look for trains or be distracted

Other conclusions - louder train horns

- Horns on all types of trains observed during the site visits were audible to our assessors. In most cases horns were classified as 'very audible'
- There is an audible difference between the 'louder' horns (on recently introduced rolling stock) and the 'quieter' horns due to due to both amplitude and tonality. This means that the louder horn is more likely to be heard by a crossing user whose hearing is impaired (e.g. through the use of music headphones or a mobile phone) at locations where there are relatively high background noise levels (e.g. near a road, factory, flight path, etc), or during occasional events (such as an idling farm vehicle, passing airplane, the noise of rain on a hood or umbrella, etc)
- The duration with which the horn is sounded can also have an impact on how likely it is to be heard. There are no criteria for the duration of the sounding of the horn, and as such this varies significantly

Other conclusions - risk by day and night

- It appears from limited data gathered for this study that the level of compliance of sounding the train horn at the whistle board at night is low (based on site surveys the level of compliance is between 18% and 33% at night – based on two site surveys – compared with 91% during the day). Therefore, if night time 'quiet periods' were introduced (during which the sounding of the horn would not be mandatory), the impact on level crossing safety risk and noise nuisance to neighbours would be incremental over the current situation, since an ad hoc reduction in the sounding of the horn appears to already be in practice
- Overall, a decision to implement any 'quiet periods' will need to take account of the risk work presented here, and an assessment of the 'cost' of the noise nuisance associated with the sounding of the horn at night
- A network-wide 'quiet period' implemented at all crossings is likely to have a potentially adverse impact on risk at specific locations that are heavily used at night. Therefore, decisions to implement 'quiet periods' should consider local characteristics, most importantly crossing use at night-time
- Few countries (of those considered in this research) implement restrictions on the sounding of the train horn at night. Exceptions are South Africa (the horn is not used between 2300 and 0500) and the United States, where

there has been a history of ‘whistle bans’ (some of which were specific to night-time), and where new rules provide for establishing ‘quiet zones’ with alternative risk controls funded by the community

Next steps

As noted previously, the results of this work will be used by RSSB, together with the results of other workstreams, including work to value the cost of noise to railway neighbours, to inform decisions regarding whistle boards. A spreadsheet tool, which is under development as part of this project, is expected to provide the industry with a means of conducting location-by-location assessments to help identify reasonably practicable measures for reducing risk that consider any local ill effects associated with whistle boards.

1. Introduction

1.1 Background

Whistle boards are an option for providing sufficient warning time to allow pedestrians to cross safely at footpath, bridleway, user worked and open crossings. The train horn is sounded by the train driver on sight of the whistle-board located in advance of the level crossing. Train horns are specifically designed to warn level crossing users not in motor vehicles such as pedestrians, cyclists, horse-riders etc, although the sound may be an additional safeguard for motorists. 6,337 crossings on Network Rail controlled infrastructure (approximately 81% of all crossings) are types where whistle boards could potentially be provided. Currently, whistle boards are provided at approximately one in five of these crossings, and Network Rail as part of its risk management processes at level crossings, has identified further locations where whistle boards are to be considered.

In around the year 2000, new types of rolling stock started to be introduced on the network which have train horns that comply with the sound levels specified in the Railway Group Standard GM/RT2484 (April 2005). These train horns are louder than the horns on older rolling stock and as such, there has been a significant increase in the number of complaints from residents living near crossings with whistle boards.

RSSB has therefore commissioned this project on behalf of the rail industry in Great Britain to better understand the risk mitigation associated with the use of whistle boards at footpath and level crossings. The results of this study will be used, together with other research, to inform decisions regarding provision of whistle boards, and identification and assessment of alternatives. The increase in the number of noise complaints has introduced a counter argument to the use of whistle boards as a risk mitigation for crossing users, whereas previously there was little or no argument against providing a whistle board where sighting was limited. In summary, there is now the need to balance the safety benefits provided by whistle boards, against the ‘cost’ of the noise nuisance associated with the sounding of the horn.

An earlier and very brief phase of the work (completed in early 2006) focussed on footpath crossings only. This more extensive second phase of work expands the scope to other crossings where whistle boards may be provided including footpaths, user worked crossings and open crossings.

1.2 Scope and objectives

The overall objectives of the work are to evaluate the risk at crossings that can potentially be provided with whistle boards, the benefits associated with whistle boards, and to support the industry in identifying the level of mitigation that is reasonably practicable to implement. The work included addressing specific questions:

- The possibility of a introducing 'quiet periods' in which sounding of the train horn would not be mandatory
- The possibility of reducing the loudness of the newer horns (for example to previous levels)

In parallel, RSSB also led work to investigate the impact of the noise of the train horn on residents near to whistle boards. This is separate from the scope of the work presented in this report, but has an important interface in reaching overall conclusions about the reasonable practicality of options to reduce the risk to a level that is as low as reasonably practicable.

The scope of the project included the following crossings at which whistle boards may be provided:

- Footpath crossings (FP) and bridleway crossings (BW)
- User worked crossings (UWC). These may also be provided with telephones (UWC+T) or miniature warning lights (UWC+MWL)
- Open crossings (OC)

The remit specifically asked that the work included examining the different exposed groups including:

- Pedestrians
- Road vehicle occupants in 'pedestrian mode'
- Horse riders
- Cyclists
- Track workers (applicable for any engineering changes to the train horn)

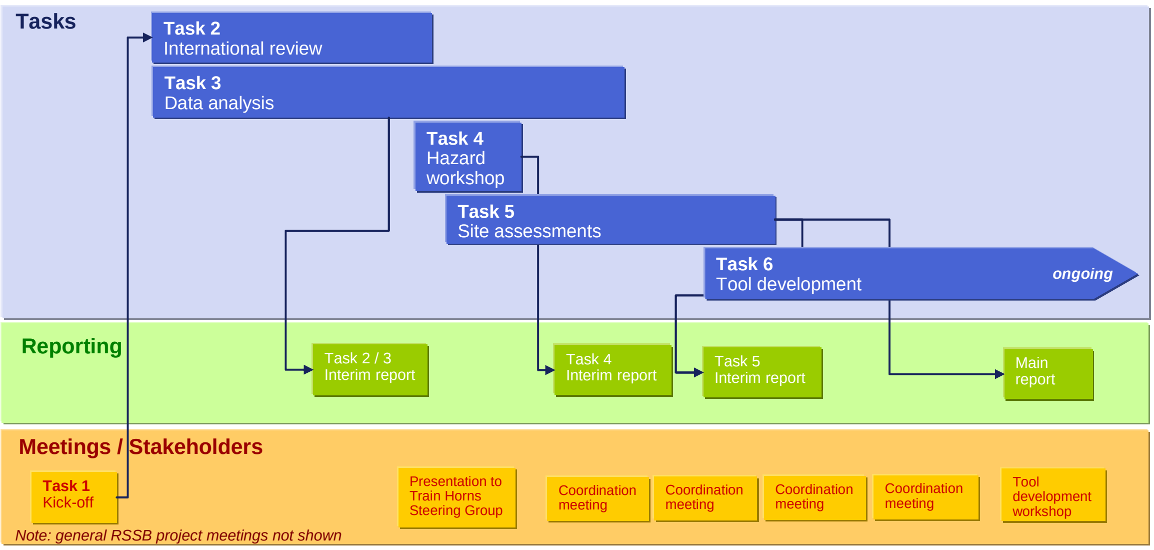
1.3 Overview of approach

The work was conducted over a six-month period from May 2006 to October 2006 and comprised the following key activities (see Figure 1).

- Extensive review of historic data from the Safety Management Information System (SMIS) and other sources
- Site visits to 51 crossings to observe user behaviour, interview users, and develop opinion on the audibility of the train horn and the frequency with which it is sounded at whistle boards
- Hazard Identification Workshop
- Investigate train horn noise criteria in other countries
- Development of a tool to be used for assessing the safety risk at individual crossings, and evaluation of the impact of various mitigation measures (this development of the tool in underway at time of writing this report)

Throughout the project, task specific reports were produced which were provided to RSSB and the Train Horns Steering Group. Progress meetings were held with the RSSB project team, and specific meetings were held with parallel workstreams which focused on noise level measurements at specific sites, and opinions on the noise of train horns from residents near to whistle boards, and other members of the public.

Figure 1: Project approach



Source: Arthur D Little

2. Safety risk at passive level crossings

This chapter presents an analysis of historic accident and near miss data at those level crossings within the scope of the project. Two main categories of data are reported:

- 'Incidents' – in which a person was struck by a train at a crossing
- 'Near misses' – a reported near miss at a crossing (usually a report by a train driver who experienced the near miss)

Data was provided from an interrogation of the SMIS (Safety Management Information System) database, between January 2001 and March 2006 (i.e. 5.25 years worth of the most recent available data).

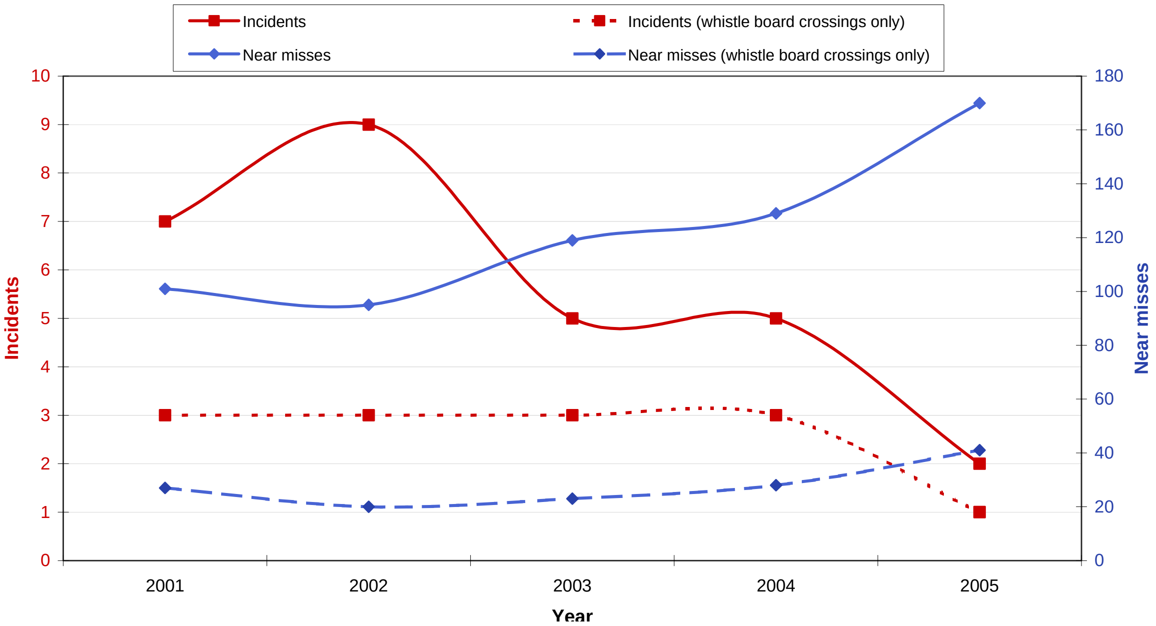
2.1 Overall trends in incidents and near misses 2001 to 2005

Analysis of the data from 2001 to 2005 suggests that there has been a decrease in the number of incidents (Figure 2). Counter to this, the same data suggests an increase in the number of near misses reported. A subset of this data presented for crossings with whistle boards is less suggestive of any trends in either incidents or near misses.

The reasons for these apparent 'trends' are not clear, but it is important to note some limitations with the data before attempting to draw any conclusions. Firstly, the number of near misses reported may be an artefact of reporting processes, and could indicate an improvement in the proportion of near misses that are reported of all those actually experienced. Secondly, the number of incidents per year is small (between nine in 2002 and two in 2005) therefore any apparent trend will be subject to significant random variation. Note that known suicides are excluded from the analysis.

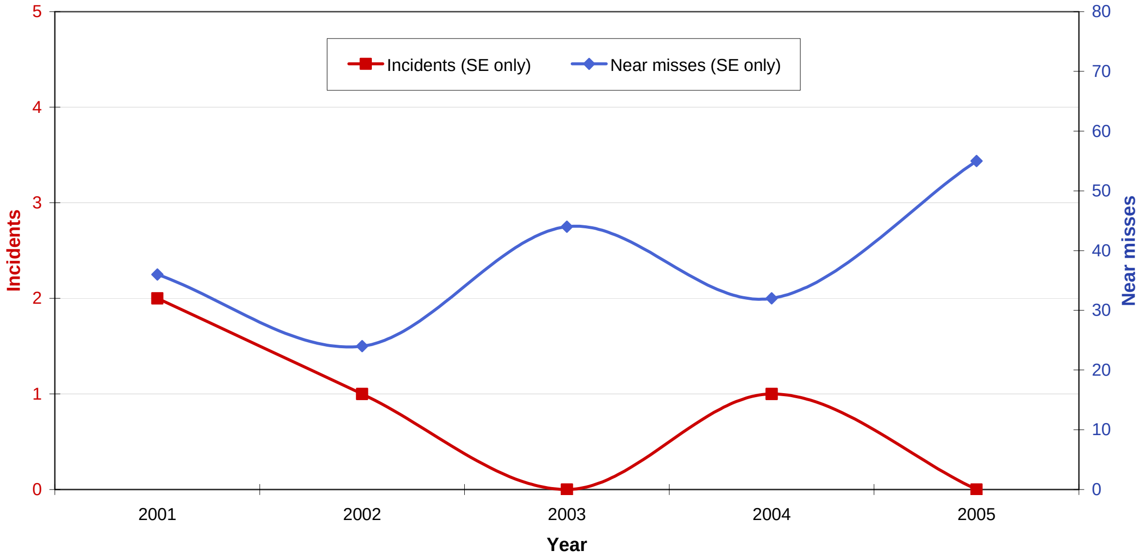
It is perhaps interesting to note that the decrease in incidents appears to coincide with the introduction of newer rolling stock, with so-called louder horns, although there is not specific evidence to suggest that the two are actually linked. Indeed, the decrease in incidents has been more at crossings without whistle boards than at crossings where whistle boards are provided - where the number of incidents has been constant until 2005 (Figure 2). The data for the south-east, where many of the newer trains have been introduced, (Figure 3) has been plotted to see if there is any further suggestion of a link between the introduction of new rolling stock and incident trends. All that can be drawn from this is that the data appears to follow the data for all areas (Figure 2) within a reasonable degree of random variation. Overall, the number of incidents is too few (between zero and 1 per year for the most recent four years) to draw any conclusions.

Figure 2: Incident and near miss trend 2001 to 2005



Source: Analysis of January SMIS 2001 to March 2006

Figure 3: Incident and near miss trend 2001 to 2005 (south-east only)



Source: Analysis of January SMIS 2001 to March 2006

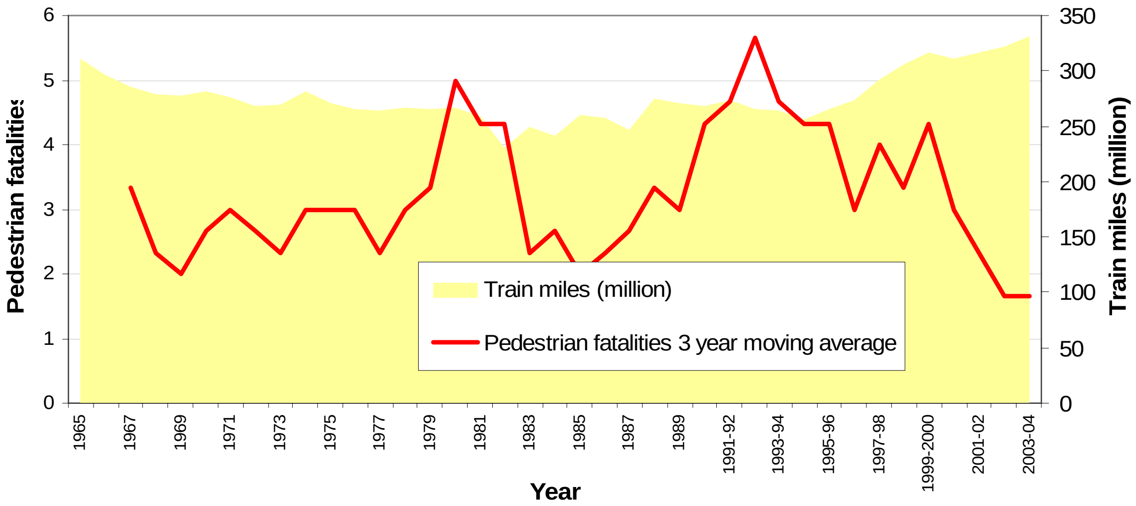
2.2 Trends in incidents over longer period

An analysis of reports published by Her Majesty's Railway Inspectorate by Professor Andrew Evans provides a much longer period over which to review incident trends. Figure 4 shows the number of pedestrian fatalities at FP and Figure 5 the number of pedestrian fatalities at UWC. In both cases the data is plotted alongside the number of train miles on the British rail network.

The main observations for FP crossings are:

- The overall trend does not appear to follow the number of train miles on the network, suggesting either random variation[1], or that other factors have a greater influence
- The number of pedestrian fatalities appears to show two noticeable peaks (around 1980 and 1993), although the overall trends appear to be within expected random variation[2]
- The number of pedestrian fatalities in recent years appears to have reduced compared with last two decades. Again, this appears not to be statistically significant

Figure 4: Historic safety performance at FP crossings



Source: Analysis by Professor Andrew Evans of data in Her Majesty's Railway Inspectorate transport safety reports, 1946 – 2003/4

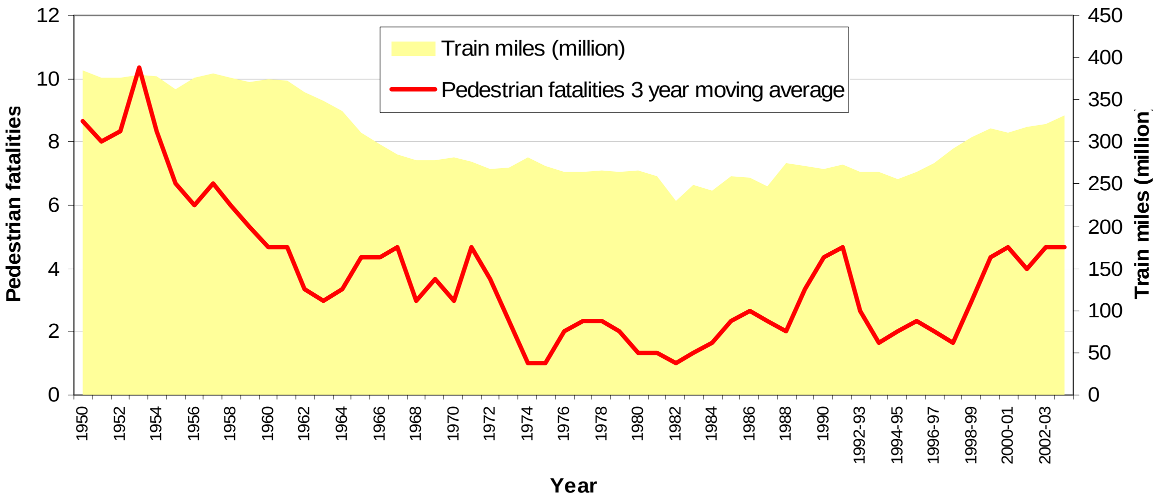
[1] The variation in fatalities over time compare closely with what would be expected from a random distribution (according to a Poisson distribution). This means that overall, there are no major unexpected variations in the number of incidents.

[2] A Wald-Wolfovitz runs test indicates that the apparent run of higher fatalities (1990-1996) or the apparent recent decrease (2000 onwards) are no more than expected random variation.

The main observations for UWC are:

- Compared with FP crossings, the overall trend appears to more closely follow the number of train miles on the network (the lowest number of pedestrian fatalities coincides with the lowest period of network utilisation in the late 1960s to the late 1990s)
- There are less obvious peaks or troughs compared with FP crossings, although this could be because the greater number of fatalities per year mean that the impact of random variation is less noticeable
- Counter to the results for FP crossings, recent years show, if anything, an increase in the number of pedestrian fatalities. This could be a result of random variation, or may be more closely following the upward trend in number of train miles

Figure 5: Historic safety performance at UWC



Source: Analysis by Professor Andrew Evans of data in Her Majesty's Railway Inspectorate transport safety reports, 1946 – 2003/4

2.3 Overall analysis of incidents and near misses

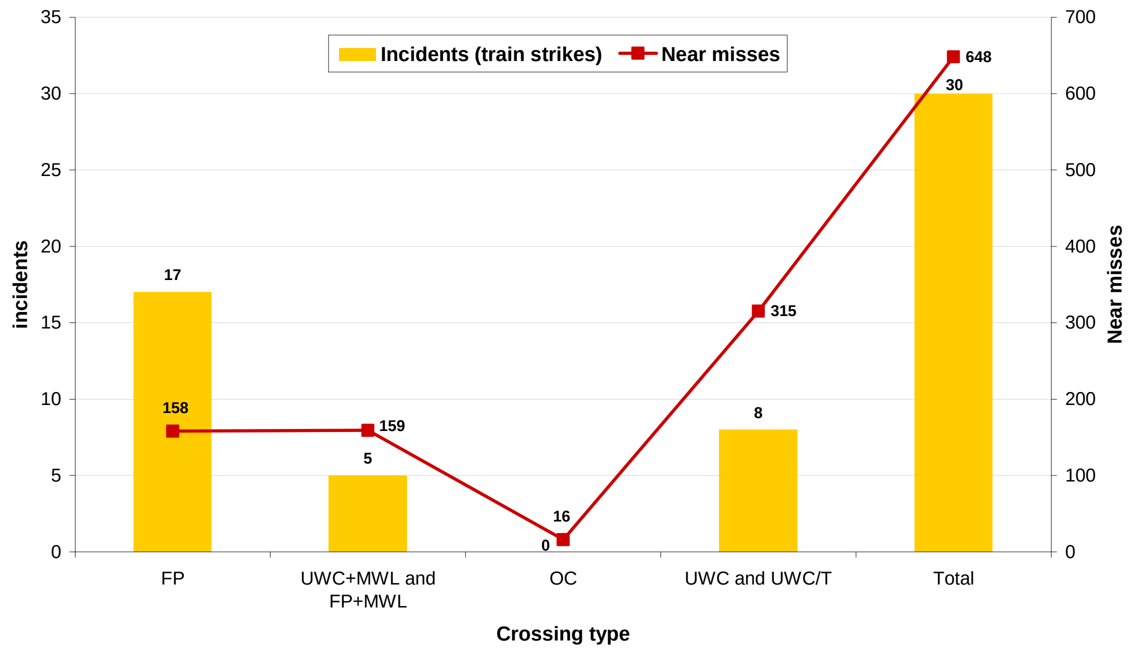
30 incidents (a train striking a pedestrian) and 648 near misses are reported in the dataset from January 2001 to March 2006 (Figure 6). This shows:

- Over half (17/30) incidents have occurred at FP crossings
- Five incidents have occurred at crossings with MWLs (FP and UWC)
- Eight incidents have occurred at UWC and UWC/T
- Overall in this period, an incident (train strike) occurs for approximately every 22 (648/30) reported near misses

- The ratio of near misses to incidents does, however, vary year on year (refer back to Figure 2), with the ratio being significantly higher in 2005, and lower in 2002. This may largely reflect random variation in the number of incidents (but as discussed in section 2.1) there also appear to be an increasing number of near misses reported
- The ratio of near misses to incidents is fairly consistent by crossing type, with the exception of FP crossings, where the data suggests that fewer near misses are reported per incident that occurs

It must be remembered that the data includes only reported near misses. The proportion of near misses that are actually reported of course is not known, although it is likely that a number are not reported. The proportion of near misses that are reported may also vary by line of route, since the ease of reporting the near miss (e.g. by in cab radio versus a report when back at the depot) may be an influencing factor.

Figure 6: Incidents by crossing type



Source: Analysis of January SMIS 2001 to March 2006

More revealing is the number of incidents normalised by the number of crossings, as this shows the rate of incidents that have occurred per crossing (Figure 7). This shows:

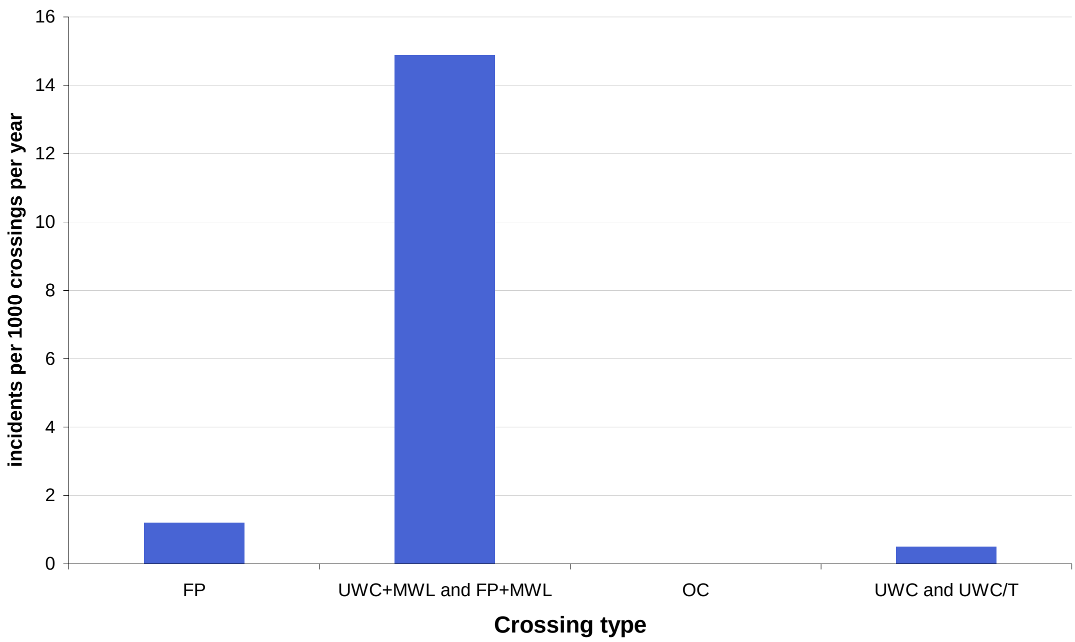
- Far more incidents occur per crossing at crossings with MWLs at a rate of approximately 15 incidents per 1000 crossings per year

- The rate of incidents at FP crossings is much lower at around 1.2 per 1000 crossings per year, and lower still at UWC and UWC/T at 0.5 per 1000 crossings per year

Taking each of these points in turn, firstly the high normalised incident rate at crossings provided with MWLs may not be unexpected when it is considered that such controls are more likely to have been placed at crossings which are known to have had a relatively high risk and / or high level of usage. If this is true, however, it means that providing the MWL does not reduce the risk to a lower typical level at other crossings since the normalised incident rate is still higher than UWC or FP crossings.

Secondly, the lower incident rate at FP and UWC compared to MWL crossings is likely to be the reverse case; these crossings on average will be more lightly used than crossings where MWLs have been provided. Many UWC for example, will have a very low pedestrian level of use and many agricultural crossings will have little or no pedestrian use at all (except when a vehicle is taken over).

Figure 7: Incidents normalised by number of crossings

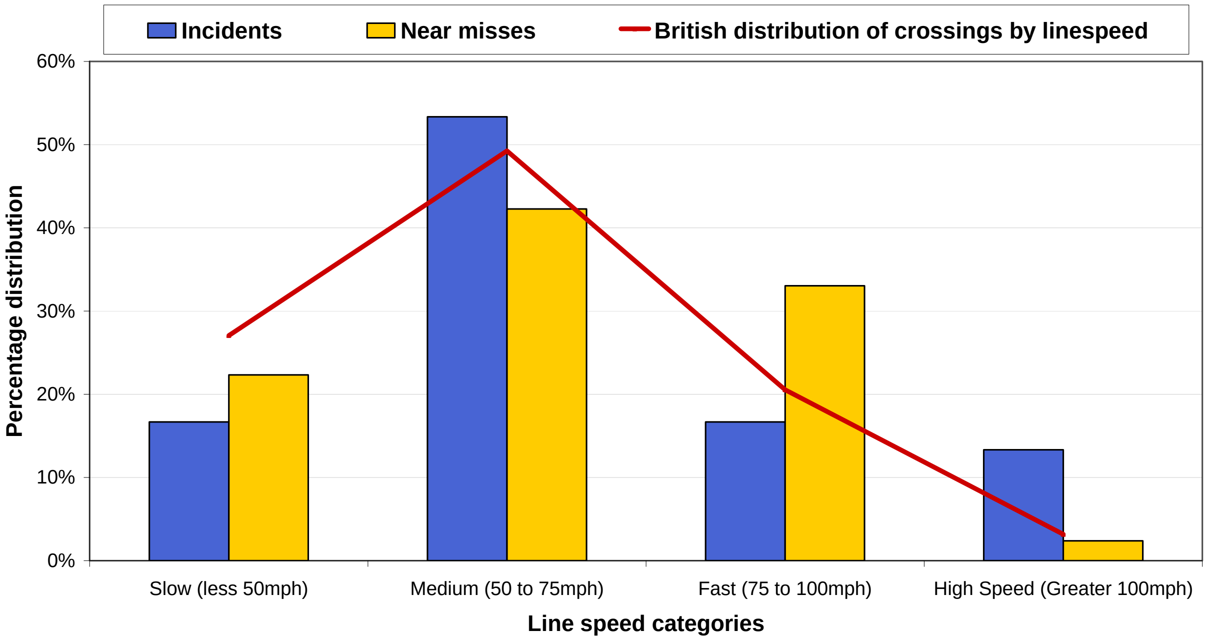


Source: Analysis of January SMIS 2001 to March 2006

2.4 Incidents and near misses by linespeed

Most incidents and near misses occur at crossings on lines with linespeeds in the range of 50-75mph (Figure 8). When compared to the number of crossings (the red line), incidents on the fastest lines are over-represented (i.e. they occur more often than the number of crossings would suggest).   This suggests that there are more incidents per crossing on lines over 100mph, although there appears to be no trend for lower speeds. It must be noted that the number of incidents in each category is quite small, and so the results are sensitive to single events (for example there were four incidents in total on lines over 100mph, two at crossings with whistle boards and two at crossings without whistle boards). There is no obvious trend for the number of near misses with linespeed; more near misses per crossing are reported for linespeeds of 75-100mph, but far fewer for linespeeds over 100mph.

Figure 8:   Incidents and near misses by linespeed



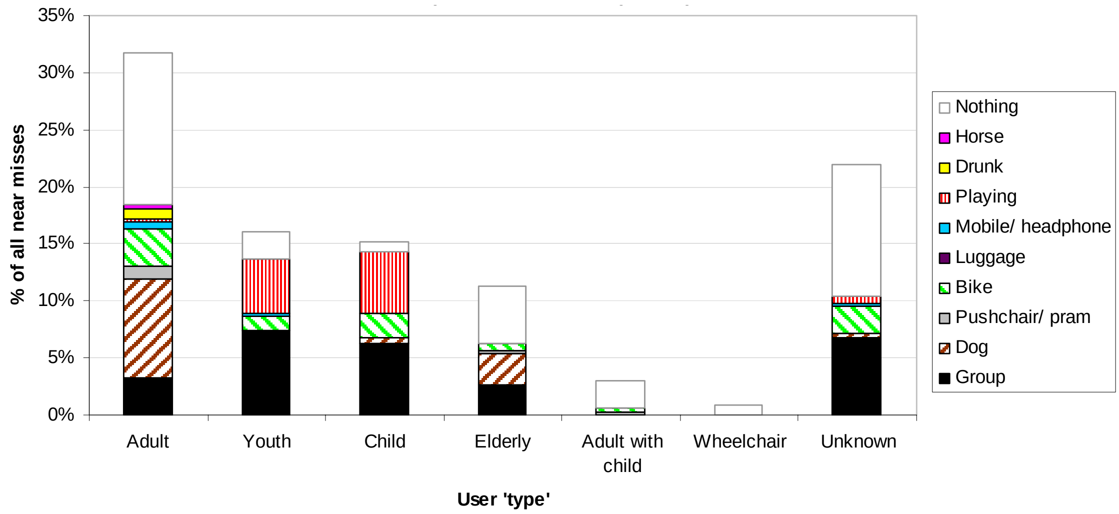
Source: Analysis of January SMIS 2001 to March 2006

2.5 Risks to different crossing users

An analysis of near miss data shows that most commonly reported are adults, of which a large proportion (about 25%) was walking dogs. Many such incidents report animals off the lead who are being retrieved by their owners, or apparently pulling the owner onto or near the line. It is clear that in such cases the dog is a ‘distraction’ to crossing the line safely.

About 25% of near misses mention a group or couple, most commonly where youth or children were involved. Around a third of children and youth appeared to be playing chicken on the line.

Figure 9: Near misses by user 'type'

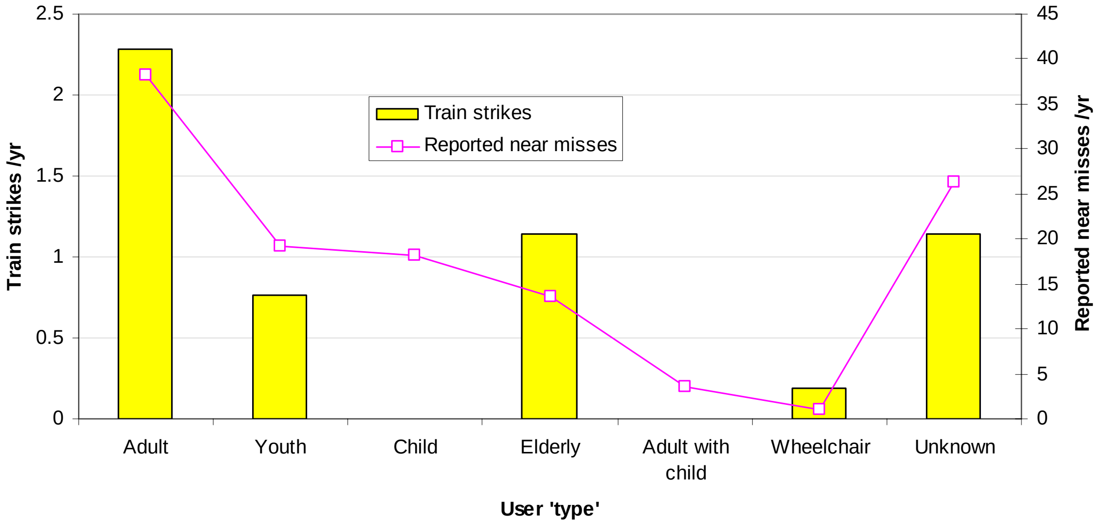


Source: Analysis of 337 near miss reports 2001 to 2006

A comparison of the number of train strikes with the number of near misses shows variation across the different user types (Figure 10).

- Notably, elderly users appear to be involved in train strikes at a relatively high rate compared with the number of near misses, suggesting that they are on average less able to get out the way of the train in the last few seconds
- In contrast, youth have a low rate of strikes compared to the number of reported near misses. This can probably be explained by the fact that many reports of near misses involving youth are apparently incidents of 'playing chicken' on the line. In such cases those involved are deliberately experiencing a near miss and are relatively skilled at avoiding being struck by the train
- No train strikes have involved children in the dataset examined, although they do appear quite frequently in reports of near misses. This could indicate random variation or 'luck', or could reflect more of a tendency of drivers to report near misses with children
- Wheelchair users appear to be over reported in train strikes compared to the number of near misses reported, suggesting impaired ability to escape in the last few seconds. (It must be noted however, that this is based on a single event)

Figure 10: Comparison of train strikes and near misses by user type



Source: Analysis of 30 train strike and 337 near miss reports 2001 to 2006

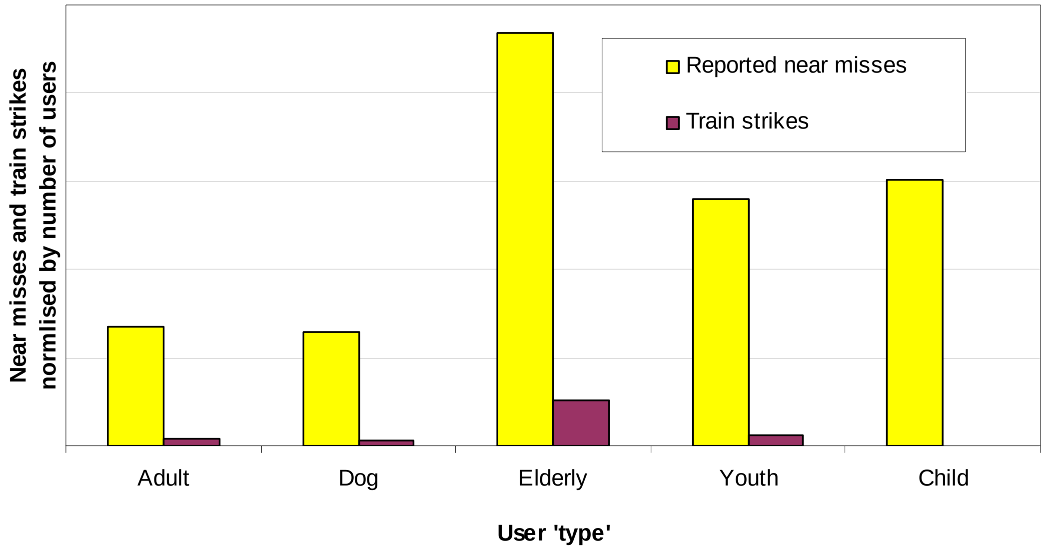
To understand the relative risk to each user group, it is necessary to know the number of users in each group. An estimate of the proportion of users in different categories has been made from the 51 crossings visited for this study. This has been used to normalise the number of incidents and near misses (from Figure 10) to show how different user types are represented compared to what would be expected from their number[3].

- It appears as though elderly users experience both more near misses and train strikes per user than, for example, other adults
- Dog walkers, although appearing very frequently in reports of miss and train strikes, appear not to be over-represented when normalised (in other words they appear frequently because they represent a high proportion of users at crossings)[4]
- Adults, dog walkers and youth appear to not have significantly different normalised rates of train strikes, although the normalised number of near misses is higher for youth (see also above)

[3] Note that in Figure 11 the categories of user are different from the previous analyses in order to match how the user types were allocated in the site visits.

[4] The proportion of dog walkers at crossings does however vary significantly by location. More dog walkers were seen at rural locations than urban or suburban areas.

Figure 11: Near misses and train strikes compared to % of crossing users



Source: analysis of 337 near miss reports 2001 to 2006. Estimated % of users based on site visits to 51 crossings

2.6 Estimate of individual risk at passive crossings

Although the number of incidents at passive crossings is known, the individual risk is poorly understood, since there is currently no accurate measure of the total number of users who are exposed to the risk.

A broad estimate of the individual risk for the crossings visited for this study, and for all FP, UWC and OC shows the following:

- For the crossings visited for this study (for list see Appendix A) the individual risk to a regular user is estimated to be 1.7 x 10^{-4} per year (see the second column of Table 1). This is based on the levels of pedestrian use estimated from the site visits to these crossings
- For all FP, UWC and OC over the network, the individual risk is estimated to be around 1 x 10^{-4} per year (the third column in Table 1). Because the overall level of pedestrian use at all crossings is not known, this is based on an 'average' level of use from a survey of crossings carried out by Human Engineering on a previous assignment for RSSB[5]

Although these estimates are only approximate (particularly that for all FP, UWC and OC) it provides some indicator of the level of individual risk. The fact that the risk at the crossings visited is estimated to be higher than the average for the population of crossings as a whole is not surprising; indeed the

[5] "Human factor risk at user worked crossings", T269, Human Engineering for RSSB, June 2004.

aim was to select crossings that had whistle boards, had experienced a number of near misses, and had high moments.

The estimate for the crossings visited for this study is higher than the level previously regarded as 'intolerable' by the UK Health and Safety Executive (1 x 10^{-4} per year for members of the public). The average level of individual risk for all crossings appears to be lower, although is estimated to be roughly at the threshold of the level previously regarded as 'intolerable'.

However, interpretation of individual risk for the railway, and in particular level crossings, is unclear and is the subject of ongoing discussion. Network Rail have recently suggested that there will be less emphasis placed on individual risk.

Table 1: Individual risk estimates

	Crossings visited	All FP, MWL, OC, UWC
Number of crossings	52	5,999
Near misses per year (per crossing)	10.7 (0.21)	123.4 (0.021)
Train strikes per year (per crossing)	0.57 (0.01)	5.71 (0.001)
Ratio of near misses: train strikes	18.7	21.6
Average no users per day	78	13
Near misses per traverse per year	7.2. x 10^{-5}	4.3 x 10^{-6}
Strikes per traverse per year	3.3 x 10^{-7}	2.0 x 10^{-7}
Individual risk per year for user making 500 traverses	1.7 x 10^{-4}/yr	1.0 x 10^{-4}/yr

Source: Arthur D Little analysis

2.7 Summary of analysis of safety risk at passive crossings

The key points from the above analyses of safety risk at passive crossings (sections 2.1 to 2.6) are:

- The number of incidents (i.e. train strikes) occurring at FP and UWC over time appears to vary in line with what would be expected from random variation. The number of reported near misses, however, appears to have increased in the past five years or so, but this is most likely as a result of improvements in reporting practices
- When normalised by number of crossings, more incidents occur at crossings with MWLs than other types (FP, UWC, and OC). This is likely to be due to the fact that MWLs have been provided at crossings with

higher risk and with a higher number of users. At FP and UWC, the rate of incidents is around 1 per thousand crossings per year

- More incidents seem to occur on the very fastest lines, although the small number of incidents means that this may not be statistically significant
- It appears as though risk does vary by user type. Most notably, elderly users are over-represented in incidents compared with other adults. Children and youths are over-represented in near misses, but are relatively rarely involved in actual incidents; in contrast to elderly users they seem adept at getting out the way of the train in the last few seconds
- Incidents involving people in groups and dog walkers appear frequently in near miss reports, suggesting that distraction contributes to potential risk
- Estimating the individual risk to users of crossings is difficult because there is poor knowledge of the level of utilisation over the crossing population as a whole. Best estimates, based on approximate levels of utilisation gathered from the crossings visited for this study and previous work carried out for RSSB, suggests that the average individual risk across all passive crossings is around $1x10^{-4}$ per year, and for the crossings visited for this study somewhat higher, at around 1.7×10^{-4} per year (based on 500 traverse per year for a regular user)

Overall, the data analysis highlights some key factors that appear to influence risk at crossings, but the low number of incidents means that it is not possible to draw any statistically significant conclusions from this data alone. Chapter 3 looks in greater detail at the data in the context of provision of whistle boards, and introduces more data from site visits and from expert judgement.

3. Safety benefits of whistle boards at level crossings

This Chapter discusses the safety benefits of whistle boards provided at level crossings and is structured in the following sections:

- Provision of whistle boards at crossings – provides an overview of where whistle boards have been provided
- Rates of incidents at crossings with and without whistle boards – considers if there are differences between the number of incidents where whistle boards have been provided, and what this tells us about the safety benefit of the whistle board
- User behaviour and error – looks at what errors are made, how these can lead to accidents, and how the whistle board can mitigate these errors
- User types and crossing characteristics – how the effectiveness of the whistle board depends on the characteristics of users and the crossing
- Do train drivers always sound the horn?
- Conclusions – pulls together key points from preceding sections

3.1 Provision of whistle boards at crossings

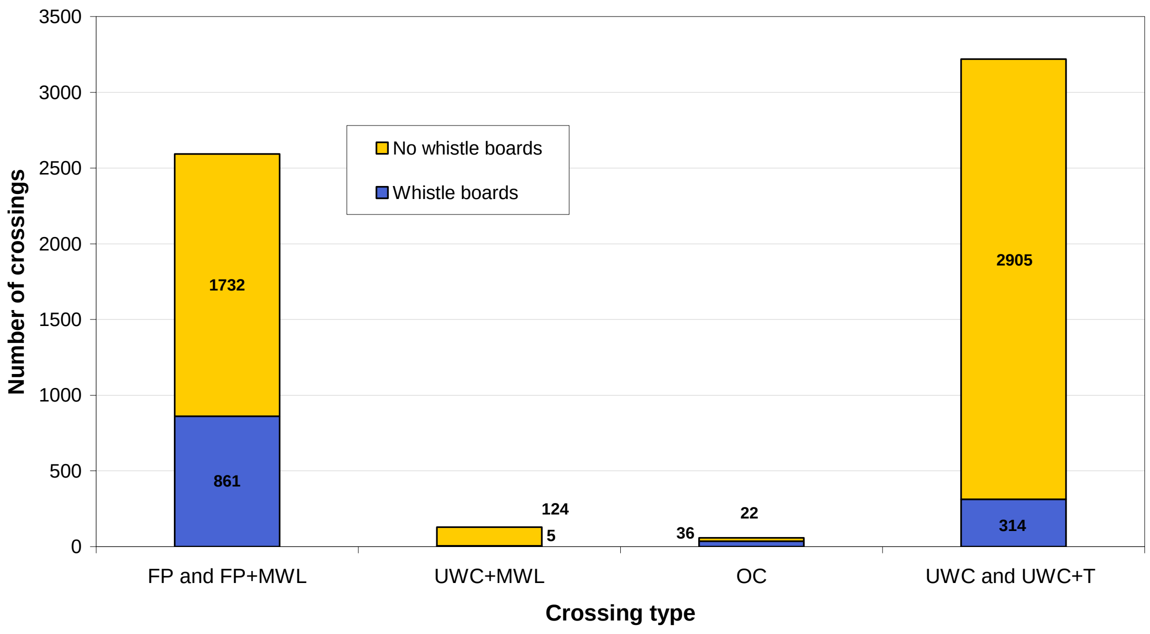
The "Railway Safety Principles and Guidance, Part 2 Section E Guidance on Level Crossings", provides guidance use of whistle boards:

- For footpath crossings, the warning time should be greater than the time required for users to traverse
- Where warning time is insufficient a whistle board may be provided not more than 400m from the crossing
- Where whistle boards are provided they are required on all railway approaches and the difference in warning times should be three seconds or less
- For open crossings, "where trains are not required to stop before passing over the crossing, a combined speed restriction and whistle board should be provided at a point from which the crossing speed begins". It also says "train drivers are also required to sound the horn of the trains between 0700 and 2330"

Analysis of data provided by Network Rail shows that approximately 20% of the combined population of FP, UWC, MWL and OC have been provided with whistle boards. The proportion of crossings provided with whistle boards varies by type (Figure 12):

- FP and FP+MWL 33%
- UWC+MWL 4%
- UWC and UWC+T 10%
- OC 62% (approximate)[6]

Figure 12: Distribution of whistle boards by crossing type

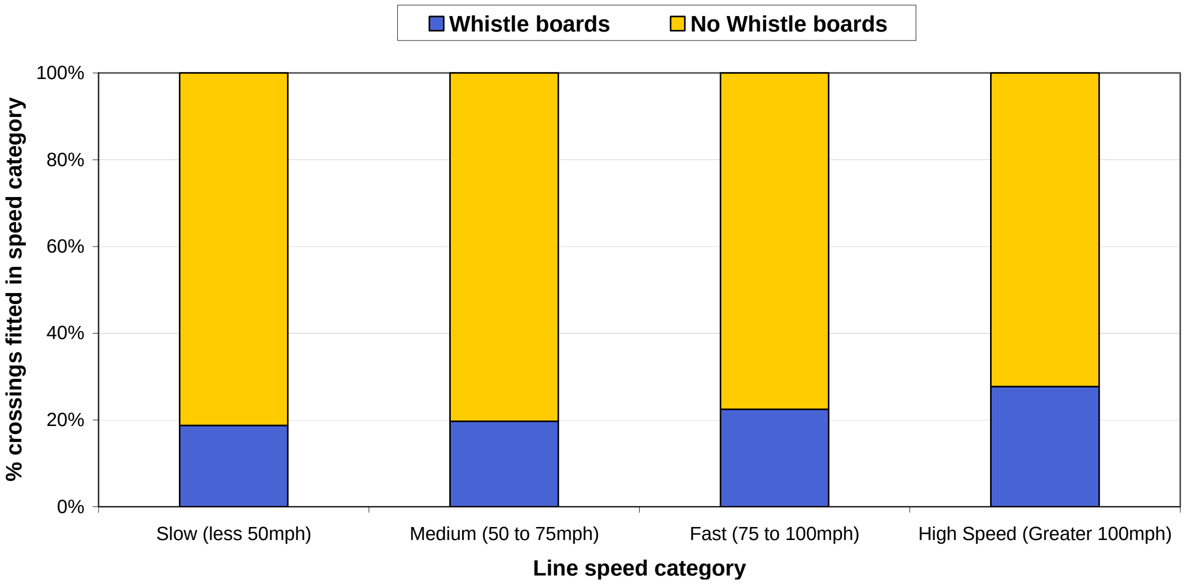


Source: Analysis of data provided by Network Rail

The data shows that the proportion of whistle boards provided varies with linespeed (Figure 13). Lines over 75mph and over 100mph have a higher proportion of crossings with whistle boards. This is of course not surprising since a higher speed will mean lower sight times, which will have prompted the decision to provide a whistle board. Counter to this, higher line speeds will typically have straighter track which will mean increased sight times.

[6] Information has been provided by Network Rail for 80% of open crossings – of these 62% have whistle boards (often a combined stop and whistle board)

Figure 13: Distribution of whistle boards by line speed



Source: analysis of data provided by Network Rail

Of the 52 crossings visited, 47 have whistle boards[7]. Of these, at 25 crossings the shortest sight time measured during the survey[8] was less than or equal to the traverse time[9]. At the remaining 22 crossings, the sight time as measured during the crossing visits was actually *greater* than the traverse time, so it is not immediately apparent why the whistle board has been provided. Figure 14 shows the breakdown of the 47 crossings with whistle boards (see Appendix A), in an attempt to understand this.

- 25 crossings had measured sight times less than or equal to the traverse time, as mentioned above, confirming that the current rules for providing whistle boards to mitigate the risks associated with short sighting have been correctly applied

[7] The survey locations were selected to have whistle boards so this is not a representative sample

[8] Actual sight times were measured using a stop watch during the surveys based on the fastest trains seen in the direction with the shortest sight distance

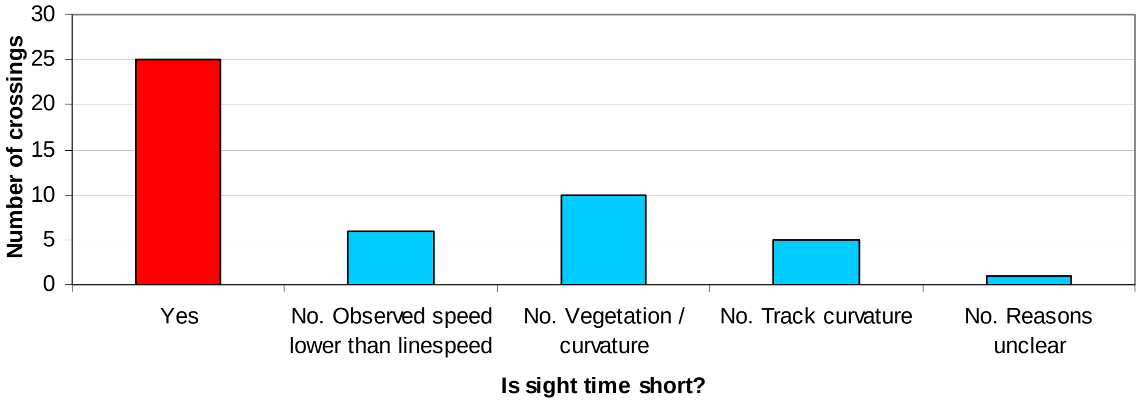
[9] Traverse times were calculated based on the Network Rail process which relates distance over the tracks and crossing surface to traverse time. Typically, single line crossings have a pedestrian traverse time of 5 seconds, double track 8 seconds

- At six crossings the observed train speeds were less (in some cases significantly) than the linespeed provided by Network Rail. Network Rail calculate the sighting time based on a measured distance divided by the linespeed, so on this basis at such locations a shorter sighting time will be derived compared with that measured on the site visits. In some cases this related to proximity to a station and all trains observed during the visits were stopping or accelerating and therefore travelling at a speed less than the linespeed. At other locations the reasons were less clear. What is not clear is whether some trains do travel at higher speeds at some of these locations (for example non-stop trains); if so then this may mean that the provision of a whistle board would be necessary
- At 10 crossings, vegetation (usually combined with track curvature) limited the sight distance, so it is possible that sight times at certain times of year can be more restricted and would thus explain the provision of whistle boards. This also suggests that at selected crossings where there is noise nuisance to nearby residents there may be potential for removal of whistle boards if vegetation control was more rigorous and timely. Theoretically vegetation control is a straightforward way of improving sight times, although in practical terms it can be difficult. Periods of rapid vegetation growth can be unpredictable (they depend on variations in temperature and rainfall), and booking possessions for the necessary access may therefore not be practical – or at best be very difficult.
- At five crossings, track curvature limited the sighting although the sighting was not measured to be shorter than the traverse time. It is therefore not obvious why a whistle board has been provided
- At one crossing the sight time seemed to be sufficient even though the trains appeared to be travelling at their linespeed and there was not an obvious vegetation issue. This single location is apparently being looked into by Network Rail for removal of the whistle boards

It is also important to note that measuring sight time can be subject to significant variation by individual taking the measurements. An example is a crossing that has an object (for example a structure or some vegetation) near to the crossing which limits the sight time from the decision point. Moving forward just a small distance can improve sighting significantly, but precisely where the sighting is measured from will be subject to some variation.

This analysis suggests that there may be some locations where it is possible, subject to site specific checks, to remove whistle boards either because (a) further vegetation control maintain sight times to the required level or (b) actual train speeds are lower than theoretical maximum linespeed. It is very important, however, that any decisions to remove any whistle boards consider the possibility that there will be a period of time after the whistle board is removed, that risk is higher due to user expectation of hearing a train horn.

Figure 14: Breakdown of crossings with whistle boards



Source: Site visits and information provided on whistle boards by Network Rail. 'Short' sighting means that at least one of the sight times is less than the time taken to traverse the crossing

3.2 Rates of incidents at crossings with and without whistle boards

The 30 incidents occurring between January 2001 and March 2006 (shown earlier in Figure 7) have been divided into whether or not the crossing is provided with a whistle board [10] (Figure 15). This shows that 7 out of 17 (41%) of incidents at FP crossings, and 5 out of 8 (63%) of incidents at UWC and UWC/T occurred at crossings with whistle boards. At crossings provided with MWLs the proportion is smaller, just one out of five incidents (20%) occurred at an MWL with a whistle board.

When normalised by number of crossings (by type and whether or not provided with a whistle board) the data is more revealing (Figure 16). This shows that at all crossing types, there are more incidents per crossing where whistle boards *are* provided.

Instinctively one might anticipate that if whistle boards are having a positive safety impact on crossing use, then the rate of incidents per crossing would be lower than for crossings without whistle boards.

- It is firstly important to consider that whistle boards have been provided at crossings that are inherently higher risk than those without (they will have shorter average sighting times than other crossings). It could be that if whistle boards were not provided (or were removed) then the risk would increase further. If this is the case then the analysis suggests that whistle

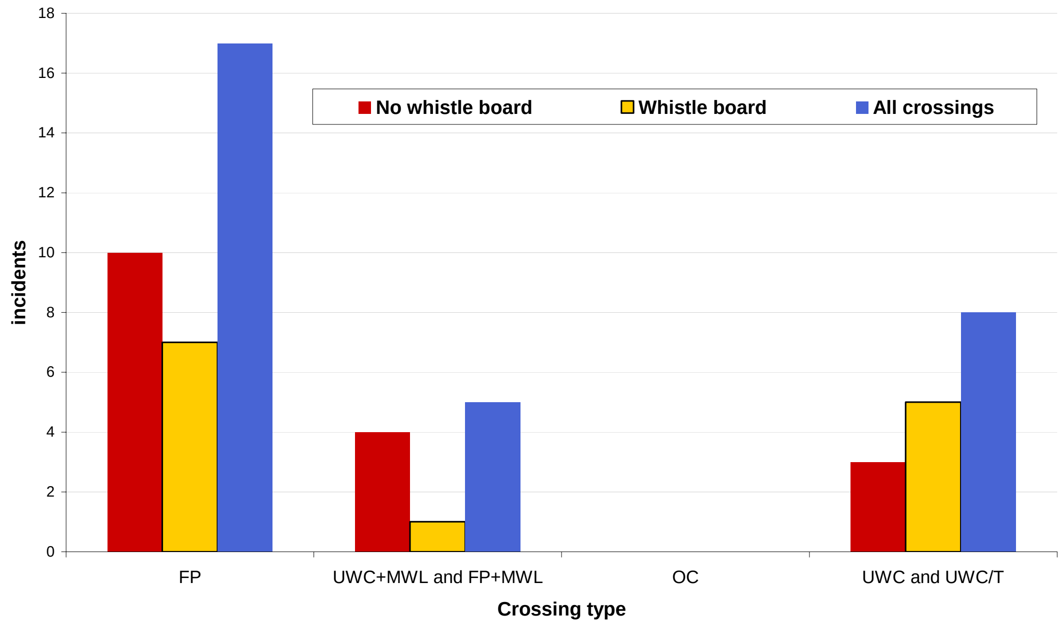
[10] Data on the location of whistle boards has been provided by Network Rail

boards are providing at best a partially effective risk control since the risk does not appear to be reduced to the equivalent level for crossings without whistle boards

- Secondly, it is not possible to verify if the train horn was actually sounded at the whistle board before the incident/s occurred. One possibility is that incidents that occur at crossings with whistle boards are biased towards occasions when trains fail to sound the horn at the whistle board – although this is difficult to verify. What is known through the site visits conducted for this study is that around 91% of trains sound the horn at whistle boards on average during the day (see section 3.3 below), and the figure may be much lower at night
- Finally, it is possible that whistle boards have typically been provided at crossings with a higher than average level of pedestrian use for all relevant crossings. An analysis of site visit information for 76 crossings surveyed by Human Engineering for RSSB (see footnote 10, page 31) suggests that this *may* be the case. The average level of use is estimated as 29 per day for crossings with whistle boards, which is more than twice as high as that for crossings without whistle boards (13 per day). This could, however, simply be a result of the crossing selected, and one or two crossings with particularly high levels of use distorting the averages. If it was representative of the national average, usage at crossings with and without whistle boards, it would go some way to explaining the different level of incidents per crossing shown in Figure 16

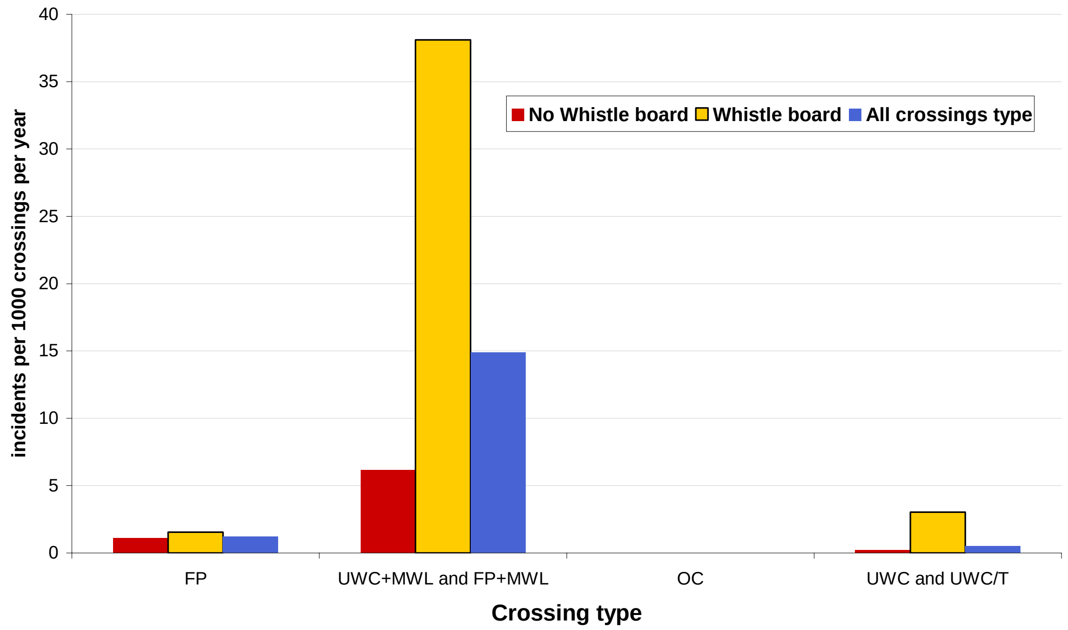
All that can be deduced from this analysis is that a review of locations where accidents have occurred cannot help to determine the safety benefit provided by whistle boards.

Figure 15: Incidents by crossing type and whistle board provision



Source: Arthur D Little analysis of SMIS data 2001 to 2006

Figure 16: Incidents by crossing type and whistle board provision (normalised)



Source: Arthur D Little analysis of SMIS data 2001 to 2006

3.3 User behaviour and error

Whistle boards may be provided where sight times are short in comparison to the crossing time, to provide an earlier warning to the user than is possible from sighting alone. What is not clear is the extent to which the horn sounded at the whistle board mitigates the risk of an individual being struck by a train due to the restricted sight times. Equally, the sounding of the train horn at the whistle board may help to prevent incidents arising from errors other than those relating to short sight times. In particular, in a number of interviews, users believe that the train horn is a reminder to look for a train, or a general warning that a train is nearby and it is important to pay attention. The horn is 'passive' on the part of the user; in other words a train horn (as long as it can be heard) will alert a user even if they would otherwise have failed to look – for example they were distracted or simply not paying attention to the dangers of crossing the line.

There are a number of different general error types which could lead to a pedestrian being struck by a train at a crossing – including being caught out by short sight times. Errors were categorised into five types at an industry workshop organised for this project. Each error type may have a number of contributing causes, but the idea is to categorise the types of error at a high enough general level. The five error types are as follows, (these are illustrated with examples in Figure 17):

- User sees train but 'nips across' and misjudges time taken to cross or time taken for train to arrive
- User fails to look for a train (e.g. because they are distracted, or complacent). Observations of users at footpath crossings suggest that between 15 and 40% of users do not look for trains. Further, 91% of users were observed not to stop before traversing the crossing [11]
- User caught out by short sight times
- User is caught out by the arrival of a second train
- User is on crossing for longer than usual (e.g. dog off the lead, slip or trip over, etc). Examples observed in the site visits for this study include a dog off the lead causing the owner to go up the track in pursuit of the animal, and users carrying bicycles over crossings with gates not designed for such a use

[11] Observations based on 462 users seen at Rylands and Cotton Mill Lanes FP crossings

These are derived from various sources including earlier work done for RSSB, looking into the risk factors at passive level crossings[12]. An Australian study of human factors in level crossing accidents[13] showed that only about thirty percent of drivers approaching an active or passive level crossing looked for trains. Although this data refers to road vehicle drivers as opposed to pedestrians it confirms that failing to look for trains is indeed not an uncommon failure. Furthermore, many of those that did search looked just before entering the crossing, too late to stop, and a few were still looking as their vehicles crossed the train tracks (which explains the incidents in such countries where the road vehicle collides with the side of the train).

[12] “User Worked and Footpath Level Crossings: Risk Review”, T000, Arthur D Little Limited for RSSB, June 2001

[13] Bureau of Transport and Regional Economics, ‘Rail Accident Costs in Australia’ refers to study by Wigglesworth (1976)

Figure 17: Error types that can lead to accidents at passive crossings

1. User sees train but misjudges time to cross/time for train to arrive

The example shows two pictures of a train just three seconds apart

2. User fails to look for train (e.g. distracted, complacent etc)

3. User caught out by short sight times

The picture shows a crossing with a four-second sight time

4. User is caught out by arrival of a second train

A train stopping at the platform blocks the view of trains approaching from the other direction. At this location warning signs are provided not to cross in front of or behind any trains.

5. User is on crossing for longer than usual (e.g. dog off the lead, slip or trip over, etc)

At this crossing, users with bicycles or windsurfers have to carry their equipment over the gate, increasing the time spent on the crossing.

Source: Arthur D Little

At an industry workshop (see page 33), three different sight time cases were described to the group – (1) crossings where all sight times are short (i.e. less than the traverse time), (2) crossings where some sight times are less than the traverse time and (3) crossings where all sight times are adequate (greater than traverse time). The group then ranked the relative likelihood of each error across these three sight time cases. The idea was to get a relative judgement of the magnitude of each type of error varying with the sight time. The results (Figure 17) show:

- The joint most likely errors were felt to be user caught out by short sighting at crossings with all short sight times, and users being on the crossing for longer than usual where sight times were adequate
- The next most likely error was judged to be users misjudging the traverse at crossings with some short sight times[14]
- Also receiving relatively high error rates were the user being on the crossing for longer than expected for other sight time cases, users being caught out by short sighting where some sight times are short, and users being caught out by a second train where sight times are all short, or some are short

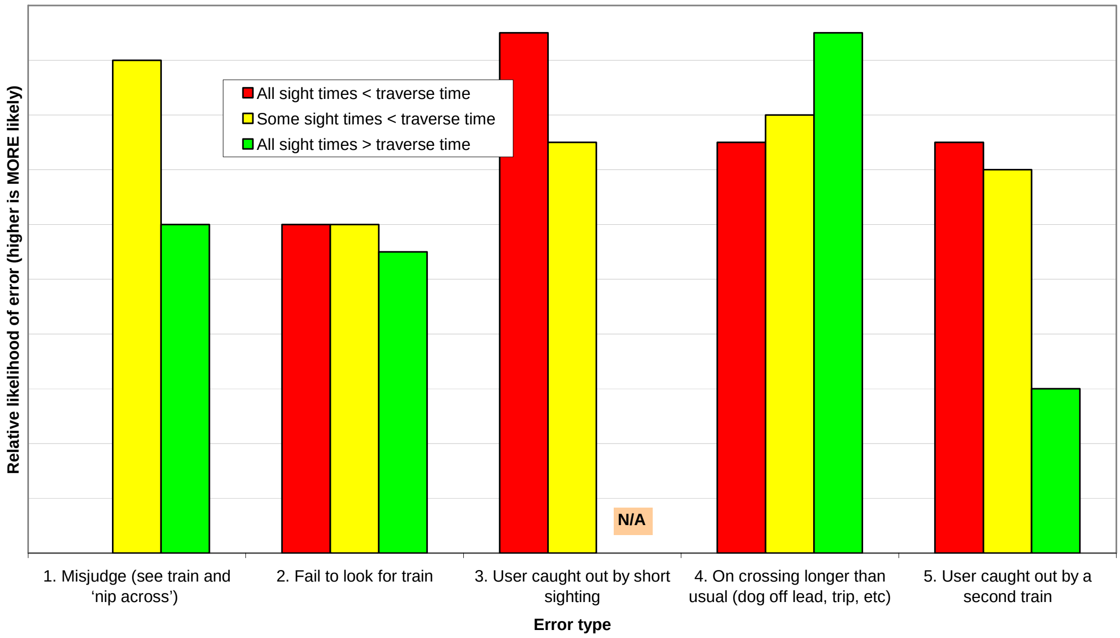
In the second part of the exercise, the same 10 individuals were asked to estimate how much they thought a train horn sounded at a whistle board would reduce the chance of the user making the error. The results (Figure 18) are shown, compared with the error rate without a whistle board (from Figure 19). Not surprisingly, the greatest benefit provided by the whistle board was judged to be for users being caught out by short sight times (after all, this is the design purpose of a whistle board). However, more interestingly, the impact of the whistle board on the failure to look for a train was estimated to be almost as high for crossings with all short sight times and even higher for other crossings.

This is an interesting result since it suggests that the benefits of the whistle board extend beyond simply warning users who are unable to see the train due to short sight times.

The results also suggest that at crossings with whistle boards, the most likely errors are being on the crossing for longer than usual, misjudge, and user being caught by a second train.

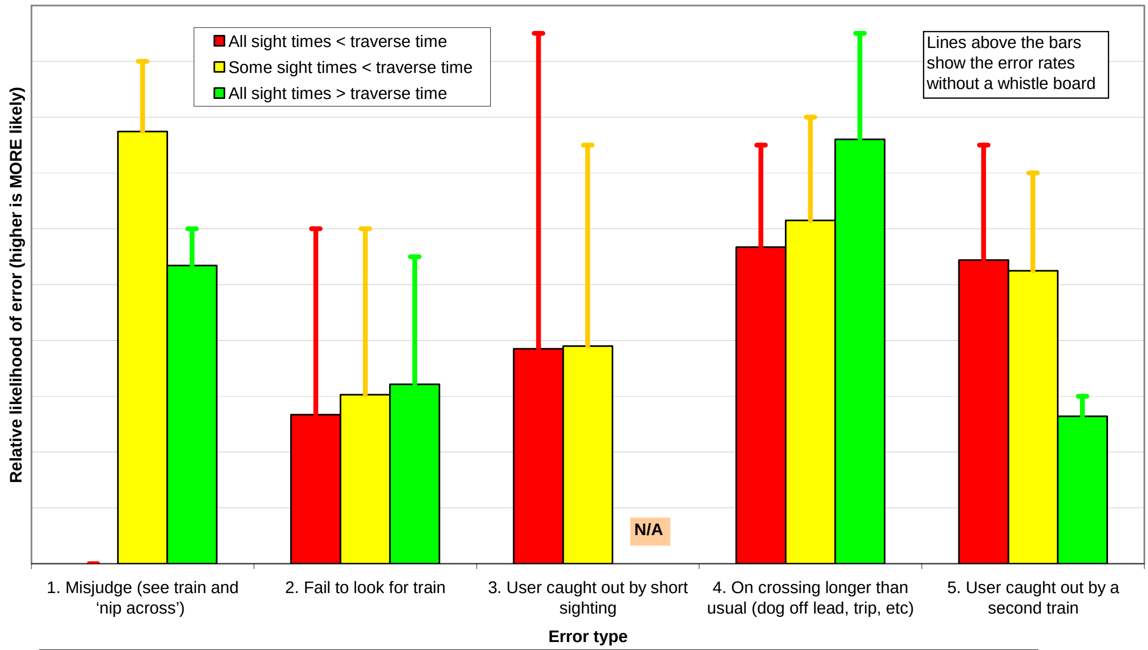
[14] Note that for crossings with all sight times short, it is very unlikely that a user would see a train and misjudge since by definition the train would have to be very close when it first came into view.

Figure 18: Relative likelihood of different errors



Source: Results of expert judgement in a workshop of 10 delegates. Each individual was asked to rank the relative likelihood of each error across the three sight time cases (all sight times < traverse time, some sight times < traverse time, or all sight times > traverse time). The average of the 10 results was taken to produce the results shown. Higher bars indicate that the group felt that the error was relatively more likely, and lower bars, relatively less likely

Figure 19: Estimated reduction in error from whistle board



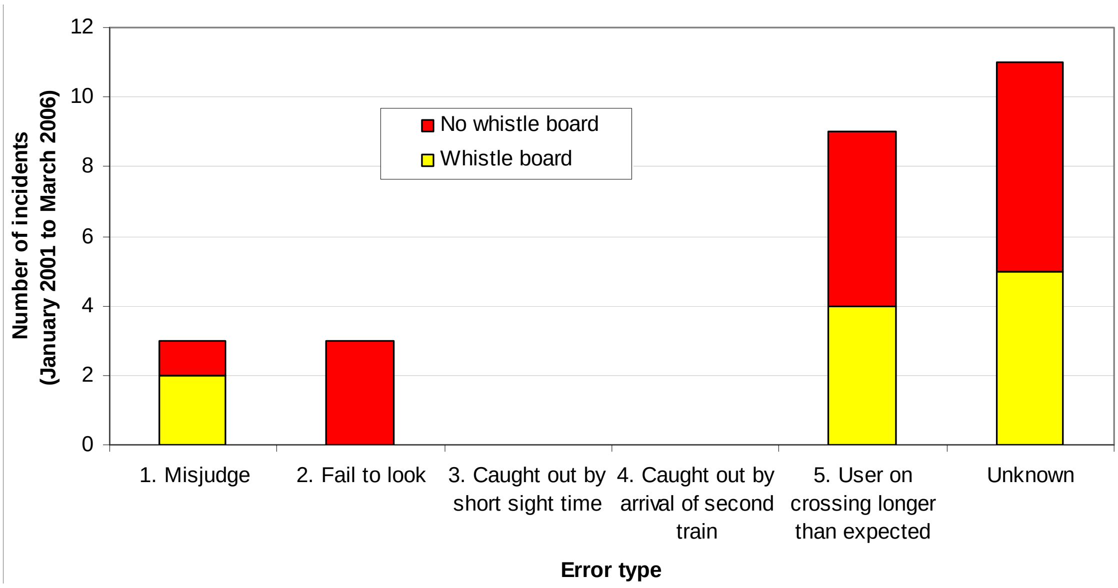
Whistle board has small impact	Whistle board large impact (around 50%)	Whistle board reduces error significantly (60% for crossings with all short sight times)	Whistle board around 25% error reduction	Whistle board around 25% error reduction where at least some sight times are short

Source: Estimates provided in workshop comprising 10 rail/level crossing experts and crossing users

An attempt has been made to allocate the 30 incidents that have occurred (reported in the data January 2001 to March 2006) into the five error categories, with the aim of understanding how the whistle board may help to reduce the rate of error at crossings. The results (Figure 20) show that many incidents (11 in number) cannot be categorised. Of the remainder of incident for which some judgement can be made:

- The most common error that has led to incident appears to be users who are on the crossing for longer than usual. Many of these are due to dogs being off the lead or distracting the owner (four in number), one involved a wheelchair using getting stuck, and another involved a man who was walking a dog slipping on the crossing
- Three incidents appeared to occur because of a failure to look by the user
- Three incidents were allocated as being 'misjudgement' by the user, as it appears that they knew the train was approaching, but did not make it across in time
- No incidents seem to have occurred within the dataset due to short sight times, or a second train approaching unexpectedly

Figure 20: Incidents by error type



Source: Judgement on pedestrian incident data at UWC, FP and MWL crossings provided in SMIS January 2001 to March 2006

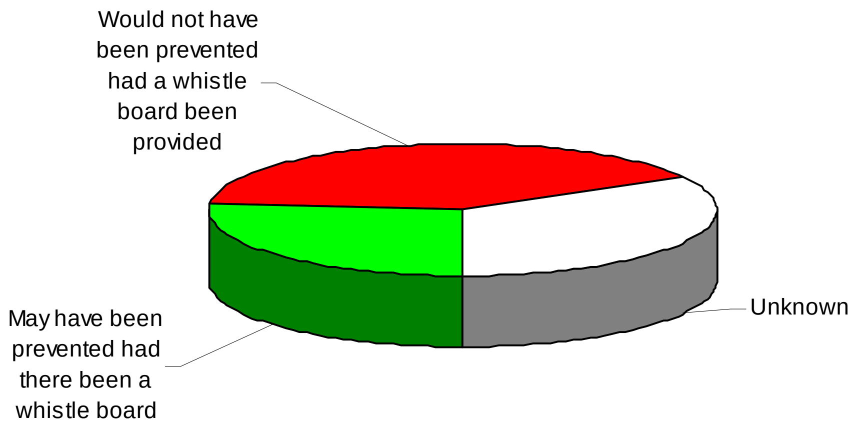
The allocation of incidents into the error categories has been used as the basis of judging whether or not a whistle board may have helped to prevent the incident at those crossings that currently do not have whistle boards. Clearly, this can only be highly subjective, but is an attempt to determine the possible impact of whistle boards on the occurrence of incidents. (It should be noted that this should not be used to infer that the crossings at which the incidents occurred should have had a whistle board – in no cases is it clear that the crossing had short sight times). The analysis (see Figure 21) shows:

- In most cases a train sounding the horn at a whistle board would *not* have had the potential to prevent the incident; of the 15 incidents that occurred at crossings without whistle boards it is judged that seven (40%) would not have benefited from a train sounding the horn at whistle board
- In four incidents (27%) it is judged that providing a whistle board may have had the potential to have prevented the incident. This does not mean that the incident would have been prevented with certainty, but that the circumstances described suggest that a train horn could have alerted the individual and *may* have instigated a response that prevented them being struck. Another aspect of uncertainty is that it is possible (perhaps quite likely) that the driver sounded the horn anyway, despite the lack of a whistle board, on sight of the person on the crossing. Three of these incidents were in the 'fail to look' error category, and the remaining one was in the 'unknown' error category. No incidents in the error categories

'misjudge' of 'user on crossing longer than expected' were judged to have benefited from a whistle board

- In the remaining four incidents, the information available is not sufficient to provide a judgement as to whether a whistle board would have had a benefit on the outcome of the incident

Figure 21: Judgements on impact of whistle boards on historic accidents



Source: Judgements on whether accidents would have benefited from whistle boards from analysis of SMIS 2001 to March 2006

The above suggests that whistle boards may reduce the errors associated with failing to look for trains by 27%, or 40% if those incidents that could not be allocated are split proportionately across "would not have prevented the incident" and "may have prevented the incident". Although this relates to crossings without whistle boards (and therefore where Network Rail have previously judged that they are not required) it compares very well with the workshop estimate of the reduction in error associated with "fail to look for the train" (Figure 19).

3.4 User types and crossing characteristics

The effectiveness of a whistle board as a risk mitigation measure will vary by location, and will depend not only on how short the sight times are, but also will vary according to various user, crossing, and railway characteristics. Examples of such factors include:

- User types (elderly or slow, horse riders, children / youth, familiar users or first time/unfamiliar users)
- Number of tracks, linespeed
- Level and type of background noise at the crossing, whether or not horns sounded at other crossings can be heard

- Whether other forms of protection are provided (MWLs or telephones at UWC)

The relative effectiveness of the whistle board at crossings with these characteristics was estimated in a workshop of 10 rail experts and crossing users. The results (Figure 22) suggest that whistle boards may be particularly effective at crossings:

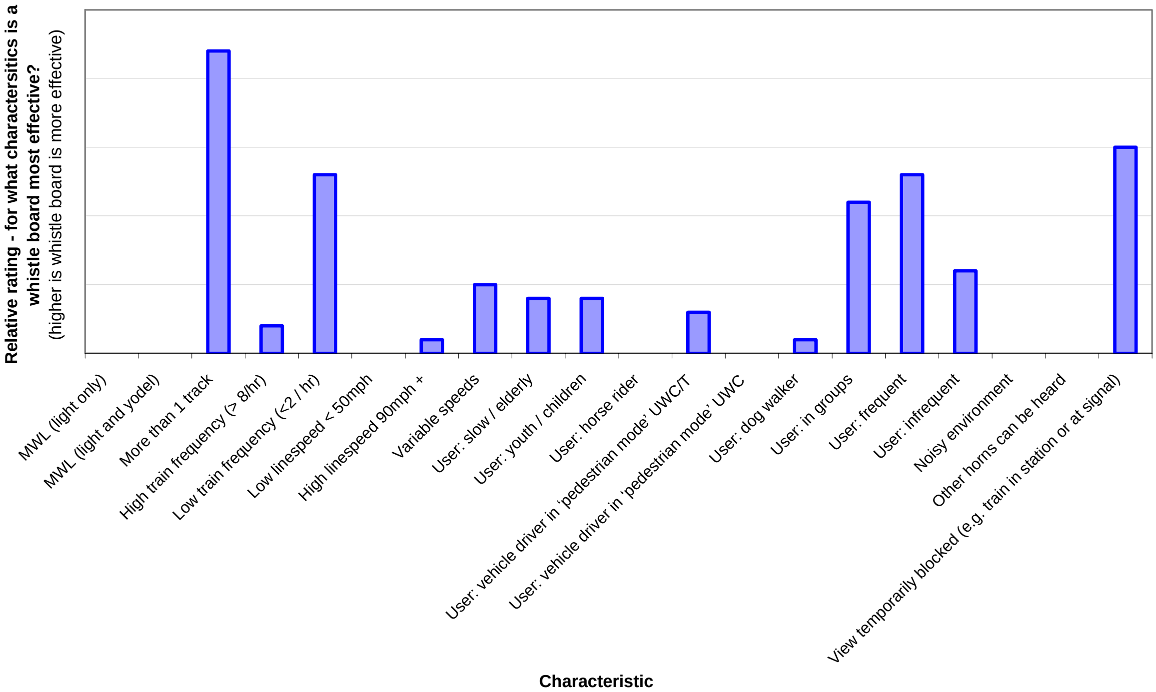
- Over more than one track
- Where there is a low train frequency (e.g. below 2 per hour). This was felt to be because users are more likely to have a low perception of risk (i.e. a low expectation that a train will be coming) and therefore may take less care when crossing. A train horn could therefore be a useful reminder to look for the train
- Users in groups, since they may be distracted by conversation of 'follow the leader' without taking care
- Frequent users of the crossing (which applies to most locations) due to complacency where risks are perceived to be low
- Where the view in at least one direction may be temporarily blocked (the most prominent example being a train in a platform blocking the view of through trains approaching the other direction – see fifth photograph in Figure 17)

Conversely, train horns sounded at whistle boards were felt to be relatively ineffective at crossings:

- Provided with MWLs, since provided that users observe and understand the MWL, there is an active warning of train approach
- Where train frequency is high (it was felt that users would be more careful to look for trains at such locations so a whistle board would have less impact than where train frequency is lower)
- Where linespeed is either particularly low or high (<50mph or above 90mph)
- Users who are elderly or slow, dog walkers, children, horse riders or vehicle drivers in pedestrian 'mode'
- Where the environment is noisy or other horns can be heard (because the horn might not be heard as reliably, or may be confused with other horns)

Although the above should only be regarded as relative judgements of the whistle effectiveness, they do suggest how the effectiveness of a whistle board may depend on the characteristics of the crossing at which it is provided. Such considerations could be used to inform decisions about where whistle boards are provided, and indeed removed, in an attempt to balance risk to crossing users and noise nuisance to nearby residents.

Figure 22: How effectiveness of whistle board varies by crossing characteristics



Source: Estimates provided in workshop comprising 10 rail / level crossing experts and crossing users

Figure 23: Examples of user behaviour

One elderly lady did not react to the horn of the approaching train: she stops just across the white decision point line and looks very carefully, she crosses but does not react as the horn sounds whilst on crossing nor as the train passes her after exiting gate.

An adult male is alerted to an approaching train during a set of three traverses. He carries a bike over the crossing, returns to collect shopping bags looking for trains before crossing. The horn then sounds (and comes into view of camera) while he is picking up shopping. He is alerted to train and stands and waits for it to pass.

Source: Site visit to Rylands FP crossing

3.5 Do train drivers always sound the horn?

The sounding of the horn at a whistle board relies entirely on the train driver's route knowledge, or seeing the whistle board, and responding to it appropriately. It is, therefore, reasonable to expect that due to human error the horn may not always be sounded (for example due to the driver being distracted while carrying out other driving related tasks).

The data gathered from the 47 sites visited at which whistle boards are provided shows that on average 93% of trains sound the horn during the day[15] - i.e. on average 7% of the time trains *do not* sound the horn at the whistle board. It is interesting to note that in some cases, the horn was sounded, but this was at a time after the whistle board had been passed by the train, and appeared to be in response to seeing the assessor at the crossing. This compliance rate appears to be a lower than would be expected from a consideration of generic human error rates[16]. The level of compliance during the night appears to be significantly lower than that during the day, based on site visits made specifically during night-time (see section 5.3). Although only a limited sample which should be treated with some caution, the proportion of trains sounding the horn at night was between 18 and 33%. At the same crossings, 100% of trains seen in the day sounded the horn suggesting that there is a difference in the compliance rate between night and day and that compliance is not only effected by location.

The proportion of horns sounded will varies by location, as illustrated by the crossings visited during this study (Figure 24). It may therefore be that drivers are exercising discretion in the sounding of the horn. Drivers may be less inclined to sound the horn at the whistle board where there has been a history of complaint, or where from experience they feel they are very unlikely to encounter anyone near the crossing but sounding the horn may disturb nearby residents. The proportion of trains sounding the horn at two busy crossings which were visited for a full day each (Rylands FP and Cotton Mill Lane FP), were higher than the average, at 96% and 97% respectively suggesting that drivers may be more inclined to sound the horn where there is more expectation of seeing a user. However, of those crossings which were observed to have the lowest compliance rates (for example those in the 50-59% and 70-79% bands in Figure 24), there are no obvious common characteristics that might explain the low compliance.

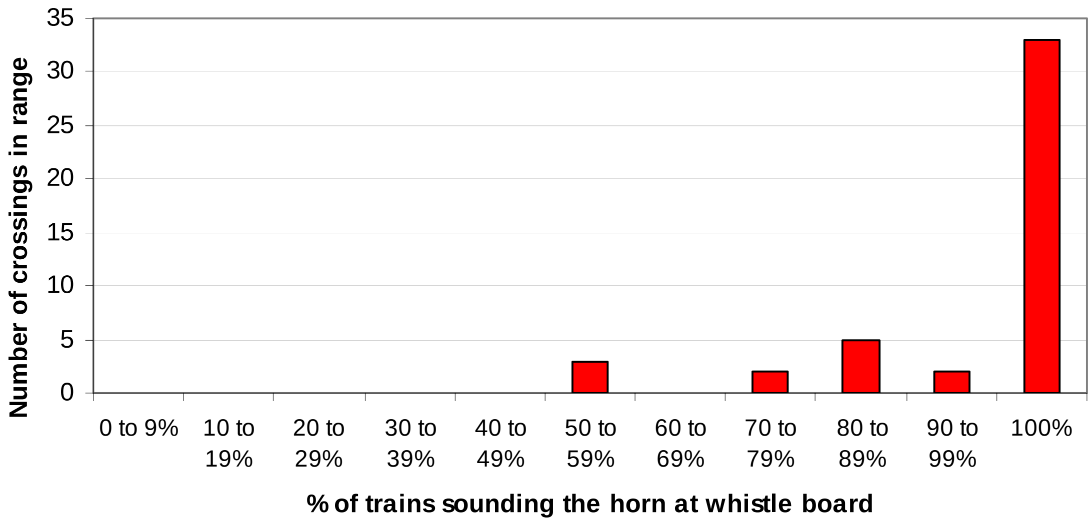
[15] This is an average across the sites visited, and is not weighted by number of trains at each location.

[16] For example HEART generic task E "Routine, highly practiced rapid task involving relatively low level of skill = 0.02, or generic task G "completely familiar, well designed, highly practiced, routine task occurring several times per hour, performed to the highest possible standards by highly motivated, highly trained and experienced person, totally aware or implications of fail, with time to correct potential error, but without significant job aids" = 0.0004

The fact that the horn is not sounded reliably at all locations is an important finding for this study, since it means that the user will not always get the required warning, and as such the benefit provided by the whistle board is somewhat less than it might be if there was a greater level of consistency in complying with the whistle board.

It is possible that the apparent lack of historical evidence for the safety benefits of the whistle board (section 3.2) is partly attributable to the fact that drivers do not always sound the horn. One possibility is that trains horns, when sounded at whistle boards, reduce risk significantly, but the occasions when they are not sounded lead to disproportionately higher risk. Also, most drivers would sound the horn on sight of a near miss even when there is no whistle board. This would mean that the train horn provides some benefit at both crossings with and without whistle boards, and as a result the benefit of the whistle board itself is not particularly evident.

Figure 24: Distribution of trains sounding the horn at the whistle board



Source: Site surveys at 47 crossings provided with whistle boards

3.6 Conclusions regarding benefits of whistle boards

It is clear that whistle boards provide safety benefit at UWC and FP crossings. They provide the only means of giving sufficiently early warning at many crossings where sight times are significantly limited. The benefits of whistle boards are likely to relate not only to giving advanced warning of train approach where sight times are limited, but also provide a more general warning of a train approaching even when sight times are sufficient. This is evident from observing users who very rarely stop at crossings (based on observations for this study, over 90% of users do not ‘stop’ before they cross) and often only glance up and down the tracks to look for trains. They are, however, more likely to stop or at least take extra care, when the horn is heard.

Whilst it is certain that there is *some* safety benefit from the horn sounded at the whistle board, there is significant uncertainty over how much benefit there is. The historic data provides no hard evidence of the safety benefit, so any estimate of the safety benefit relies heavily on judgement. There are simply too few incidents on which to draw statistically significant conclusions, and 'before and after' assessments at single locations are not feasible – partly due to low rates of incidents and partly because the date on when whistle boards were provided at each location is not readily available. While train drivers appear to not always sound the horn (a failure of about 7 in 100 according to the data gathered for this study), they are likely to sound the horn in the event that a pedestrian is on or near the crossing, meaning that the benefit of the horn sounded *at the whistle board* (as opposed to *when the pedestrian is seen*) is even less clear.

The best estimate of the national safety benefit of whistle boards is that it is of the order of 1 to 2 FWI per year. This estimate is based on three separate analyses:

- Since 2001 there has been an average of approximately 2.5 pedestrians struck by trains per year at crossings with whistle boards. The estimated reduction in user error if whistle boards were provided (at crossings with at least some short sight times) would be around 33%[17]. This means that if no whistle boards were provided at any crossings, it might be expected that there would have been 3.7 pedestrians struck by trains on average per year – i.e. the reduction from whistle boards is something over 1 FWI per year
- A subjective analysis of the narrative for incidents available in SMIS suggests that for around 27% of incidents that occurred at crossings without whistle boards, a whistle board *may* have helped to prevent the accident, compared with 40% where it was judged a whistle board would have not have helped. As far as can be determined, these errors appeared to be associated with failure to look for trains. For the remaining 33% of incidents it was not possible to make a judgement, so assuming that these would be split according to the ones that could be assessed, the reduction in errors associated with failure to look for trains would be very approximately 40%. Clearly, whistle boards are not provided to mitigate against this type of error, so it is difficult to use this result to provide an estimate of overall safety benefit at crossings with short sight times. However, this reduction in error rate is consistent with that estimated in the workshop session, so it would seem reasonable to say that it supports the estimate above – i.e. something over 1 FWI per year

[17] Average of estimates from 10 delegates at industry workshop – see section 3.3 for details

- Data from the US comparing accident rates at crossings before and after implementation of whistle bans [18] suggests that the safety benefits of whistle boards is very significant, although it must be noted that the context is very different from the whistle board used in Britain[19]. US data suggests that there was an average of an 84% increase in accidents when whistle bans were introduced, and a reduction when they were subsequently lifted of between 38% and 68%. A crude application of this data to the British rate of accidents at crossings with whistle boards suggests that, without whistle boards the number of fatalities at these crossings would increase by about 2 FWI per year (an 84% increase from 2.5 FWI per year)

It is interesting to compare the estimated benefit of whistle boards (1 to 2 FWI per year) to some other key railway risks. For example, the latest Risk Profile Bulletin (Issue 5) reports the following:

- The risk relating to pedestrians at FP, UWC and OC is 4.7 FWI per year (the safety benefit of 1 to 2 FWI per year associated with the whistle board is approximately 20-40% of this risk)
- The risk to pedestrians struck by trains at all level crossings is 7.3 FWI per year
- The risk associated with passenger train collision with road vehicles on level crossings is 2.6 FWI per year

In addition to a reduction in incidents, whistle boards will also prevent a number of near misses per year, and therefore reduce the incidents of shock or trauma to train drivers.

Based on the current industry Value to Prevent Fatality (£1.5M) the estimated safety benefit provided by the 1,200 or so whistle boards in monetary terms is £1.5M to £3M per year. Based on an approximate cost of £5,000 for providing a whistle board, the total annual cost (undiscounted and assuming a life of 10 years) for the 1,200 crossings would be £600,000. Therefore, if decisions to provide whistle boards were made purely on the basis of the safety benefits to crossing users (i.e. the noise impact to railway neighbours was not included), then they would be reasonably practicable.

[18] Federal Railroad Administration (1995) 'Nation-wide study of Train Whistle Bans'

[19] In the US, the train whistle is used not only for pedestrians but also as an important means of warning road vehicle drivers who may be approaching either open, or gated crossings

If safety risk was equally distributed over these crossings, the benefit of the whistle board would amount to some £1,250 to £2,500 safety benefit per crossing per year. It is well understood, however, that safety risk is not evenly distributed over crossings, and that busy crossings, or those with 'bad actor' characteristics will attract a much larger share of the risk, and conversely lightly used crossings with few particular risk increasing characteristics will have much lower risks.

If the *very highest risk* crossings were, say, two orders of magnitude higher than this average, safety benefits as high as £250,000 per year could be attributed to the whistle board at such locations. There can only be a very small number of such crossings, however, since a single crossing with a risk this high would represent a significant proportion of the total risk. Network Rail could identify such crossings through risk assessment, in particular by using the All Level Crossings Risk Model (ALCRM), which is currently in the process of being rolled-out in Network Rail and will be used to assess risk at all crossings. Because the results of the model will be stored in a database, this should readily enable identification of the highest risk crossings once the model has been run.

Equally, at a larger number of very lightly used crossings, the safety benefits associated the whistle board could be much lower – under £100 per year. Work to provide a monetary value associated with the health effects to railway neighbours is, at time of writing this report is ongoing, and will be an important input to the decision making framework, essentially providing an additional parameter against which safety benefits of the whistle board can be balanced in a more comprehensive cost-benefit analysis. Pending the outcome of this work, it seems likely that at such crossings with relatively low risk, the cost valuation assigned to a modest impact on the health of railway neighbours would reduce, and could potentially outweigh, the safety benefits to crossing users provided by the whistle board.

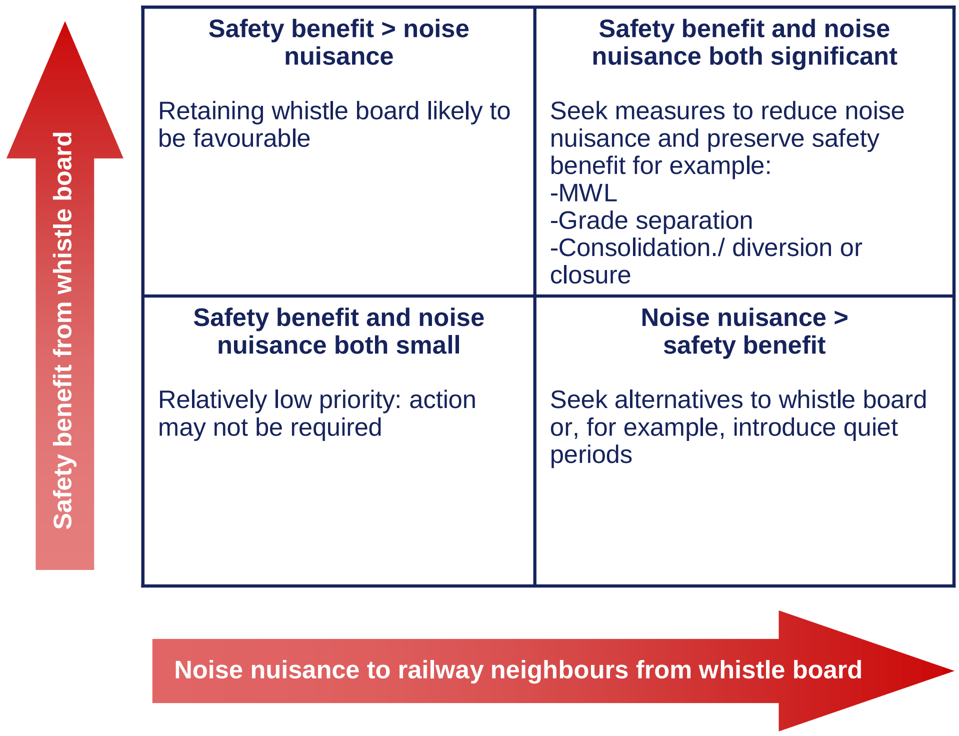
Decisions on whether to retain whistle boards or provide alternatives will need to be made on a crossing by crossing basis. Figure 25 illustrates the principle, showing how the balance of safety benefits and the noise nuisance may vary by location, and how this may lead to different decisions (note that the figure is intended to only be illustrative of the principle *not* to give guidance on decisions).

The above analysis, although subject to significant uncertainty, indicates that at some relatively high-risk locations, the safety benefits of whistle boards might be significant (the 'top' of Figure 25). As such, it is only likely to be possible to justify reduction in the use of the whistle board at these locations where ill effects to railway neighbours are very significant.

There may also be locations where the safety benefits of the whistle boards are relatively low in comparison to the ill effects of the noise to railway neighbours – for example very lightly used crossings (the bottom right of Figure 25).

It might be expected that most crossings will fall into the 'bottom left' quadrant on Figure 25, and as such not be high priority. The distribution of crossings over the other three quadrants will depend substantially on the results of the work to provide a value on the cost of noise impacts to railway neighbours. Higher values will have the effect of increasing the number of crossings on the right hand side of the figure – thus pushing the balance further towards seeking alternatives to whistle boards.

Figure 25: Consideration of whistle boards and alternatives



Source: Arthur D Little

4. Impact of louder horns

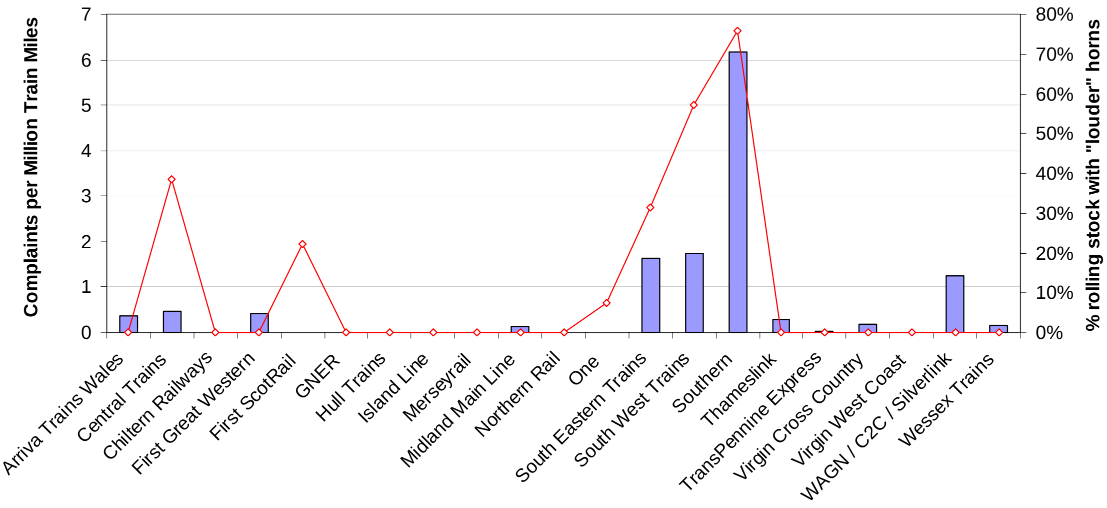
This Chapter gives a perspective of the safety impact of the ‘louder’ horns provided on recently introduced rolling stock, in comparison with the horns on older rolling stock.

4.1 Introduction

There is a widely held view that the increase in the number of noise complaints is associated with the introduction of new rolling stock with louder horns that comply with the Railway Group Standard (see Chapter 6). Certainly, there appears to be a good correlation between the number of complaints normalised by train miles with the proportion of rolling stock with ‘louder horns’ (Figure 26).

One possible option being considered to mitigate the impact of the noise disturbance of train horns is therefore to reduce the sound to some lower level more in line with that of older trains. The actual sound levels produced by different train horns across the variety of types and ages of trains is, however, not well known, so deciding on a specific set of revised criteria is very difficult at this stage. It is clear that further work focussing on the acoustic properties of horns, and measurements of actual sound levels on different train types would be required to inform any decisions about revised criteria.

Figure 26: Complaints about train horns compared with distribution of ‘louder horn’ rolling stock



Source: Analysis of data provided by RSSB on number of complaints received 1 June – 31 December 2006. Rolling stock analysis based on information available in “The Comprehensive Guide to Britain’s Railways: Ninth Edition”

4.2 Perspective on safety benefit of louder horns

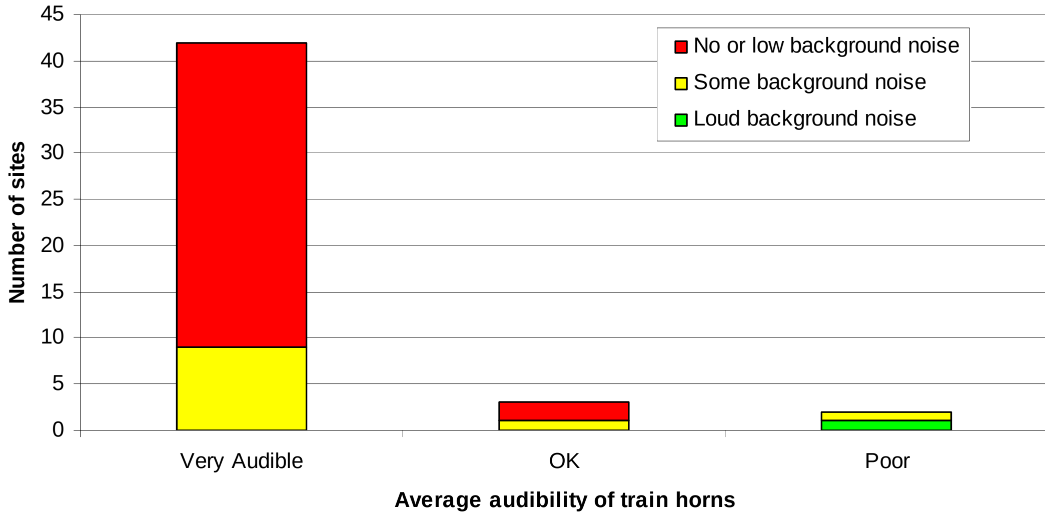
For the British rail network overall, it cannot be shown from an analysis of available data that louder horns on recently introduced rolling stock provide a tangible additional safety benefit compared with that associated with the 'quieter' horns on older trains. Incremental safety benefits over the crossing population are therefore likely to be small, but on a crossing-by-crossing basis will be highly dependant on local characteristics, such as the level and types of background noise and the types of users.

This perspective is based purely on observations made during the site visits carried out for this study, and the understanding of the nature of incidents gained from the analysis of data (Chapter 3).

Firstly, in all cases, horns on all types of trains observed during the site visits were audible to our assessors. In most cases horns were classified as "very audible".

However, our assessors at the sites visited did hear a difference between the 'louder' horns (or recently introduced rolling stock) and the 'quieter' horns. This difference appeared to be due to both amplitude and tonality (some train horns have a 'sharper' sound, which in our opinion can be more distinguishable from other background noises). This means that the louder horn is more likely to be heard by a crossing user whose hearing is impaired (e.g. through the use of music headphones or a mobile phone) at locations where there are relatively high background noise levels (e.g. near a road, factory, flight path etc), or during occasional events (such as an idling farm vehicle, passing airplane, the noise of rain on a hood or umbrella, etc) which create a high level of noise relative to the train horn (Figure 27). High levels of wind (common at a few crossings) may, depending on wind direction, carry the sound of the horn away from the crossing; the louder horn is also more likely to be more audible during these circumstances.

Figure 27 Average audibility of train horns sounded at each of the crossings visited



Source: Site surveys at 47 crossings provided with whistle boards

It is also worthwhile noting that the duration with which the horn is sounded, which the site visits suggest varies significantly, can alter the likelihood that the horn will be heard. There are no criteria for the duration of the sounding of the horn, although such criteria are used South Africa and Canada (see Chapter 6).

On the basis of the site visits we therefore conclude that any incremental safety benefit of the louder horn will be related to audibility by those users whose hearing is impaired and at crossing environments where background noise levels are high, meaning that there is less chance that the noise of the horn will be noticeable to the user. At many locations, horns sounded on other lines or other nearby crossings can be clearly heard, which is more likely if the horn is louder. This may have a negative impact on safety, if users were to misinterpret the location of the horn, although interviews with users suggest that this is unlikely, or could possible provide a benefit to nearby crossings which are not provided with whistle boards (effectively providing an 'early warning' for users). The fact that actual safety benefits are location specific, therefore, means that an industry approach that considers local variation is necessary.

In parallel, an extensive analysis of data has been unable to conclusively demonstrate a tangible incremental safety benefit associated with the increased volume of 'louder' horns. In particular, it has not been possible to conclusively demonstrate a link between the number of trains striking pedestrians and the introduction of rolling stock with louder horns. Quantifying the benefit of the whistle board regardless of the loudness of the horn is itself difficult (Chapter 3), because historic accidents and near misses cannot be shown to be reduced where there is a whistle board. As such, quantifying any incremental benefit of the louder horn within this data is more difficult still.

Finally, the actual sound level of the horns on different types of rolling stock is poorly understood. This means it is not possible to give an opinion on what the current required sound level of train horns can be reduced to without a significant adverse impact on safety. A better understanding of current sound levels (on the mixture of older trains) and user responses to these levels would be required to make an informed assessment.

The analysis of near miss and incident data estimates that the safety benefit of installation of whistle boards is very approximately 1 to 2 FWI per year (see Chapter 3, section 3.6). The additional benefit of louder train horns can only be a proportion of this, and given that to most users the older quieter horns will be clearly audible anyway, suggests that the additional safety benefit can only be small proportion of 1 to 2 FWI per year.

Should the industry decide to reduce the required sound level to some lower value, then this would have an impact on the overall balance of crossing user safety benefit versus railway neighbour noise impact. Generally, this would increase the number of crossings at which the whistle board could be justified. It is therefore advisable not to take any decisions to remove whistle boards based on the current train horn sound criteria, unless it were confirmed that these criteria were to be retained.

5. Risk by night and day

One option being considered to mitigate the impact of the noise disturbance of train horns sounded at whistle boards is the introduction of 'quiet periods'. The idea is that during a quiet period the sounding of the horn would not be mandatory but drivers would sound the horn when perceived to be needed (to provide a warning to a user who the driver believes to be in danger). It is therefore important if this option is to be further explored, to understand the pattern of incidents by night and day.

This Chapter assesses the relative risk of using a crossing in the night and daytime.

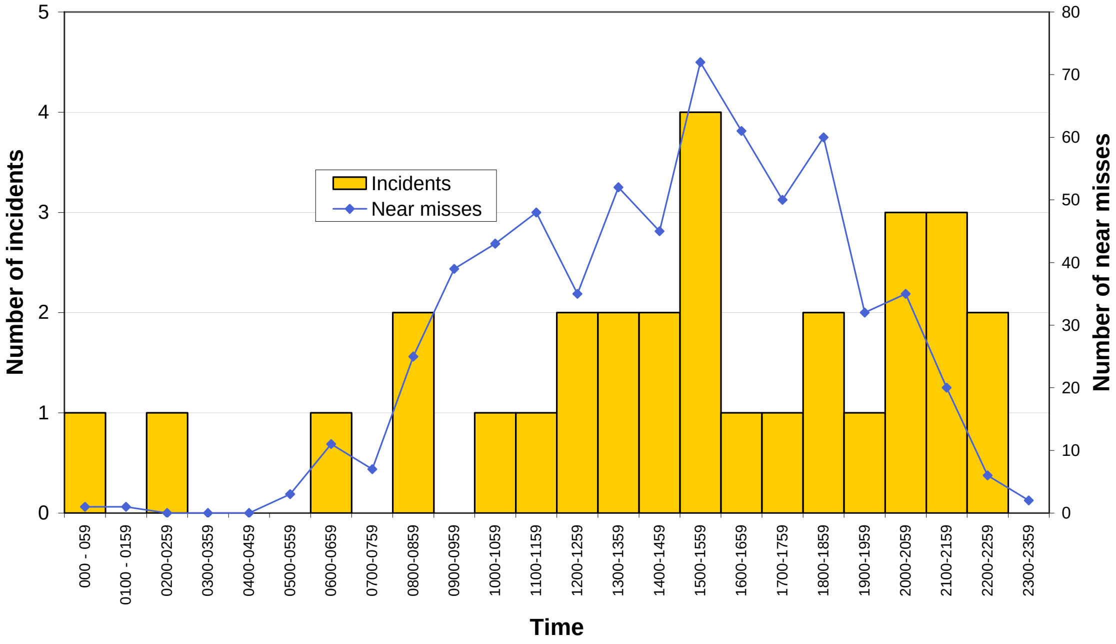
5.1 Incidents and near misses by time of day

The pattern of near misses over the day is as might be expected from considering when people using crossings and trains are most likely to come into near conflict (Figure 28). Near misses increase sharply just before work / school, peak in the middle of the afternoon, and then drop from the evening peak until the small hours. The pattern of incidents broadly follows this, although incidents appear to occur more at night-time than the pattern of near misses would suggest. The higher rate of incidents for each reported near miss at night may indicate that night-time traverses are inherently riskier, or could simply indicate that fewer near misses are reported at night since it is more difficult for the train driver to see someone on the crossing ahead.

For the implementation of 'quiet periods' to be practical, it is likely that it would have to be based on fixed times, for example between 2300 and 0700. The number of incidents and near misses that have occurred in the day (0700 to 2300) and night (2300 to 0700) are shown in Figure 29). This shows that 10% of incidents (3 out of 30) and an even smaller proportion of near misses occur between 2300 and 0700.

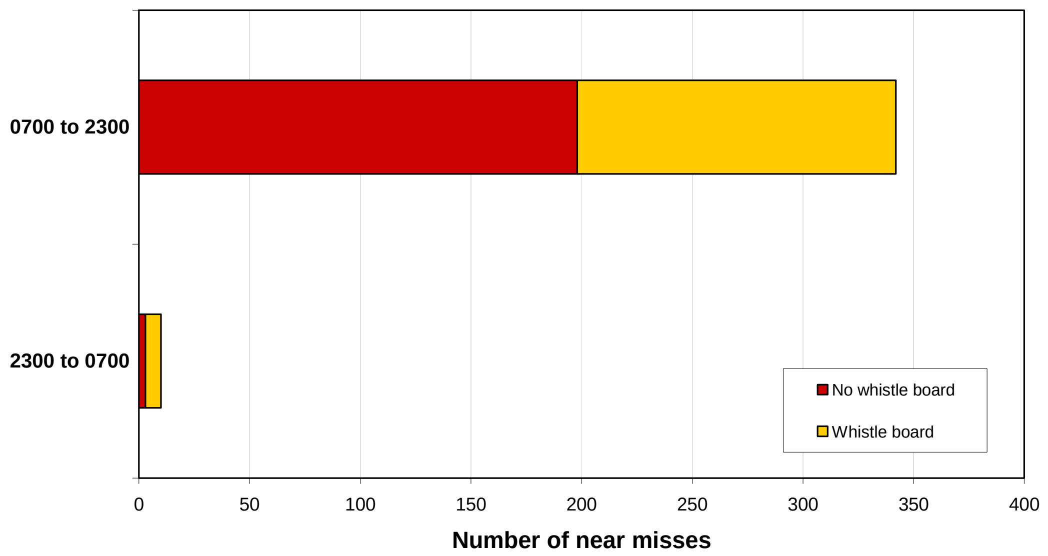
A quiet period finishing earlier in the morning, say at 0500, would mean that fewer crossing users would use the crossing when no whistle was sounded, although this would provide less benefit in terms of the noise disturbance to railway neighbours. If quiet periods are to be further explored, it will be necessary to determine the correct balance between the benefit, in terms of the reduced noise nuisance to railway neighbours, and the reduced safety benefit to level crossing users.

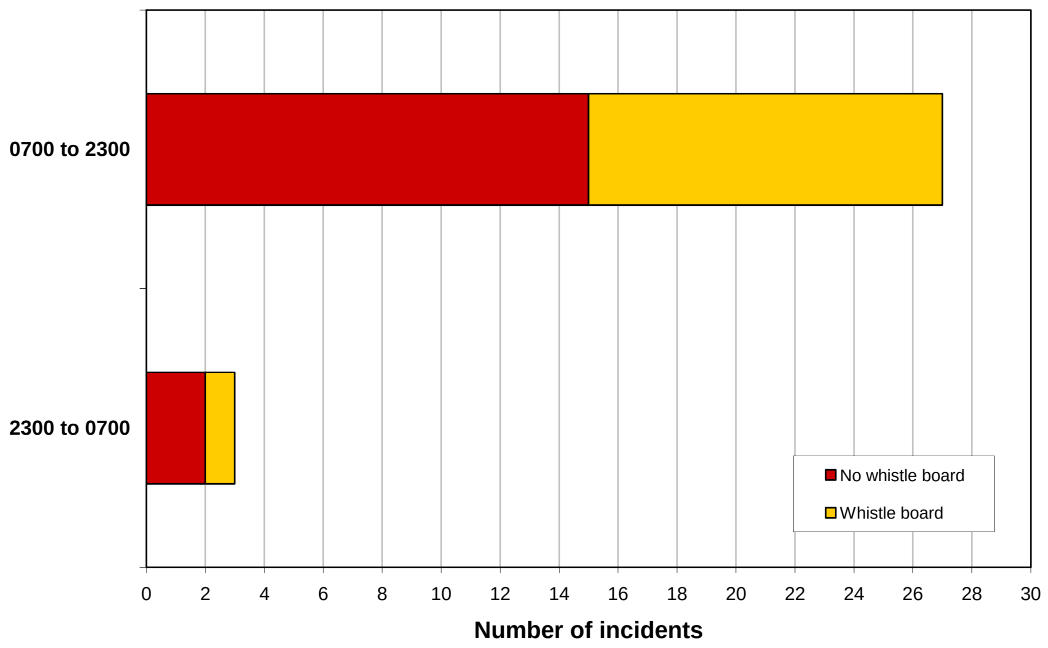
Figure 28: Near misses and incidents by time of day



Source: Analysis of January SMIS 2001 to March 2006

Figure 29: Near misses and incidents 0700-2300 versus 2300-0700





Source: Analysis of January SMIS 2001 to March 2006

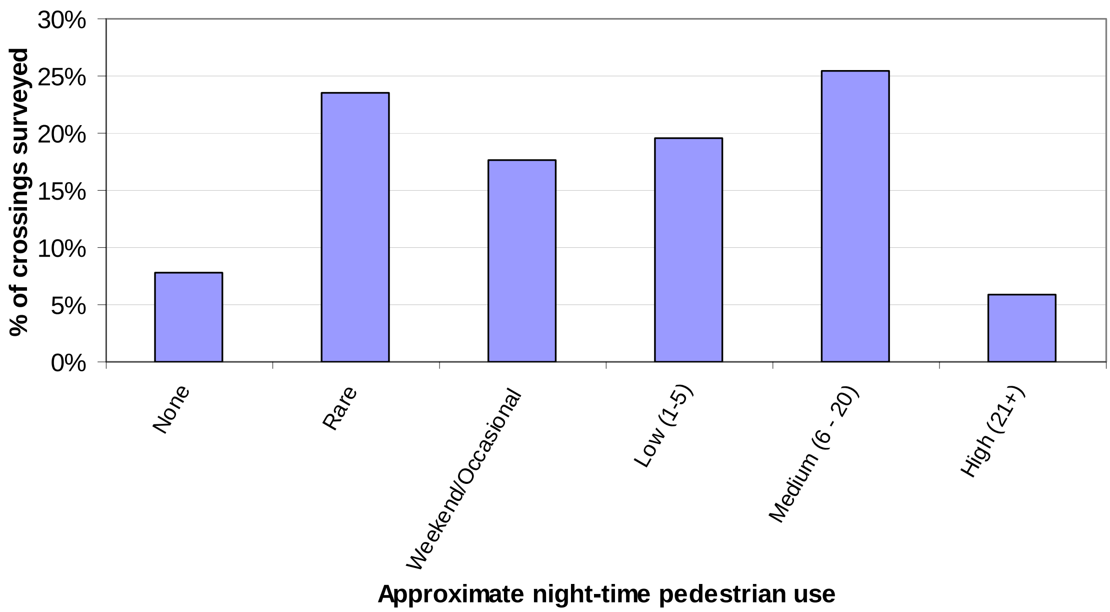
5.2 Relative risk associated with night and daytime use

To understand the risk to which individuals are exposed when using crossings at night compared with daytime, incidents occurring at night and day need to be normalised by pedestrian moment (pedestrian usage x number of trains). The difficulty is that the use of crossings at night is highly location specific, and is not well known across the broad population of crossings.

A coarse estimate of night-time use has been made based on the information gathered for the 51 crossings visited as part of this project. The results (Figure 30) show that only very few (around 6% of the of the 51 surveyed) of the crossings surveyed are estimated to have high levels of night-time use (night-time means 2300-0700 as opposed to ‘after dark’). These crossings provide either access across residential areas or, in one-case, access to a night club. At nearly 50% of crossings, night-time use is estimated to be either ‘none’, ‘rare’ or only ‘occasional’. The aggregate result of these estimates is that there is an ‘average’ of three traverses per night over crossings surveyed.

It must be noted that such an estimate can only be regarded as very approximate, and has been made from interviews with users, location of the crossing with respect to local environment and what the crossing is used to access.

Figure 30: Estimated night-time use at crossings surveyed



Source: Estimates from site visits to 51 level crossings. Night-time means 2300-0700 not hours of darkness

Timetable information provided by Network Rail has been used to estimate the number of train movements over 24 hours and the number at night (2300-0700) at each of the locations visited. The averages are:

- 73 trains over a typical 24 hours
- 11 trains between 2300-0700 (i.e. 15% of all trains in 24 hours)

The number of trains at night varies significantly by line of route, and is usually comprised extensively of freight traffic or empty coaching stock, with some early morning and late evening passenger trains on some routes. An alternative figure for the number of trains running at night is provided in a paper by Evans and Dennis[20] which gives an overall figure of 9%, although this is based on trains between 2330 and 0700 (instead of 2300 to 0700). This suggests that the estimate of 15% estimated for the crossings visited on this study is not unreasonable.

The result (Table 2) is that night-time incidents occur 15.4 times more frequently *per pedestrian moment* than during the day.

Table 2: Comparison of day and night incidents versus moment

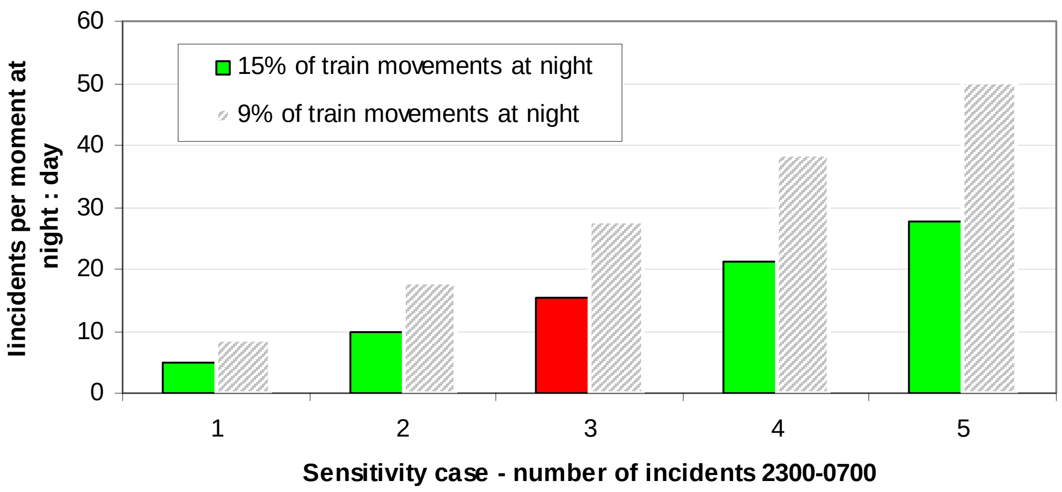
Period	Incidents	Average pedestrian use	Average trains	Moment (per day)	Incidents per moment
'Day' 0700-2300	90%	75	61.6	4619	1
'Night' 2300-0700	10%	3	11	33	15.4
Source	*Figure 28, 10% of incidents 2001 to 2005 at all crossings have occurred 2300-0700*	*See above. Estimates from 51 crossings visited in this project*	*Network Rail timetable information provided for 51 locations visited for this project*	*Average pedestrian user X average trains*	*Incidents ÷ moment, then normalised so number of day is equal to 1*

Source: Arthur D Little analysis

[20] "Train horns at public vehicular level crossings: an approach to noise complaints", Richard Evans and Colin Dennis, RSSB

The result is sensitive to the low number of incidents that have occurred at night (only three); it may have been random chance that some of these incidents happened at night, and equally more incidents could have occurred at night. Figure 31 shows a sensitivity analysis by increasing and decreasing the number of incidents occurring at night around the actual number of three. In the lowest case (assuming only one incident occurred at night), night-time traverses still occur five times more per moment, and in the highest case considered (five incidents at night) night-time traverses would be 27 times more frequent per moment. This shows that we can be reasonably confident that night-time traverses are notably higher risk than those in the day when normalised by moment. The light grey bars show the same sensitivity cases but using 9% of train movements at night data from the paper by Evans and Dennis. In all cases the relative night-time risk is higher still, giving further confidence in the result that night-time traverses are inherently riskier.

Figure 31: Night time incidents sensitivity analysis



Source: Arthur D Little

It is perhaps not surprising that using crossings at night presents a relatively higher risk than during the day. Possible reasons include:

- There is a greater likelihood that users will have impaired judgement through the effects of alcohol or tiredness
- Poorly illuminated crossings mean that trip hazards may be more of a problem, or at least users will be focused on their steps rather than looking for trains
- The site visits suggest that the compliance of sounding the horn at whistle boards is significantly lower than during the day (see below section 5.3).

This means that any positive effect of the whistle board on preventing incidents will be lower at night than in the day

- This may be the period of the day (at least at some locations) during which the fastest trains pass over the crossing (empty coaching stock which does not stop at platforms)

5.3 Train horns at night

Two specific visits were carried out at night to crossings which had already been visited during the day. Although only a small sample, the results (Figure 32) suggest that compliance with the whistle board is significantly lower at night than during the day. Across the 47 crossings with whistle boards visited during the day, an average 91% of trains sounded the horn at the whistle board[21]. At 'Crossing A', a UWC/T on a line used mainly by freight traffic at night, 100% of trains in the day sounded the horn during the day, this fell to 50% between 2100 and 2300, and just 18% after 2300[22]. At 'Crossing B', a busy crossing in a residential area with some night time use by pedestrians, 100% of trains sounded the horn during the day, but this fell to 33% after 2300[23].

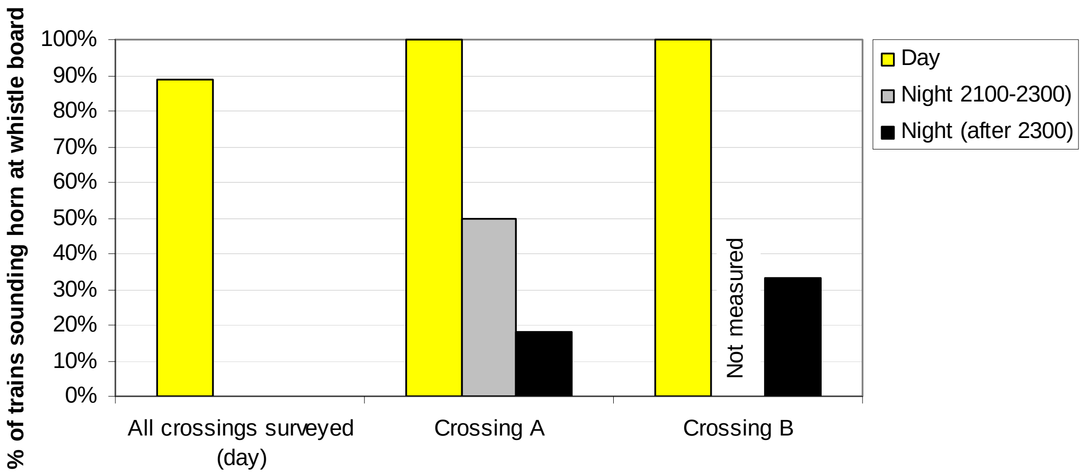
One reason for the apparently lower rate of compliance at night may be that some drivers are using discretion in the sounding of the horn at times when nearby residents would be disturbed. What this analysis cannot reveal is how the compliance rate varies by location. It is likely that in general compliance rates will be higher where drivers know that a crossing is used at night (for example it is a route from a pub, night-club, or access an industrial site and is used by shift-workers). It is interesting to note that this was not the case at one crossing visited at night which is known to be used at night, but where only 33% of trains sounded the horn.

[21] In some cases the train sounded the horn when in sight of the site assessors but had already passed the whistle board. These cases have been regarded as NOT sounding the horn at the whistle board

[22] A total of 17 trains were seen at night at 'Crossing A'; 6 between 2100 and 2300, and 11 after 2300

[23] A total of 9 trains were seen at night (after 2300) at 'Crossing B' – six of which did not sound the horn

Figure 32: Proportion of trains sounding horn at whistle board: day versus night



Source: Arthur D Little site surveys

5.4 Practice and experience in other countries

In most of the countries considered in this study (see Chapter 6) there are no specific restrictions on sounding of the train horn by time of day. Exceptions are:

- South Africa, where the requirement is to sound the horn, hooter or whistle between 0500 and 2300 only (apart from when specific local conditions prevail)
- Canada, where there is no blanket night-time whistle restriction, although exemptions may be sought at specific locations to restrict the whistle use between 2300 and 0700 to minimise noise complaint

Whistle bans, including night-time whistle bans, have been used in parts of the USA. The Federal Railroad Administration[24] report that following implementation of an emergency order in Florida to reinstate the whistle, night-time (in this case 2200 – 0600) incidents decreased 69% from the level when the ban was in force. The whistle band was applied at crossings with some kind of active protection only, and the accidents are largely associated with road vehicles, so care should be taken in interpreting this result for GB. Interestingly, the change in the accident rate in the daytime was not significantly affected.

Outside of Florida, many other locations in the US have implemented whistle bans, some of which have apparently been reversed, partly triggered by the

[24] Federal Railroad Administration "Nationwide study of train whistle bans", 1995, US Department of Transport

Florida experience or because locally there was opinion that safety was being compromised. Most of these bans were over 24 hours, and a small minority (about 6%) were night-time only.

The same study concludes that the impact of whistle bans on average increased accident rates 84% (although again only at highway crossings excluding footpaths). The study concludes that the impact of night-time whistle bans over the broader set of crossings (i.e. not Florida) is much less clear.

5.5 Conclusions regarding night-time risk and implementation of quiet periods

The analysis suggests that risks to users, per traverse, are significantly higher – perhaps around 15 times higher - at night than during the day. At most locations, however, because the level of night time use by trains and users is comparatively so low, the collective risk at night-time is comparatively small. This may, not be so at a relatively small number of specific locations with a large number of train movements at night (usually freight) and where pedestrians use the crossing for night time access, such as to and from places of shift work, pubs or night clubs. At such locations, it is reasonable to expect that the collective risk at night would be comparatively much higher.
Based on only two site visits made during the night for this study, it appears as though compliance with sounding the train horn at the whistle board is significantly lower at night compared with during the day (site visits suggest compliance rates of between 18 and 33% at night compared with 91% during the day). The number of incidents that have occurred in the past (10% of which were between 2300 and 0700) will therefore have been influenced by this current ad hoc practice, and as such implementation of a ‘quiet period’ during the night would therefore have only an incremental impact on both the level of safety risk, and the level of noise to nearby residents.

Overall, a decision to implement any ‘quiet periods’ will need to take account of the risk work presented here, and an assessment of the ‘cost’ of the noise nuisance associated with the sounding of the horn at night. A network-wide ‘quiet period’ implemented at all crossings is likely to have a potentially adverse impact on risk at specific locations which are heavily used at night. Therefore, decisions to implement ‘quiet periods’ should consider local characteristics, most importantly crossing usage at night-time. If a ‘quiet period’ were to be introduced widely, but not at such crossings, it may be necessary to provide two types of whistle board, to clearly indicate at each crossing whether or not a ‘quiet period’ was in effect. Care would need to be taken with the design of the two whistle boards to ensure that they were readily distinguishable from one another by the driver.

6. Train horn noise criteria

This Chapter summarises the train horn criteria in the Railway Group Standard, and summarises different criteria used in other countries. Further details of the criteria, and related discussions, are provided in Appendix B.

6.1 British criteria

The Railway Group Standard GM/RT2484 (April 2005) specifies the minimum sound level requirements for horns.

"*Minimum sound pressure levels for warning horns and corresponding speed ranges of trains shall conform to those set out…below*".

	Minimum C or A weighted sound pressure level (L_C or L_A) at 5 m
Trains with a speed of 30 km/h	95dB
Trains with speeds of more than 30 km/h (approx 20 miles/h) but less than or equal to 80 km/h	105dB
Trains with speeds of more than 80 km/h (50 miles/h) but less than or equal to 160 km/h	112dB
Trains with speeds greater than 160 km/h	115dB

There is no mandatory maximum level, but the Standard states that *"to minimise the environmental impact and hearing damage risk it is advisable that the minimum levels set out in Table 1 are not exceeded by more than 5dB"*.

Because the required minimum levels are speed dependant, *"It is desirable and permissible for warning horn noise levels to vary automatically with the actual train speed (in accordance with Table 1) so that a minimum environmental impact is made and safety is not compromised. In the absence of such an arrangement a lower sound pressure level horn shall be provided in addition to the one used at maximum speed, the sound pressure level of this horn shall correspond to a value in Table 1 consistent with the speed at which it is intended to be used (to give a suitably loud warning to persons on or about the track when approaching at speeds less than the maximum)"*.

Sound pressure levels are measured in an open site 5 metres from the front of the train.

Regarding the noise level from the side of the train the standard says *"in order to minimise environmental impact it is advisable that the A or C weighted sound pressure level when measured 5 m from the side of the train, at the same height as the horn, in line with the front of the horn is at least 5dB lower than the level measured in front of the train."*

Recently introduced rolling stock apparently meets the minimum requirements specified in the standard. This includes 170s, 458s, 375/377s, 444s, 450s and 350s. This rolling stock represents only a proportion of all rail vehicles currently in use, and as such, there is a wide variety of horns of different loudness and tone.

6.2 Criteria elsewhere

Rail administrations in seven countries, as well as Europe, have provided information relating to train horn use and in particular any noise criteria. A summary of the key points is provided in Table 3, with further details provided in Appendix B. Note that this is not intended to be a complete review of relevant standards for each railway, but rather a simple comparison of key differences based on the information provided.

It is important to note in comparing the criteria that there are significant differences in the nature of rail operations, cultures, and level crossing types across the different countries included. In particular, the role of the whistle or horn can vary significantly; it is commonly used as a warning for road vehicles drivers, at crossings which have a generally lower level of protection than is the case in Britain.

There are different criteria used across the railways for which information is available, with three countries apparently having no formal specific minimum noise criteria. Maximum sound level criteria are specified in Poland which states 5dB above the minimum, and USA which states 110dB in front of the train. The extent to which these maximum levels are enforced is not known.

No criteria with the exception of Britain vary noise levels with speed, although it might be anticipated that the relevant TSI for trains other than those that are high-speed (currently being produced) is similar to British criteria.

Noise complaints, according to those consulted, appear to be generally less of an issue than in Britain. This is likely to reflect the nature of the railways and population densities as much as any other factors (Canada, Australia and South Africa have significantly lower population densities and have significant railway route miles crossing isolated areas). USA has had a significant history of complaints relating to train whistles, and has seen very large numbers of whistle bans implemented (and in some cases reversed). This continues to be a very live issue, and a recently introduced rule set by the Federal Railroad Administration provides opportunities fore creating 'Quiet Zones' (see Appendix B).

There is little in the way of noise criteria to the side of the train, with the exception of Poland, where an Environmental Decree asks for particular maximum levels depending on land use. Again, it is not clear the extent to which this is enforced.

Horn use is restricted to the hours of 0500 to 2300 in South Africa. In Canada there is no night-time whistle ban, although exemptions are allowed based on local circumstances. In the USA, some whistle bans have been total (i.e. no whistles at any time of day) and a smaller proportion have been night-time only. Elsewhere, horns are used 24 hours per day.

Only in South Africa and USA there are criteria for the minimum time for which the horn should be sounded. In South Africa the requirement is for at least three seconds, and in the USA the new FRA rule calls for '15 to 20 seconds before the crossing until the crossing is reached'.

Table 3: Summary of train horn requirements in other countries

Country	Criteria						Notes
	Maximum noise	**Minimum noise level**	**Side of train**	**Horn duration**	**Other**	**Time of day**	
Europe	123dB (5m from train)	115dB (5m from train)		No		24 hours	Currently high speed rolling stock TSI only
Britain	Advised that minimum levels are not exceeded by more than 5dB	Speed dependant (5m from train): 30km/h 95dB, 80km/h 105dB, 160km/h 112dB, >160km/h 115dB	No	No	Two separate soundings of different frequencies	24 hours	Desirable for levels to vary automatically OR have a lower pressure horn for lower speeds
Ireland	No specific criteria – see Europe				No		
Poland	125dB horn 110dB whistle	120dB horn 105dB whistle	Environmental decree - 45dB to 65dB depending on land use	Unknown		24 hours	
Spain	None	None	None	No		24 hours	
USA	110dBA 100 feet in front of train	96dBA 100 feet in front of train	None	15 to 20s before crossing and *until* arrival at the crossing		24 hours (although Quiet Zone may be specified)	Local areas may set up Quiet Zones, provided that alternative warning measures are provided
Canada	None	96dBA at 30.5m (an arc 45 degrees from front of locomotive)			Not less than three chords	24 hours. 2300-0700 restrictions at some locations	
South Africa	None	None	None	At least 3s		0500 – 2300	
Australia	None	None	None	”Sounded clearly and distinctly”, but	Five chimes or equivalent	24 hours	

				depends on circumstances			

Source: information provided by rail administrations consulted for this study

7. Overall Conclusions

The study makes eight key conclusions, and 14 supporting conclusions as presented below.

The results of this work will be used by RSSB, together with the results of other workstreams, including work to value the cost of noise to railway neighbours, to inform decisions regarding whistle boards. A spreadsheet tool, which is under development as part of this project, is expected to provide the industry with a means of conducting location-by-location assessments to help identify reasonably practicable measures for reducing risk that consider any local ill effects associated with whistle boards.

7.1 Key conclusions

1. The review shows that there is significant uncertainty over the national level of safety benefit provided by whistle boards
   - The best estimate of the national safety benefit of whistle boards is that it is of the order of 1 to 2 Fatalities and Weighted Injuries (FWI) per year
   - This translates to a ‘value’ of £1.5m to £3m per year (using the current industry Value to Prevent Fatality)
   - Distributed evenly over the 1,200 (approximate) crossings provided whistle boards, this equates to an average of between £1,250 and £2,500 per year per crossing
   - However, safety risk is not evenly distributed over level crossings, and as such the safety benefits at the highest risk crossings could significantly exceed this (for example £250,000 at a very small number of the very highest risk crossings assuming that they have 100 times the average risk)
2. Whistle boards are an inexpensive (ca £5,000 per whistle board) means of providing sufficient warning at crossings with restricted sight times. Therefore, although safety benefits at most crossings will not be high, whistle boards can be justified on cost-safety benefit grounds
3. We have been informed that other work currently being carried out by RSSB shows that the ill effects to railway neighbours from train horns sounded at whistle boards can be significant. As such, it is likely that at the lower risk footpath and user worked crossings (such as those that have only light use), the cost valuation assigned to a modest impact on the health of

railway neighbours would counter, and could potentially outweigh, the safety benefits to crossing users provided by the whistle board

4. There is reportedly a strong association between the increase in number of complaints relating to noise of train horns and the introduction of rolling stock with ‘louder horns’, and we understand that the industry is considering a return to ‘quieter horns’ to reduce this impact. This work has found no evidence that, overall, this would lead to a significant change in the risk to crossing users

5. Should the industry decide to reduce the sound level of train horns to reduce the ill effects to railway neighbours, then this will change the balance of the crossing user safety benefit versus noise impact across the population of crossings. Generally, this would increase the number of crossings at which the whistle board could be justified. We would therefore caution against decisions to remove whistle boards based on the current noise levels of train horns

6. Another option being considered by RSSB, is the introduction of ‘quiet periods’ during defined periods of the night, during which sounding of the train horn would not be mandatory. The work shows that risk to users normalised by exposure (number of trains x number of traverses) is around 15 times higher at night than during the day, although at most crossings low levels of night time use means that the contribution to overall safety loss is small. However, at crossings that are used comparatively heavily at night (we expect that this is true of only a relatively small number of locations) the night time contribution to risk would be significant. A network-wide ‘quiet period’ implemented at all crossings is likely to have a potentially adverse impact on risk at such locations. Therefore, decisions to implement ‘quiet periods’ should consider local characteristics, most importantly crossing use at night-time

7. The site visits suggest that there are locations where whistle boards could be considered for removal, since sufficient sight time may be available either because actual train speeds are lower than linespeed, or if vegetation could be further controlled

8. Should the industry decide to remove any whistle boards, it will be very important to consider any possibly adverse impacts on risk during the ‘transition’ period. Many users will have become accustomed to the sound of the train horn being a prompt to look for an approaching train; this expectation could lead to increased risk for a period after the whistle board is removed

9. Based on the above, the risk to crossing users, and therefore the safety benefits associated with whistle boards, will vary by crossing. Therefore, decisions on whether or not to retain existing whistle boards, provide new whistle boards, and provide alternatives will need to be made on a crossing by crossing basis, and make use of the ongoing work to provide a measure of the ill effects of the train horn on railway neighbours.

7.2 Other conclusions - risk at passive crossings, generally

- A review of historic data shows that there are no discernable trends in the number of pedestrians struck by trains at FP and UWC; variations year on year appear to be random
- When normalised by number of crossings, more incidents occur at crossings with miniature warning lights than other types (FP, UWC, and OC). This could be due to the fact that miniature warning lights have been provided at crossings with higher risk and with a higher number of users
- Risk appears to vary by user type. Elderly users are over-represented in incidents compared with other adults. Children and youths are over-represented in near misses, but are relatively rarely involved in actual incidents; in contrast to elderly users they seem adept at getting out the way of the train in the last few seconds

7.3 Other conclusions - safety benefit of whistle boards

- Site visits show that train drivers do not always sound the horn at whistle boards. Data collected for this study indicates that the average compliance rate is around 93% in the daytime, is highly variable by location, and is also lower at night (data suggests between 18% and 33%). This suggests that drivers are using judgement in the sounding of the horn. Therefore, the level and consistency of compliance of sounding the horn at whistle boards is an issue for the industry to address
- Although the safety benefit of whistle boards averaged over all 1,200 crossings is not high, (very broadly £1,250 to £2,500 per crossing per year) at some relatively high-risk locations (such as those with very high levels of use or where sight times are particularly short), the safety benefits of whistle boards will be comparatively higher. As such, it is likely to only be possible to justify reduction in the use of the whistle board at these locations where ill effects to railway neighbours are very significant

- The broad estimate of the safety benefit associated with whistle boards (1 to 2 FWI per year – see key conclusion 1) can be compared to some other railway risks as follows (all from the Risk Profile Bulletin Issue 5):
  - Current pedestrian risk at FP, UWC and OC is 4.7 FWI per year
  - Risk to pedestrians struck by trains at all level crossings is 7.3 FWI per year
  - Risk associated with passenger train collision with road vehicles on level crossings is 2.6 FWI per year
- User observations and a structured industry workshop suggest that as well as giving advanced warning of train approach where sight times are limited, whistle boards also provide a more general warning of a train approaching for users who may not look for trains or be distracted

7.4 Other conclusions - louder train horns

- Horns on all types of trains observed during the site visits were audible to our assessors. In most cases horns were classified as 'very audible'
- There is an audible difference between the 'louder' horns (on recently introduced rolling stock) and the 'quieter' horns due to due to both amplitude and tonality. This means that the louder horn is more likely to be heard by a crossing user whose hearing is impaired (e.g. through the use of music headphones or a mobile phone) at locations where there are relatively high background noise levels (e.g. near a road, factory, flight path, etc), or during occasional events (such as an idling farm vehicle, passing airplane, the noise of rain on a hood or umbrella, etc)
- The duration with which the horn is sounded can also have an impact on how likely it is to be heard. There are no criteria for the duration of the sounding of the horn, and as such this varies significantly

7.5 Other conclusions - risk by day and night

- It appears from limited data gathered for this study that the level of compliance of sounding the train horn at the whistle board at night is low (based on site surveys the level of compliance is between 18% and 33% at night – based on two site surveys – compared with 91% during the day). Therefore, if night time 'quiet periods' were introduced (during which the sounding of the horn would not be mandatory), the impact on level crossing safety risk and noise nuisance to neighbours would be incremental over the current situation, since an ad hoc reduction in the sounding of the horn appears to already be in practice

- Overall, a decision to implement any 'quiet periods' will need to take account of the risk work presented here, and an assessment of the 'cost' of the noise nuisance associated with the sounding of the horn at night
- A network-wide 'quiet period' implemented at all crossings is likely to have a potentially adverse impact on risk at specific locations that are heavily used at night. Therefore, decisions to implement 'quiet periods' should consider local characteristics, most importantly crossing use at night-time
- Few countries (of those considered in this research) implement restrictions on the sounding of the train horn at night. Exceptions are South Africa (the horn is not used between 2300 and 0500) and the United States, where there has been a history of 'whistle bans' (some of which were specific to night-time), and where new rules provide for establishing 'quiet zones' with alternative risk controls funded by the community

Appendices

Appendix A: Summary of crossings visited

Crossing name	Type	Location	Territory	ELR	Whistle board	Line speed (mph)	Tracks
Allcards	FP	Horsham	SE	TBH1	Yes	75	2
Angle Lane	UWC+MWL	Shepreth	SE	SBR	No	90	2
Barry Wrides	FP	Cardiff	Western	CAM	Yes	60	2
Bradshaw Fields	FP	Adlington	LNW	MVE2	Yes		2
Broomhill	FP	Knottingley	NE	WAG1	Yes	50	2
Chapel-en-le-Frith	UWCT	Chapel-en-le-Frith	LNW	BEJ	Yes	50	2
Cotton Mill Lane	FP	St Albans Abbey	LNW	WSA	Yes	50	1
Cronkinson	FP	Nantwich	LNE	SYC	Yes	60	2
Cronkinsons Farm	FP	Nantwich	LNE	SYC	Yes	60	2
Ffynnongain MSL	UWC+MWL	Whitland	Western	SWM	Yes	75	2
Folly Farm	FP	Canterbury West	SE	ACR	Yes	70	2
Gelynis	UWC+MWL	Cardiff	Western	CAM	Yes	65	2
Gomshall	FP	Gomshall	SE	RSJ0	Yes	70	2
Great Dalby Road	FP	Melton Mowbray	LNE	GSM2	Yes	75	2
Greenfields	FP	Oldham	LNW	MVL3	Yes	45	2
Grove	FP	Hastings	SE	TTH	Yes	60	2
Gun Lane	UWCT	Trimley St Martin	SE	FEL	Yes	75	1
Halfpenny Lane	FP	Featherstone	LNE	WAG1	No	50	2
Hathersage West	FP	Hathersage	LNW	MAS	Yes	90	2
Hempstead	UWCT	Uckfield	SE	SCU1	Yes	70	1
Hirstwood	FP	Saltaire	LNE	TJC3	Yes	90	2
Johnstown	FP	Wrexham	LNE	WSJ2	Yes	70	2
Kearsley	FP	Farnworth	LNW	MVE1	Yes	75	2
Keepers Lane	UWCT	Trimley	SE	FEL	Yes	75	1

Crossing name	Type	Location	Territory	ELR	Whistle board	Line speed (mph)	Tracks
Kirby Muxloe	UWCT	Kirby Muxloe	LNE	KSL	Yes	45	1
Llanharran Pub BW	BW+T	Llanharran	Western	SWM	Yes	75	2
Llanstephan MSL	FP+MWL	Camarthen	Western	SWM	Yes	75	2
Mountsorrell Bridleway	BW+T	Mountsorrel	LNE	SPC5	Yes	110	6
New House Farm	UWCT	Shrewsbury	Western	SHL	Yes	90	2
No Name	FP	Trimley	SE	FEL	Yes	75	1
Park Allley	FP	Canterbury West	SE	ACR	Yes	70	2
Park Farm	FP	Lingfield	SE	HGG1	Yes	70	2
Penketh Hall	UWCT	Warrington	LNW	SDJ2	Yes	40	2
Pinks Hill	FP	Wood Street Village	SE	GTW1	Yes	70	2
Pleasington Golf 1	UWCT	Hoghton	NW	FHR4	Yes	70	2
Portobello	FP	Taffs Well	Western	CAM	Yes	55	2
Race Course	FP	Lingfield	SE	HGG1	Yes	50	2
Roundham	UWC+MWL	Kidlington	Western	DCL0	Yes	110	2
Rushfords	FP	Lingfield	SE	HGG1	Yes	85	2
Rylands	FP	Chorley	LNW	MVE2	Yes	60	2
Sportsfield	UWCT	Featherstone	LNE	WAG1	No	50	2
St Marys	FP	Bingham	LNE		Yes	60	2
Tan House	FP	Wokingham	SE	RDG1	Yes	70	2
Tidemills	UWCT	East Blatchington	SE	STS	Yes	70	1
Tonford	FP	Canterbury West	SE	FDM	No	90	2
Tovil	FP	Maidstone	SE	PWS1	Yes	70	2
Waterworks	FP	Laindon	SE	FSS2	Yes	75	2
Whitchurch	FP	Cardiff	Western	CRY	Yes	45	1
Whitehall	UWC+MWL	Canterbury West	SE	ACR	Yes	70	2

Crossing name	Type	Location	Territory	ELR	Whistle board	Line speed (mph)	Tracks
Willingdon Trees	FP	Willingdon	SE	KJE	Yes	80	2
Woodlands	UWCT	Little Stretton	Western	SHL	Yes	90	2

Appendix B: Train horn criteria in other countries

Europe

The recently revised High Speed Rolling Stock TSI version ST115EN02 (which is expected to come into force in 2007) provides requirements for the sound level outside a train. For other locomotives and conventional trains there are currently no specific requirements, although these are expected to be similar to those for high speed trains.

The basis requirement provides a range (maximum **and** minimum) for the sound level of the horn:

- *"A or C weighted sound pressure level produced by each horn sounded separately (or in a group if designed to sound simultaneously as a chord) shall be between 115dB and 123dB when measured and verified in accordance with the method defined below"*. It goes on to state that *"the 115bD sound pressure level shall be achieved when the system air pressure is at 5bar and the 123dB sound pressure level shall not be exceeded when the system air pressure is at 9bar"*.

The sound level is measured and verified in an open area, 5 metres from the front of the train (the same as the British Rail Group Standard) at the same height as the horn and over a ground covering of new clean ballast.

Ireland

Irish Rail has undergone significant investment in recent years, and as such is replacing what was a significantly ageing rolling stock fleet. The regulator, the Railway Safety Commission, state that they have not been involved in train horns as part of vehicle approval processes, nor as an operational matter. It is understood that Irish Rail in its specifications makes use of British requirements only regarding the minimum noise levels required. The regulator is not aware of any significant noise complaint issues, more of an issue has been the noise of idling diesel locomotives near to residential areas.

South Africa

A representative from the Railway Safety Regulator, South Africa, has provided an overview of whistle boards in South Africa. The noise level emanating from the locomotive has been and is a live issue in South Africa, although more from the perspective of the train crew being subject to high levels of noise, rather than the noise to railway neighbours.

Every crossing that is formally recognised is required to have a whistle board, and failure to sound the horn is regarded as legal non-compliance. There are no criteria specified for the maximum volume of train horns nor for the tone, pitch, or other characteristics of the sound. Different classes of locomotive have been introduced and there are wide variations in the horns provided on each class, both in terms of the tone and volume.

The requirement to sound the horn, whistle, siren or hooter at whistle boards is between 0500 and 2300 only, and it is specified that the horn must be sounded for at least three seconds. Should, due to the view or other reasons, circumstance exist or arise at a particular level crossing which make it necessary for an additional locomotive warning whistle to be given in order to prevent an accident, the driver must give such additional warning. Between 2301 and 0459, the locomotive is not required to sound the horn unless specific local circumstance prevail, which according to the judgement of the train driver may require the horn to be sounded to prevent an accident.

Noise complaints are reported to be very few, although in the past some pressure groups may have emerged on a local basis. These are thought to have emerged more as a response to the noise of shunting moves rather than train horns.

USA

In the US, different states have previously regulated the sounding of locomotive horns with railroads able to resist such regulation through litigation and other means. There is a long and complex history of whistle bans being introduced (and in some cases reversed) in particular areas.

A new rule issues by the Federal Railroad Administration sets the following requirements:

- Requires that horns are sounded at public level crossings[25]
- The maximum sound level for the sounding of horns is 110dBA at 100 feet in front of the train in the direction of travel

25 Exceptions are where speeds do not exceed 15mph and the train crew equipped with 'flaggers' to provide warning to motorists. There is also an exception to the rule for corridors provided with Supplementary Safety Measures

- The minimum sound level for the horn is 96dBA 100 feet in from of the train in the direction of travel
- The horn must be sounded 15 to 20 seconds prior to and *until* the train arrives at the crossing
- The horn should not be sounded greater than ¼ mile in advance of the crossing

Importantly, the rule provides an opportunity for any community in the US to establish a 'quiet zone' where the conventional train horn may be silenced at crossings. The minimum requirement for crossings within a quiet zone is for flashing light signals with gates. Each highway approach to every crossing within a new quiet zone must have an advance warning sign that advises motorists that train horns are not sounded at the crossing. In addition, the installation of one of several FRA-approved Supplemental Safety Measures or Alternate Safety Measures may be required at all or some grade crossings within the Quiet Zone. In providing a quiet zone, it is the community, rather than the railway, that funds the provision of the safety control measures.

The 'quiet zone calculator' (http://www.fra.dot.gov/us/content/1337) is a web-based tool created by the FRA to allow local jurisdictions to research the feasibility of creating a quiet zone in their community that complies with FRA's Horn Rule. City planners, traffic engineers and other transportation professionals are the anticipated users of the calculator. The calculator determines the risk level for the proposed quiet zone corridor. The risk level will then be evaluated to determine whether quiet zone criteria have been met. If not, supplemental safety measures can be applied to reduce the risk until the criteria have been met.

Canada

A representative of Transport Canada has provided some information on the requirements relating to train horns.

The requirements for train whistles are managed through the Canadian Rail operating Rules. Locomotives other than in designated service operating in a controlling position shall be equipped with a horn that is tuned in chords of not less than three tones meeting the following design criteria:

- Must produce a minimum sound level of 96 dBA at any location on an arc of 30.5 metres (100 feet) radius subtended forward of the locomotive by angles 45 degrees to the left and to the right of the centreline of the track in the direction of travel

- The control of the horn shall be located to allow for convenient operation from the locomotive operator’s normal operating location

Whistle boards are located 1/4 mile from the crossing. If the sightlines are poor, the railway apparently has to reduce train speed in order that the crossing users have about a 20 seconds warning.

There is not blanket night-time whistle ban, although on some crossings where noise can be an issue, the railways may be exempted from sounding the whistle during certain period (i.e. 2300 to 0700). Rule 14(L)(ii) of the Operating Rules requires whistling for public crossings at grade "except as may be prescribed in special instructions". The railway company can initiate an exemption by issuing an instruction, which eliminates the application of rule 14(L)(ii) (guidelines are provided on Transport Canada's website: http://www.tc.gc.ca/railway/guideline/eliminatingwhistling.htm). In overview, the issue can be managed locally between the relevant authorities and the rail operating companies, and an inspector form Transport Canada may be invited to confirm (or otherwise) that the arrangements are adequate. There are guideline requirements for provision of lights and bells (for example) to be used as an alternative to the whistle board.

Transport Canada do report that they receive some complaints relating to noise and this is what is driving a number of municipalities to seek exemption from the rules for the sounding of the train horn.

Australia

The Australian railways are comprised of the various state railways that are operated separately, with interoperability arrangements in place to manage safe working between states.

Train horns are referred to in the relevant interoperability standards:

- The 'Manual of Engineering Standards and Practices' (section 13) states that *"the warning horns shall….(be) five chime or equivalent"*, but does not appear to give any actual noise level criteria
- The Code of Practice for the Defined Interstate Rail Network (Part 1, section 5.5) states that *"train crews shall sound the locomotive warning device clearly and distinctly"*, and that *"the intensity, length and repetition shall be varied according to the circumstances and the distance over which the warnings need to be heard"*. Train horns are required to be sounded on the approach to level crossings (there is nothing more specific about the types of crossing or any exceptions)

Poland

In Poland, whistle boards are used at level crossings to instruct the train driver to sound a horn or whistle. The whistle board is apparently located as a function of the maximum train speed (in km/h), multiplied by a coefficient that

depends on ‘local circumstances’ with a value between 6 and 8. For linesspeed of 60km/h therefore, a whistle board would be located between 360m and 480m from the crossing.
The requirements for train horns are described in Polish standard PN-91/K-88100 which differentiates the sound levels required for train horns and train whistles. For train horns the requirements is for 1220-125dB for a train horn and for a train whistle, 105-110dB. In both cases the measurements is taken 5m from the device. Trains are required to sound the horn regardless of time of day (i.e. 24 hours per day).

There also is a requirement defined in the Environmental Minster Decree, that the noise level from the side of the train is between 45 and 65dB depending on the time of day and land use. It is not clear, however, how this translates to the design requirements for train horns as it does not relate to the measured sound level at a fixed distance from the train or device.

Noise complaints are reportedly very rare.

Spain

In Spain, there are specific requirements for whistle boards depending on the type of crossing:

- At fixed signs crossings the whistle board is located 500m from the crossing and also at 250m from the crossing if the visibility is less than 500m when the user is 5m from the centre of the tracks
- At crossings with lights only, half or full-barriers, whistle boards are provided as for fixed sign crossings. However, in urban areas no whistle board is needed if the crossing has an acoustic warning as well as the lights
- At crossings at stations which are ‘protected by the station master’ whistle boards are provided 100m from the crossing. Trains stop before the crossing, check it is clear and then whistle before moving off slowly

There are no specific criteria that relate to the sound level of train horns. As far as we have been able to determine, complaints relating to train horn noise are not an area of concern in Spain, perhaps in part due to the acceptance of high levels of noise in everyday life.

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